THE INFLUENCE OF PRENATAL EXPERIENCE ON DIFFERENTIAL RESPONSIVENESS TO VOCAL EXPRESSIONS OF EMOTION IN NEWBORNS

by

DIANE MASTROPIERI

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

1996

UMI Number: 9630490

UMI
300 North Zeeb Road
Ann Arbor, MI 48103

This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

4-29-96
Date

Chair of Examining Committee

4/29/96
Date

Executive Officer

Professor Gerald Turkewitz

Professor Gordon Barr

Professor William Fifer

Professor Susan Karp Manning

Professor Myron Hofer

Supervisory Committee

THE CITY UNIVERSITY OF NEW YORK

Abstract

THE INFLUENCE OF PRENATAL EXPERIENCE ON DIFFERENTIAL RESPONSIVENESS TO VOCAL EXPRESSIONS OF EMOTION IN NEWBORNS

by

Diane Mastropieri

Adviser: Professor Gerald Turkewitz

This study investigated newborn differentiation of vocal expressions of emotion and the relevance of prenatal experience to such differentiation.

Differentiation of emotion was tested by examining the responses of newborn infants (12-72 hours after birth) to the presentation of four vocal expressions (i.e., happy, sad, angry, and neutral). Differential responding was observed, as indicated by a significant increase in eye opening in response to the presentation of happy speech patterns as compared to eye openings in response to the other vocal expressions.

To examine the relevance of prenatal experience in influencing this ability, responding in infants with different prenatal acoustic experiences (i.e., prenatal exposure to either English and Spanish maternal speech)

were compared. Differential responding was observed only in those infants listening to emotional speech in the language which they had experienced prenatally. Infants born to Spanish speaking mothers showed an increase in eye opening in response to the presentation of the happy vocal expressions in Spanish, similar to that observed in the English infants listening to English vocal expressions. In contrast, no significant evidence of differential responding was found in the two groups of infants listening to the same vocal expressions when they were presented in an unfamiliar language (i.e., Spanish infants listening to English expressions and English infants listening to Spanish expressions).

These results indicate that the ability to differentiate emotion exists earlier in development than previously anticipated. More importantly, the results suggest that the origin of differential responsiveness to emotional speech is based upon learning that occurs during the fetal period. A potential mechanism - temporal contiguity between the prosodic acoustic characteristics of emotional speech and stimuli created by the associated maternal physiologic changes - is proposed to account for this influence of prenatal experience on newborn behavior. That newborns were capable of differentiating among the different sounds experienced prenatally, while infants without prior experience could not, suggests that the presence of other stimuli in the fetal environment (i.e., stimuli created by maternal physiological responses concomitant on emotion) serve to make the distinctive emotional speech patterns distinguishable.

Acknowledgements

First and foremost, I thank Dr. Gerald Turkewitz for his guidance, support, and encouragement. Throughout my experience working with Dr. Turkewitz, I have developed a very deep sense of respect, trust, and admiration for him. I greatly admire his wisdom and insight. His creative thinking has inspired me to think more creatively. He has given me clear direction and guidance, yet has also provided the encouragement for me to pursue my work independently. And, because of his sensitivity and patience, Dr. Turkewitz gave unconditional support both personally and professionally. I have considered it both an honor and a pleasure to have worked with such a wonderful mentor.

I also wish to thank the other members of my dissertation committee. Thank you to Dr. Gordon Barr for his very clear and helpful criticisms and comments and for his encouragement, and to Dr. William Fifer, whose own research also served as a source of inspiration for this project, for his helpful input, direction, criticisms and comments. I thank Dr. Susan Manning for her helpful comments and criticisms, and for her support throughout my graduate career. And, thank you to Dr. Myron Hofer for his helpful comments and for agreeing to serve on the committee on very short notice.

Thank you to St. Johns - Queen's Hospital, Elmhurst, New York for granting permission to conduct these studies at their facility. Thanks especially to Dr. Nicholas D'Arienzo, Sister Helen Faulds, and the nursing staff of St. John's for their cooperation and assistance, as well as to the parents and their infants for participating in this study.

Thank you to Yvette Martens for her assistance in data collection and scoring and to Eugene Mastropieri, Jr. for his assistance with the audio recordings.

I also thank my family and friends for their love and support over the years. Especially, I thank my mother, Patricia Corallo, for being especially patient, understanding and helpful to me over the past few months. Also, thank you to my step-father, Ronald Corallo, my brother, Eugene Mastropieri, Jr., sister-in-law, Allison G. Mastropieri, and father, Eugene Mastropieri, Sr.

And finally, thank you to Michele Nadder for being a constant source of strength and encouragement and to Caroline Olko for always lending a helping hand when I needed it. And, thank you to Ellen Breheny for always being warm, supportive, and very helpful in so many ways.

This research was supported in part by a National Research Service Award, the National Institutes of Mental Health (5 T32 MH15341).

Table of Contents

List of Tables

List of Figures

CHAPTER I

INTRODUCTION

The fetal period represents a unique and important period in our development. Although some negative environmental influences (e.g., the effects of maternal disease, malnutrition or prolonged anxiety) on the developing fetus have been examined fairly extensively, only recently have researchers begun to explore more typical features of the fetal environment as potential influences on early development (see Hofer, 1988). For example, recent research on maternal voice recognition and the listening preferences of the newborn have demonstrated the importance of prenatal auditory experiences in influencing postnatal behavior (DeCasper & Fifer, 1980; DeCasper & Spence, 1986). Yet, aspects of the fetal environment may provide unique opportunities for organization that go beyond the effects of prenatal acoustic experiences, and these opportunities may have important consequences for subsequent development as well. For example, some maternal physiological changes (such as those that accompany emotional experiences) may be detected by the developing fetus. If these changes are detected, and are accompanied by the auditory stimulation provided by maternal vocal expressions of emotion, this would provide an opportunity for associative learning in utero. This form of prenatal learning may serve as a basis for the postnatal differentiation of emotion.

Studies of the development of emotional perception have generally focused on the infant's ability to perceive facial expressions. The development of this ability necessarily occurs postnatally. As a result, a number of investigators have concluded that infants do not develop the capacity to perceive emotional expressions until several months of age, possibly because the visual system of the human infant is poorly developed at birth relative to the other sensory modalities (Aslin, 1987; Gottlieb, 1971). The auditory system, however, is well developed at birth. And, since there is evidence for auditory as opposed to visual dominance in early infancy (Lewkowitz, 1988a,b), the emotional information conveyed vocally may be more salient to the young infant than the emotional information conveyed in facial expressions. Yet, very few studies have examined infants responses to vocal expressions of emotion.

The Communicative Functions of Prosody

The role of nonlinguistic vocal cues, such as voice intonation or prosody, has been examined in adult communication. Research in this area has revealed that adults are capable of judging the emotional state of the speaker on the basis of this information (Safer & Leventhal, 1977). The role of specific vocal cues has been examined as well. Scherer (1974) looked at five such cues, which included pitch, pitch variation, amplitude, amplitude variation and tempo. Each of these acoustic cues was varied independently, to assess which were relevant in providing information about affect. Subjects were presented with a simple tonal sequence modeled after the intonation contours of speech, and were asked to judge whether or not the sample could be an expression of various specific emotions. The results indicated that the subjects did use the various acoustic cues for identifying different emotions. For each specific emotion, different cues were found to be important. In general, pitch variation and tempo had the greatest influence on subjects' ratings.

The same types of nonlinguistic vocal information signifying various types of affect may be communicated in early mother - infant interactions as well. Several studies have demonstrated that infants both perceive and respond to various features of speech, including prosodic modifications, long before understanding other aspects of language (Fernald, 1984; Fernald, 1985; Fernald & Kuhl, 1987; Werker & McLeod, 1989).

In addition, the type of speech that infants are exposed to early in life typically possesses some unique features. These features include an increase in pitch, an increase in pitch range, slower rhythm and tempo, shorter utterances, and longer pauses, as compared to speech directed towards adults (Fernald & Simon, 1984). This type of speech has been referred to as "motherese" or "infant directed speech" (IDS).

Cross-cultural studies examining the acoustic parameters of speech directed to infants in several European languages, as well as Japanese (Fernald, Taeschner, Dunn, Papousek, de Boyssen-Bordies & Fukui, 1989) and Mandarin Chinese (Greiser & Kuhl, 1988) have documented that a number of the acoustic features of IDS are universal. And, both male and female speakers have been found to use the exaggerated intonation patterns associated with IDS. But, although adults tend to alter many of the acoustic parameters of their speech when addressing young infants, pitch and pitch modulation seem to be the critical factors in determining the IDS preference in young infants (four-month-olds), whereas amplitude and durational characteristics do not seem critical in determining this preference (Fernald & Kuhl, 1987).

Although it is not yet clear what type of information, if any, infants derive from such acoustic features, Fernald (1984) has proposed that the acoustic characteristics of motherese are important for several reasons, some of which will be mentioned here. First, the increased pitch of motherese distinguishes it from background noise, thereby reducing the effects of masking. Second, the exaggerated intonation allows the infant to track a single sound source, enabling the speaker to maintain the infant's attention. And finally, the acoustic features of motherese can also serve to convey affective information to the infant, and may serve as a basis for learning the affective meanings of particular vocalizations. Furthermore, Fernald (citing Scherer, 1974) suggests that this type of speech is likely to convey information about positive affect in particular, since higher pitch and expanded pitch range are often used to convey information about positive affect in adult communication. Although joyful speech differs from IDS in terms of durational characteristics (i.e., joyful speech is characterized by an increase in tempo, whereas IDS is characterized by a decrease in tempo), both types of speech share those acoustic features which have been found to be important in determining young infants' IDS preference (i.e., increased pitch and expanded pitch range).

Evidence suggestive of the perceptual similarities between IDS and joyful speech was provided in a study by Werker and McLeod (1989), who examined affective responses of 18- and 30-week-old infants as perceived by naive and trained adults. Infants were videotaped while listening to two types of speech, infant-directed speech (IDS) and adult directed speech (ADS). Using this procedure it was found that adults have different emotional reactions to infants listening to the different types of stimuli (i.e., adults view infants listening to IDS as more "cuddly" or "pleasant" than those infants listening to ADS). And, the trained observers also detected more affective responding in infants listening to IDS.

This provides one possible explanation for the preference for motherese found in four-month-olds (Fernald, 1985) and in one-month olds (Cooper & Aslin, 1990). The communication of positive affect is likely to have reinforcing value, causing the infant to selectively attend and respond to such stimulation. However, this explanation is only plausible if the capability for associating affective information with specific types of speech patterns exists at such an early age. If such a capability does exist, then the basis for its origin remains to be determined. It is not yet known whether the preference for motherese results from experience. If it does, this does not necessarily indicate that this experience occurs postnatally, particularly since recent research has revealed a preference for IDS in newborn infants which is comparable in relative magnitude to the IDS preference that exists in one-month-old infants (Cooper & Aslin, 1990). This evidence suggests the possibility that this preference has its origin in prenatal experience. And, perhaps the affective information contained in various tones of voice is learned prenatally as well.

The Influence of Prenatal Acoustic Experience on Neonatal Behavior

A number of experiments have examined the role of prenatal exposure to the maternal voice in determining postnatal auditory preferences. For example, in 1980, DeCasper and Fifer demonstrated such a preference in newborns using an operant-choice procedure. In this procedure, the infants could activate a recording of either the mother's voice or the voice of another female by altering their sucking rate on a nonnutritive nipple. The results indicated that newborns are not only capable of discriminating between the voices of adult females, but also that the maternal voice is an effective reinforcer for newborns. In contrast, DeCasper and Prescott (1984) found no such preferences for the paternal voice over the voice of other males when the same operant-choice procedure was used. This effect was not a result of an inability to discriminate the voices of adult males, since the use of a habituation/dishabituation procedure revealed that the newborns did have this ability. This evidence supports the notion that preferences for the maternal voice in newborns results from prenatal as opposed to postnatal experience, since many infants in this study had had postnatal experience with the father's voice.

To provide more direct evidence that these effects result from prenatal experience, DeCasper and Spence (1986) conducted a study in which pregnant women recited a particular children's story aloud twice a day, beginning at approximately 7 1/2 months of pregnancy and continuing until delivery. The newborns were then tested with the same procedure used in the DeCasper and Fifer (1980) study to determine whether the familiar story (i.e., the story to which the infant was exposed prenatally) was more reinforcing than a novel story. The results showed that the newborns preferred the familiar story.

These studies, in addition to providing evidence for the role of prenatal auditory experience, suggest that the maternal voice is particularly salient to the fetus in utero, whereas other voices, such as that of the father, are less so. Additionally, intrauterine heartbeat sounds have also been found to be salient to the fetus, and these sounds also serve as effective reinforcers for the newborn (DeCasper & Sigafoos, 1983).

The Role of Prosody in Influencing the Listening Preferences of the Newborn

Research by Panneton (1985, cited in Cooper & Aslin, 1989) examined whether the basis for the postnatal listening preferences observed in newborns following prenatal exposure to speech sounds is primarily related to suprasegmental (or prosodic) characteristics of speech (i.e., frequency, frequency variation, intensity and rhythm) or if the basis for these preference is primarily related to segmental characteristics of speech (i.e., specific phonemes). To accomplish this, Panneton tested the ability of newborns to recognize melodies which they were exposed to prenatally. The segmental characteristics of both a novel and a familiar (i.e., the melody presented prenatally) melody were held constant by substituting the syllable "la" for all of the lyrics. The newborns were then tested using a similar procedure to that used in the DeCasper studies (DeCasper & Fifer, 1980;

DeCasper & Spence, 1986), and the newborns demonstrated a preference for the familiar melody.

Using a modification of the contingent sucking paradigm described earlier (see page 8), in which specific syllables (e.g., ah vs. ee) were used as discriminative stimuli, Moon and Fifer (1990, cited in Fifer & Moon, 1995) further demonstrated the importance of suprasegmental characteristics in determining the postnatal listening preferences of the newborn. In this study, the newborns increased sucking to a signal paired with a filtered version of the mother's voice (low-pass filtered at 1000 Hz, thereby removing the segmental characteristics) as compared to a signal paired with an unfiltered version of the mother's voice. The newborns demonstrated this preference for maternal speech sounds resembling those heard "in utero" regardless of whether or not they were accompanied by heart beat sounds, also resembling those heard "in utero", presented in the background.

Spence and DeCasper (1987) also demonstrated that a filtered version of the maternal voice is reinforcing to the newborn. But, newborns hearing unfamiliar voices prefer to listen to an unfiltered version. This apparent contradiction may be explained in terms of the prenatal acoustic experience of the fetus. The filtered version of the maternal speech closely resembles the speech sounds to which the fetus is exposed in utero, whereas newborns have not had similar experience with filtered versions of the unfamiliar voices. In contrast, newborns do not show a preference for their mother's speech if she speaks in a monotone, thereby removing the prosodic cues (Mehler, Bertoncini, Barriere, Jassik-Gerschenfeld, 1978). Therefore, the listening preferences of the newborn resulting from fetal exposure to maternal speech appear to be based on the detection of prosodic aspects of speech rather than being based an the detection of specific phonemes.

Since prosodic cues have also been found to be important in the communication of emotion (Scherer, 1974; Safer & Leventhal, 1977; Scherer, 1986), it suggests the possibility that prenatal exposure to maternal vocal expressions of emotion can serve as a basis for the postnatal perception of different emotional tones of voice.

A Potential Basis for Associative Learning In Utero

A model by Turkewitz (1988, 1989) provides one possible explanation accounting for the salience of the maternal voice and other internally generated sounds in utero. He proposes that different types of auditory stimuli are salient during different periods of gestation, depending upon the progressively changing characteristics of the uterus, which influence the nature of the fetal acoustic environment.

According to Turkewitz, most sounds to which the fetus is exposed early in gestation are those that are internally generated (e.g., gastrointestinal and cardiovascular noise), rather than externally generated (e.g., the maternal voice). This is because, at earlier stages the uterine wall is still relatively flaccid, thereby attenuating sound generated from the external environment. Later in development, the uterine wall becomes thinner and more taut, thereby amplifying externally generated sound. Consequently, there is an increase in the incidence of sound originating from the external environment which characterizes the later acoustic environment of the fetus. The maternal voice becomes especially salient during this period because this amplification of airborne sounds, and because maternal speech reaches the fetus via a second route, conduction along the vertebral column. Additionally, the voice of the mother is accompanied by other types of stimulation, including tactile stimulation caused by movements of the maternal diaphragm.

In addition to accounting for the salience of the different sounds available in the intra-uterine environment, this model suggests that there may be a variety of other potential sources of stimuli which characterize the fetal environment. It is well known that there are many physiological changes associated with emotion and arousal (i.e., respiratory, cardiovascular, muscular, and hormonal changes). And, with the possible exception of some hormonal changes, these changes in physiological state are likely to be temporally contiguous with changes in voice intonation. For example, changes in voice intonation associated with an emotional state such as anger may be accompanied by increased respiration, causing a different pattern of diaphragmatic movements, as well as increased muscular tension, and an increase in heart rate. Some of these physiological changes may provide additional sources of stimulation for the fetus. Furthermore, the temporal relationships between the stimulation created by the maternally-mediated, distinctive physiological patterns that accompany emotion and the distinctive maternal prosodic emotional speech patterns would provide an opportunity for associative learning (via classical conditioning) in utero.

Since the proposed model assumes temporal contiguity of these maternal physiological changes and the changes in maternal speech patterns, some consideration of the temporal relationship of these stimuli is necessary. The requirement of temporal contiguity implies a delay of no more than 1 or 2 seconds for the strongest associations to be formed. There are also requirements regarding the ordering of stimuli. Usually, the most effective conditioning procedure involves a conditioned stimulus (CS) which precedes the unconditioned stimulus (US). Therefore, (if the maternal physiological response patterns were considered to serve as the US) for the proposed associative conditioning processes to be most effective, changes in maternal speech patterns should precede autonomic changes. However, if these particular types of stimulation are particularly salient to the fetus, then it is possible that simultaneous or backwards conditioning may also be effective.

The ordering of events, and temporal relationships between them, in human emotional responding is controversial. According to the James-Lange and Schacter & Singer (1962) theories of emotion, the autonomic changes precede behavioral changes and the cognitive experience of an emotion. Likewise, Scherer (1986) has suggested that autonomic changes immediately precede and influence changes in voice intonation. However, Walter Cannon (1927) proposed that all of these changes occur simultaneously. Therefore, it is difficult to determine the order of occurrence of the maternal autonomic changes and the changes in speech patterns. Furthermore, the extent to which the changes in speech patterns are influenced by autonomic changes (e.g., respiratory and muscular changes) should also be taken into consideration.

The opportunity for associative learning seems to exist, but it remains to be determined if such processes actually occur. If the fetus is capable of making such associations, this potential form of learning could serve as a basis for a differential response to different vocal expressions of emotion after birth.

The Physiological Concommitants of Emotion

In order to explore the possibility that such processes occur, the nature of the physiological concommitants of emotion must first be considered, particularly those that are likely to be detected by the fetus.

Generally, studies of the effects of maternal emotion on the developing fetus, and the subsequent implications of these experiences, have been restricted to examinations of prolonged or trait anxiety. Animal models have been used to explore the effects of long-term maternal stress/anxiety on postnatal "emotionality" in rat pups (Thompson, 1957) and in rhesus monkeys (Schneider, 1992; Clarke and Schneider, 1993).

Similarly, the effects of prolonged maternal anxiety on the behavior of human infants has also been examined (Sontag, Reynolds and Torbet, 1944). And, recently, ultrasound observations of fetal behavior (at 36-37 weeks of gestation) indicated an increase in the frequency and duration of fetal motor activity in response to maternal state anxiety (Van den Berg, 1990) showing that short-term or transient maternal emotion can impact the fetus as well. Yet, the possible cumulative effects of transient maternal emotions and the potential differential effects of maternal emotional states other than anxiety on fetal and/or neonatal behavior and development have not been explored.

Theoretical Considerations: General Arousal vs. Physiological Specificity

Although it is widely accepted that the physiological changes associated with changes in emotional state are mediated by the autonomic nervous system (ANS), which influences the activity of a number of systems, including the cardiovascular system, the respiratory system, the digestive system, and the endocrine system to name a few, the precise nature of the patterns of physiological change associated with emotional states is unclear. Generally, two theories of the physiological concommitants of emotion have been proposed. These theories are sometimes referred to as the General Arousal and Specificity Theories.

General Arousal Theory (Cannon, 1927) proposes that a general increase in physiological arousal accompanies all types of emotion. Therefore, all types of emotion arousing stimuli would result in identical patterns of physiological change (e.g., an increase in heart rate, blood pressure, respiration, sweating, etc.).

In terms of the present model being proposed, this would suggest that it may be possible for newborns to discriminate emotional versus nonemotional tones of voice based upon their prenatal experiences with these two different voice types, since these voice types would be accompanied by different sets of stimuli arising from the differences in maternal physiological states of arousal. On the other hand, this theory also suggests that newborns would not be able to discriminate between different emotional tones of voice based upon prenatal associative learning, as a result of the co-occurrence of distinctive maternal speech patterns and the physiological changes occurring in the mother, since all emotions share a common pattern of arousal.

In recent years, however, many researchers involved in the study of emotion have supported Specificity Theory. According to this view, there are different patterns of physiological change associated with different emotions. At the very least, it has been suggested that different patterns of physiological change may be found for pleasant versus unpleasant emotions. Specifically, it is believed that stimuli that elicit negative or unpleasant emotions are accompanied by a dominance in activity of the sympathetic nervous system (SNS), whereas stimuli that elicit positive or pleasant emotions are accompanied by a dominance of activity of the parasympathetic nervous system (PNS) (Morgan, 1965; Scherer, 1986; Stanley-Jones, 1970). If this is the case, then we might expect that newborns will be able to differentiate emotional tones of voice on the pleasant versus unpleasant dimension.

But, according to the original formulation proposed more than a century ago by James (1893) and Lange (1885/1967), the autonomic changes associated with emotion are even more differentiated, such that different physiological response patterns may be seen for various different emotions. This model has gained support from a number of recent theorists (Ekman, Levenson & Friesen, 1983; Gellhorn, 1964; Kemper, 1987; Scherer, 1986; Stanley-Jones, 1970). And, Ekman (1984) has taken this model a step further to suggest that states of arousal that are not accompanied by a distinctive physiological response pattern should not be labeled as emotion.

Empirical Studies: Hormonal Evidence

Some of the earliest evidence for physiological differentiation between discrete emotions was provided by Ax (1953). This study demonstrated that the emotions fear and anger are characterized by different endocrine secretions by the adrenal medulla, such that anger is accompanied by an increase in the secretion of norepinephrine (NE) and fear is accompanied by an increase in the secretion of epinephrine (E). Both of these hormones can lead to further changes in the organs and systems that are innervated by the ANS. For

example, both of these hormones raise blood pressure, although they do so in different ways.
E leads to an increase in heart rate, whereas NE causes constriction of the small blood vessels (Morgan, 1965).

But, in addition to the different patterns of autonomic activity resulting from increases in the amount of E or NE present in the bloodstream, it seems likely that there would be differences in the patterns of autonomic activity existing prior to the release of these hormones, since the activity of the adrenal medulla is influenced by the SNS. If the SNS responds identically for fear and anger, then it would be expected that the adrenal gland would also respond identically for these two emotions. But since the response of the adrenal gland can be distinguished for fear and anger, it must be assumed that the SNS uses different signals for these emotions. It may also be possible that the SNS (or ANS in general) sends distinct signals for different emotions to other target organs as well.

Although the Ax (1953) study supports the hypothesis that at least some emotions are physiologically differentiated, the results of Schacter and Singer's (1962) study challenged these findings. This study showed that when subjects are administered injections of E, and are not given an appropriate explanation concerning the physiological effects of the injection, they are likely to look to situational cues for an explanation or label for the state of physiological arousal being experienced, rather than relying specifically on physiological cues to determine which emotion they are experiencing. On the basis of these data, the authors concluded that while autonomic arousal is a component of emotion, the emotions are differentiated strictly on a cognitive level.

Alternatively, it has been suggested that the presence of the adrenal hormones alone are not sufficient to specify any one identifiable emotion. Furthermore, it has been suggested that although the adrenal hormones, E and NE, clearly play a role in the experience of emotion, there may be a tendency for researchers to overestimate the role of these hormones. The physiological changes accompanying an emotional experience involve changes in a number of systems. And, although it is likely that many different emotions share a common set of physiological changes, those factors that differentiate the emotions may be very subtle and/or complex. The presence of E and/or NE in the bloodstream may produce only a component of the physiological changes that accompany true emotions. And, the temporal pattern of release of these hormones into the bloodstream during the experience of an emotion is likely to differ from that achieved with an injection. Furthermore, the temporal pattern of release may also differ for different emotions.

Taking these factors into account suggests that it is unlikely that injecting uninformed subjects with E would result in the experience of patterns of physiological change that resemble those accompanying a true emotional experience (McNaughton, 1989). However, it does seem possible that the methods used in the Schacter and Singer (1962) study could increase the probability that a subject would make an assessment of stimuli in his/her environment to help explain the ambiguous physiological changes he/she is experiencing and then label those feelings accordingly.

More recently, however, evidence from Erdman and van Lindern (1980) suggests that the administration of certain drugs may be more effective in eliciting physiological response patterns that more closely mimic those experienced in 'true' emotions. In this study, subjects were administered either a beta-adrenergic stimulating drug (orciprenaline), a beta-adrenergic blocking drug (oxprenolol), or a placebo in an effort to examine the effects of sympathetic arousal on the intensity of an emotional experience. Since the authors initially supported the view that the administration of drugs (e.g., E) is not sufficient to induce true emotions, the emotion-inducing stimuli used in this study were situational cues. Subjects in the three different drug groups were exposed to one of two stimulus conditions, either a neutral situation or an anger-inducing situation. In the neutral condition, subjects received a letter informing them that the results of an IQ test taken earlier would not be available until after the experimental session. In the anger condition, the subjects received an insulting letter informing them that the results of their IQ test were very poor. Previous work by the first author (Erdman & Becker, 1978, cited in Erdman and van Lindern, 1980) indicated that this condition does, in fact, induce a state of physiological arousal and subjective reports of anger. Self-reported emotions were then used to compare subjects in the two conditions. The results indicated that the anger-inducing situation led to increased reports of anger (as compared to the neutral-control condition) in the placebo group only. And, as may be expected, subjects in the beta-adrenergic blocking agent group showed no difference in reported anger as compared to the neutral-control condition. But, most interestingly, those subjects who had received the beta-adrenergic stimulating drug reported feeling anxiety more often than anger. To account for these results, the authors explain that orciprenaline has effects on the circulatory system that are more similar to the effects of epinephrine rather than norepinephrine. And, the physiological pattern of change resembling that which is produced by epinephrine (i.e., a large increase in HR and systolic BP, but not diastolic BP) has been shown to be more closely associated with the experience of fear or anxiety (Ax, 1953). Since subjects in the orciprenaline condition who were exposed to the anger-inducing situation showed higher anxiety than anger scores, the results of this study are consistent with the findings of Ax (1953), not with those of Schacter and Singer (1962). Thus, this study supports the Specificity Model of the physiological concommitants of emotion.

It is difficult to speculate about the range of possible ways in which such transient hormonal changes accompanying different maternal emotional states could serve as potential sources of stimuli available in the intra-uterine environment. Although there is evidence indicating that these changes do, in fact, have an immediate influence on fetal behavior (Van den Berg, 1990), it is not clear how placental transfer of these hormones, <u>or</u> the resulting changes in fetal activity would influence fetal processing of maternal speech sounds. However, one possible source of stimulation provided for the fetus as a consequence of these hormonal changes may involve contractions of the uterus.

Uterine Contractures

Late in gestation, the fetus is in direct contact with the uterine wall due to an insufficient amount of amniotic fluid to surround the fetus (Nathanielsz, 1995). As a result, mild uterine contractions, refered to as contractures, may provide tactile and/or vestibular stimulation for the fetus.

Uterine contractures occur periodically throughout gestation. These contractures are governed, in part, by the activity of the ANS. The myometrial cells of the uterus receive input from the sympathetic NS via adrenergic nerves. And, the response of the uterine muscle to different neurotransmitters, including E, NE, and acetylcholine (ACh), depends upon a number of factors.

First, the relaxation of uterine muscles to accommodate the developing fetus during pregnancy may influence myometrial contractility (Huszar & Walsh, 1989).

Second, it is hypothesized that the uterus contains both excitatory (α) and inhibitory (β) adrenoreceptors. And, presumably, the ratio of α to β receptors is influenced by changes in hormonal status, specifically estrogen or progesterone dominance (Huszar & Walsh, 1989).

And, finally, uterine responding is not the same to all neurotransmitters, and responding to different neurotransmitters may vary as a function of hormonal status (i.e., estrogen or progesterone dominance) as well. In general, NE and ACh are considered contractile agents (Huszar & Walsh, 1989), while E causes relaxation of the uterus (Moawad, 1973). However, differences in uterine responding have also been found among various species. In the human uterus during early and middle pregnancy, E has been found to cause stimulation of uterine contractions, whereas NE leads to a mixed response. In contrast, the presence of E at term inhibits uterine activity while NE stimulates uterine activity (Moawad, 1973).

There is evidence that this form of myometrial activity influences the fetus in a variety of ways. Contractures have been shown to increase fetal intracranial pressure and reduce fetal oxygenation. There are also changes in fetal endocrine function and behavioral state (see Nathanielsz, 1995, for review). Further, changes in myometrial activity are hypothesized to affect both structual and functional development of the fetal brain (Nathanielsz, 1995).

The specific response of the uterus during pregnancy to different emotional states, as well as the implications of these response patterns (i.e., changes in myometrial activity associated with emotion) for the fetus remain to be further explored. Since the neurotransmitters involved in modulating uterine contractility have also been shown to play a role in emotion (Ax, 1953; Erdmann & van Lindern, 1980), it is likely that the patterns of uterine activity would be modified during states of emotion. And, if the altered patterns of uterine activity co-occur with maternal vocal expressions of emotion on a consistent basis, this would provide an opportunity for associative learning to take place, since the modified tactile and/or vestibular stimulation (or other forms of stimulation) provided may serve to make these particular speech patterns more distinct.

The Cardiovascular System

Changes in the cardiovascular system, such as heart rate accelerations and decelerations, have also been found to differ for different emotional states. For example, research by Ekman, Levenson and Friesen (1983) has shown that although heart rate accelerations are associated with a variety of different emotional states, the greatest increases in heart rate (HR) were found in response to anger arousing stimuli (+ 8.0 $\pm$

1.8 beats per minute) and fear arousing stimuli (+ 8.0 ± 1.6 beats per minute), whereas stimuli eliciting happiness result in smaller increases in HR (+ 2.6 ± 1.0 beats per minute).

On the other hand, a number of studies examining heart rate patterns associated with various emotional states have found conflicting results, particularly when anger has been examined. Some such studies have found cardiac accelerations during angry states, whereas others have found cardiac decelerations. The particular pattern of results obtained seems to be dependent on a variety of potential influences. Factors that may be important include the type of stimuli used to elicit anger, and whether or not the subject is given the opportunity to act on his/her anger. (see Thompson, 1988 for review).

Changes in heart rate in either direction (ie., heart rate accelerations and/or decelerations) are likely to have consequences for the fetus, since DeCasper and Sigafoos (1983) have shown that the fetus is likely to hear these sounds in utero. Therefore, this is another potential stimulus that the fetus may come to associate with different tones of voice.

Additionally, changes in placental blood flow arising as a consequence of maternal heart rate changes may also provide a source of stimulation for the fetus.

The Digestive System

Disturbances of the digestive system have also been associated with some emotional states, such as anxiety (see Thompson, 1988 for review). The sounds associated with these disturbances are also believed to be audible to the fetus, and could serve as another source of auditory stimuli available to the fetus during certain maternal vocal expressions of emotion.

The Respiratory System

Respiratory changes, such as rate and depth of respiration, have also been examined for different emotions (Averill, 1969). The results of this study showed greater respiratory changes associated with mirth as compared to sadness. However, as Averill points out, this difference was likely to result from the laughter that accompanied the state of mirth. And, in general, the results of studies examining respiration patterns are difficult to interpret, since respiration is under both voluntary and involuntary control, and because the apparatus used to measure respiration may interfere with normal breathing (Thompson, 1988). However, reliable findings concerning respiration would be particularly important to the present model, since respiratory movements may provide tactile stimulation to the fetus, as suggested by Turkewitz (1988, 1989).

The Striated Musculature

In addition to the autonomic changes already discussed, Gellhorn (1964) suggested that specific emotions are associated with specific changes in the somatic nervous system (striated musculature) as well, which involve both phasic activity (e.g., contractions in the muscles of the face) and tonic activity (e.g., alterations in posture). In terms of the tonic activity of the striated musculature, it is suggested that a decrease in muscle tone characterizes certain emotional states (e.g., sadness), whereas an increase in muscle tone is characteristic of other emotional states (e.g., joy). Such changes in muscle tone, particularly in the maternal abdominal region, may influence the fetal environment. Specifically, increased muscle tone may constrain the fetal environment, thereby restricting the range of possible fetal movement, while decreased muscle tone may result in the opportunity for greater freedom of movement.

Based on some of the recent research exploring physiological changes associated with emotion, it seems likely that the fetus may detect at least some differences in the patterns of arousal associated with maternal emotional states, although the evidence concerning the specificity of physiological changes is not clearcut. Some of the practical limitations involved in studying a number of systems have already been discussed. But, in general, the study of emotion is limited by both practical and ethical issues.

First, there have been some inconsistencies in defining discrete emotions in the literature (Sherer, 1986; Thompson, 1975), leading to poor reliability across studies. Second, the physiological responses involved are often complex and interrelated (McNaughton, 1989; Thompson, 1975). Third, emotional states are often not studied in a natural context, but rather are induced in a laboratory setting. How similar these induced emotions are to those that occur more spontaneously in a natural setting is open to question, since emotions experienced in a laboratory setting are likely to differ in intensity. And, there are ethical constraints on attempts to induce some emotions that are highly intense (see Sherer, 1986).

Furthermore, emotions induced in a laboratory setting may also differ in quality, since the same emotional state may not be induced in all subjects participating in a given study. Stimuli that have been designed to elicit a specific emotion may, in fact, elicit different emotions in different individuals or, possibly, blends of two or more emotions rather than a single "distinct" emotion. Consequently, the physical concommitants of the different emotions elicited will vary as well (Barrett & Campos, 1987; Fox & Davidson, 1986b). Researchers often attempt to control for this possibility by requiring subjects to give self-reports of the emotion they are experiencing. However, it is well known that such reports are often influenced by a variety of demand characteristics, including social desirability, and by each individual subject's ability and sensitivity to assess and define his/her emotional experiences accurately.

Measurements of physiological concommitants of emotion are further complicated by individual variability in physiological reactivity. The work of Lacey and his associates (Lacey, Bateman & van Lehn, 1953; Lacey & Lacey, 1958) has indicated that individuals differ markedly in their physiological responses to stress. But, for a given individual, the physiological response pattern is often highly stereotyped, such that the individual will show a characteristic response pattern to a variety of stressors (e.g., mental arithmetic, hyperventilation, cold pressor test). The characteristic response pattern of an individual is often manifested as a high degree of reactivity with respect to one particular physiological function (e.g., heart rate variability <u>or</u> galvanic skin response), with low reactivity with respect to other physiological functions. The characteristic response pattern of different individuals may differ markedly in terms of which physiological function(s) will manifest the highest (or lowest) level of reactivity. Additionally, some subjects show a greater tendency towards a stereotyped pattern of response to a wide array of stressors, whereas others are less rigidly stereotyped and show greater variability in the pattern of responding to different stressors. However, the proposed model does not require that the patterns of physiological concommitants of emotion be universal among different individuals. This model only requires that the mother's pattern of responding for specific emotions is consistent, because consistent pairing of stimulation caused by maternal physiological changes and acoustic stimulation would be necessary to provide the fetus with an opportunity for associative learning.

As a consequence of the limitations involved in studies of the physiological concommitants of emotion, it is difficult to predict whether the newborn would be more likely to have developed the ability to discriminate emotional from nonemotional tones of voice, pleasant from unpleasant tones of voice, or among discrete emotions. The first step in determining which, if any, of these possibilities occur would be to determine if newborns respond differentially to different emotional tones of voice.

Although differential responsiveness on the part of the newborn to different emotional tones of voice would not indicate that the newborn is actually perceiving emotion, it is not necessary to show that newborns can perceive emotion to determine that newborns respond differentially to emotional tones resulting from prenatal experience. The differential responsiveness involved may simply be a precursor to the development of emotional perception.

Emotional Perception in Infancy

Some studies have used procedures designed to determine if infants are capable of discriminating among various expressions of emotion. The majority of these studies have examined responses to facial stimuli and/or composite expressions involving both face and voice.

For example, Caron (1988) examined discrimination of "naturalistic" expressions of emotions which were videotaped composites of dynamic facial expressions accompanied by the appropriate vocal expressions. Using a habituation/ dishabituation paradigm with looking time as the dependent measure, Caron looked at the ability to discriminate among three discrete emotions, including joy/happiness, sadness, and anger.

Joy vs. Sadness

Caron found that the ability to discriminate happy from sad composite expressions was present in 4- and 5- month olds, but infants in both age groups showed evidence of an order effect. Performance was generally better when the sad expression was presented first, whereas infants seemed to have greater difficulty with this task when they were first shown the happy expression in the habituation phase of the experiment and then tested with the sad expression in the dishabituation phase.

In a similar study, Walker-Andrews and Grolnik (1983) examined discrimination of sad versus happy tones of voice in 3- and 5-month-old infants, also using a habituation/dishabituation procedure. Infants were shown a slide of either a happy or sad facial expression accompanied by the appropriate vocal expression. Then, once the criterion for habituation was reached, the vocal expression was changed while the slide depicting the facial expression remained the same. Discrimination was defined as an increase in looking time following the change in vocal expression. The results indicated that the 5-month-olds were capable of detecting a change in vocal expressions, regardless of whether the change involved a transition from a sad to a happy tone or from a happy to a sad tone. In the 3-month-olds, there was an increase in looking time when the change involved a transition from a sad to a happy tone of voice, yet there was no increase in looking time when the change involved a transition from a happy to a sad tone. As the authors of this study suggest, these results do not clearly determine whether the 3-month-olds were discriminating between the two emotional tones of if the increase in looking time indicated an alerting response to the happy tone of voice, as Walker-Andrews and Grolnik suggest, or possibly a preference for the happy tone.

If a preference for joyful/happy expressions does exist among young infants, then the origin of this preference should be explored. The first step in examining its origin might be to determine when this preference emerges developmentally. If it is found to be present among newborns, then it is possible that it may result from prenatal experience. Perhaps the maternal physiological changes associated with joy are in some way reinforcing to the fetus.

Joy vs. Anger

The next set of emotions that Caron (1988) examined were joy and anger. The ability to discriminate between these two emotions is of particular interest, since the vocal expressions of these emotions share many acoustic properties. Scherer (1986) reviewed several studies that examined the specific acoustic characteristics involved in the vocal expression of various emotions. Based upon the most consistent results found among these studies, he described joy and anger as sharing several properties, including increased mean fundamental frequency, increased frequency range and variability, increased mean intensity, and increased speech rate. On the other hand, sadness is often characterized by a decrease in fundamental frequency, decreased frequency range, decreased mean intensity, and a decrease in speech rate. Nevertheless, adult judges seem remarkably capable of judging different emotional tones of voice, including joy and anger.

Determining whether infants respond differentially to these particular emotions is also theoretically important, since it would help to determine the basis of differential responsiveness to emotional tones of voice. If young infants respond differentially to vocal expressions of emotion solely on the basis of differences in the physical characteristics of the expressions (i.e., intensity, frequency, etc.), then we would expect that they would have greater difficulty discriminating between acoustically similar emotional expressions, such as joy and anger, as compared to emotional expressions that are less acoustically similar, such as joy and sadness. On the other hand, if it could be determined that young infants do respond differentially to emotional tones of voice that share many acoustic properties, then this would support the hypothesis that young infants are capable of detecting subtle differences in the vocal tones that are related to emotion.

Based upon the acoustic similarities of these emotions, Caron predicted that joy and anger would become discriminable later than joy and sadness. Therefore, the 4-month-olds were not tested for this discrimination. The 5- and 7-month-old age groups were tested, and discrimination of the two composite expressions was found in 7-month-olds only.

In contrast, Walker-Andrews and Lennon (1986) found that 5-month-olds could discriminate between these emotions on the basis of vocal cues alone. To account for these differences in results, Caron proposes two possible explanations. The first possibility is that the voices used in the Walker-Andrews and Lennon study were more discriminable than those used by Caron. The second possibility is that the visual information present in the composite expressions may interfere with the discrimination of the vocal expressions. To determine which of these explanations is more probable, further studies on the effects of the voice alone would be necessary.

Despite the fact that there is some question concerning whether or not, and under what conditions, 5-month-olds are capable of discriminating between acoustically similar vocal expressions of emotion, it may be worthwhile to test infants of a younger age for this ability. The fact that joy and anger share many acoustic properties does not necessarily imply that younger infants, and possibly even newborns, would be incapable of discriminating between these two emotions. In fact, it is possible that joy and anger may be more discriminable to a newborn than to an older infant. Prenatally, a fetus may experience joy and anger as being quite different because of some of the physiological changes in the mother associated with these emotions (specifically those changes that are temporally contiguous with speech). Whereas an older infant may have had a fair amount of experience with the expression of these emotions after birth, and may come to view them as being more similar based on the shared acoustic properties of these emotions. In this way, happy and angry expressions of emotion may become less discriminable with age rather than more discriminable.

Several studies have revealed a loss in the ability to discriminate certain types of vocal stimuli with increasing age (Best, McRoberts & Sithole, 1988; Werker & Tees, 1983, 1984). Specifically, the ability to differentiate between speech sounds which are not components of one's native language has been tested in various age groups. The results of these studies have indicated that this ability becomes restricted with experience, such that infants are better able to differentiate this type of stimuli than are adults and children as young as four years of age (Werker & Tees, 1983). And, evidence indicates that exposure to the native language restricts phonetic perception by six months of age (Kuhl, Williams, Lacerda, Stevens & Lindblom, 1991).

Another way to examine emotional perception, and possibly recognition, in infancy has been suggested by Oster (1981), who recommended examining the emotional facial expressions of the infant in response to the stimuli presented. For example, in a recent study, the emotional responses of 7-month-old infants to the still-face paradigm, involving the absence of facial affect and motion displayed by the infant's mother, were examined using facial expressions (e.g., smiling and "cry faces") and fussy vocalizations as the response measures. Significant decreases in infant smiling were observed in response to the presentation of a still-face.

The use of such a procedure, however, does have some limitations, particularly when the behavior of newborns is being studied. According to Izard (1980), newborns display only a limited set of emotions, which includes distress, disgust and interest. Although this does not necessarily indicate that the newborn only experiences these three emotions (Campos, Barrett, Lamb, Goldsmith & Sternberg, 1983), it does suggest that adult judges may find it very difficult to identify the emotional state of a newborn.

An alternative procedure is the use of electroencephalogram (EEG) asymmetries to explore changes in hemispheric activation associated with positive vs. negative emotional states. This procedure has been found to be useful in examining emotional responses in newborns (Fox & Davidson, 1986a) to taste-elicitors, and in older infants (10-month-olds) to emotion elicitors such as the approach of a stranger and maternal separation (Fox & Davidson, 1988).

Davidson & Fox (1982) have also used this procedure to explore differences in hemispheric activation associated with the perception of videotaped facial emotional displays. Their findings indicate differential hemispheric activation for the perception of positive vs. negative emotions in 10-month-old infants. However, the usefulness of this procedure to examine newborn emotional perception has not yet been explored.

Despite these limitations, a few studies have looked at affective responses of young infants (but, not newborns) in response to emotional displays. Haviland and Lelwica (1987) exposed 10-week-old infants to repeated live demonstrations of the emotions: joy, anger and *sadness. Presentations consisted of both* facial and vocal cues, which were displayed by each infants' own mother. Their choice of model was based on the belief that previous experience with the model would enhance responsiveness. By measuring the infants' facial expressions and direction of gaze, these researchers concluded that emotional displays resulted in emotional responses in the infants that could not be attributed to matching the parent's expression.

For example, maternal displays of joy resulted in significantly increased "interest" facial displays (as determined by the Maximally Discriminative Facial Movement Coding System; Izard, 1979) and an increase in forward gaze responses. Maternal displays of anger were associated with a significant decrease in "interest" displays and a significant increase in "no movement" facial responses. Sad maternal displays were associated with a significant increase in mouthing behavior (i.e., sucking or chewing), often accompanied by a downward gaze.

Visual vs. Acoustic Cues

In addition to examining discrimination between specific pairs of emotions, Caron (1988) also set out to determine if the discrimination of these emotions is based primarily upon visual cues (facial expressions) or acoustic cues (vocal expressions). To do this, he compared the performance of infants who were shown only the facial cues to those who were shown the composite expressions (i.e., both facial and vocal cues). For example, in one experiment, the 7-month-olds were tested for the joy versus anger discrimination when presented with the facial expressions only. In this case, no discrimination was found. Whereas, in an earlier experiment, 7-month-old infants shown composite expressions of these emotions did discriminate between them. Caron interprets these findings as an indication that the auditory modality is dominant in early infancy. Although this may be correct (Lewkowicz, 1988a,b), it is difficult to make this assumption concerning emotional perception based solely on this type of experiment. It would also be necessary to see what happens when only the voice is presented. If discrimination occurs, then this would support Caron's assumption, but it is also possible that the combination of both the facial and vocal cues is necessary for discrimination to occur.

The aim of the initial study in this series was to determine whether newborn infants respond differentially to different vocal expressions of emotion. The subsequent series of experiments was aimed at examining the relevance of prenatal experience in influencing this ability by comparing the responses of infants with different prenatal acoustic experiences (i.e., prenatal exposure to different maternal languages). Responses to three emotional expressions were examined: joy, anger and sadness. In addition, a neutral tone of voice was included in the study so that responding to emotional versus nonemotional tones of voice could be compared. Because of evidence indicating the relevance of prenatal acoustic experience in influencing the newborns ability to differentiate emotional speech, all speech samples were low-pass filtered so that the speech sounds would more closely resemble speech sounds experienced prenatally (Spence & DeCasper, 1987; Moon and Fifer, 1990, cited in Fifer & Moon, 1995).

CHAPTER II

PILOT STUDY

Method

Subjects

Twelve (6 male and 6 female) full-term, healthy newborn infants (24 to 57 hours old, M = 40.45) were recruited from the nursery at St. John's Queens hospital, Elmhurst, New York. Data from an additional 2 infants was discarded due to a failure to achieve a quiet alert state. Only those infants who met the following criteria were tested:

1) uncomplicated gestation and delivery
2) estimated gestational age between 38 and 42 weeks
3) Apgar scores of at least 8 at one and five minutes after birth
4) birth weight between 2500 and 3900 grams
5) had received prenatal care
6) no abnormalities noted at or since birth
7) no indication of drug abuse during pregnancy
8) among male infants, circumcision had not occurred within 12 hours prior to testing

Stimuli and design

A stimulus tape consisting of sixteen 15 s audio presentations separated by 1 s intervals of silence was used. The 16 trials consisted of four presentations of each of the following intonation patterns: happy, sad, angry, and neutral. The happy, sad and angry audio segments were excerpts from a videotape produced and supplied by Albert Caron, which has been used in a previous study examining infant discrimination of emotional expressions (Caron, 1988). Four female speakers recited the same script using each of the three emotional expressions. Since the tape supplied by Caron did not include neutral presentations, a fifth female speaker recited the same script using a neutral tone of voice. For the neutral segments, the same speaker's voice was utilized four times. The ordering of the 16 trials was balanced using a Greco-Latin square design. Within each block of four trials, each speaker and each intonation pattern was presented once (with the exception of the neutral presentations). In addition, presentation order was controlled by requiring that each successive infant began testing with the block of four trials that follows the one with which the previous infant began.

Procedure

The mother was given the opportunity to listen to the stimulus tape before it was played for the newborn. She was also invited to accompany the infant during testing. The infant was then brought into a quiet, empty nursery. The experimenter or, on some occasions, the infant's mother held the infant in an upright position and spoke to the infant in order to attain a quiet alert state. Once the infant was in a quiet alert state, he/she was placed in the supine position in the bassinet. The two speakers were attached to the sides of the bassinet (approximately 7 inches from the infants head). The stimulus tape was played continuously until all 16 trials had been presented (approximately 4 1/2 m) at a maximum amplitude level of 80 dB SPL. The infant's responses to the stimulus tape were recorded using a video camera attached to a tripod, located at the end of the bassinet near the infant's feet.

Scoring

The infants' videotaped responses were assessed in terms of overall activity level, crying, mouthing, direction and quality of limb movements, head and eye movements.

Activity level. Level of activity was scored according to the following four descriptive categories: quiet with no movements, low intensity movements (e.g., shifting and/or small head and limb movements), high intensity movements (e.g., thrashing of the limbs or a startle response).

Crying. All trials during which crying occurred were noted, and specifications were made according to the following three categories: initiation of cry, continuation of cry, or cessation of cry. However, testing was discontinued if crying was excessive (i.e., persisting for more than 1 m), or if the mother of the infant indicated that she wished to discontinue testing. Two of the 12 infants tested failed to complete 16 trials due to excessive crying.

Mouthing. The incidence of rhythmical sucking movements, tongue protrusions, and/or lip pursing (in the absence of oral stimulation from the infant's hand or blanket) during a trial was noted.

Direction of head turns. All head turns were noted, and the direction (right or left) was specified. However, since the infants' heads were not placed in the midline by the experimenter, the majority of infants began testing with their heads turned towards the right. This was likely to be due to the right head-turning bias typically seen in newborns (Turkewitz & Birch, 1971).

Eye openings. All trials in which the infants' eyes opened or remained open were noted.

The judges were blind to the experimental conditions in that the videotapes were scored with the sound turned off.

Results

Because four of the infants tested failed to complete all 16 trials due to excessive crying (2) or experimenter error (2), the absolute number of responses in each category was converted to a proportion score for each infant. (All of the infants tested did complete at least 12 trials.) Repeated measures analyses of variance (ANOVA) were performed comparing the proportion scores in the different vocal expression conditions for eye opening and for mouthing.

The results indicated differential responsiveness to the different tones with respect to mouthing behavior, $F(3,33) = 3.75$, $MSE = 0.02$, $p < .05$. Post-hoc comparisons using the Tukey test (CV = 0.12) showed that mouthing behavior occurred significantly more frequently during sad ($M = 0.17$) and neutral ($M = 0.17$) presentations as compared to happy presentations ($M = 0.02$). Mouthing behavior occurred in six out of twelve infants in the sad condition, five in neutral, two in angry, and one in the happy condition. The frequency of mouthing during angry presentations ($M = 0.06$) did not differ significantly from the other three conditions.

The mean proportion score for eye openings was highest in the happy condition (M = 0.41), followed by the neutral ($M = .40$), sad ($M = 0.37$) and angry ($M = .30$) conditions. Although preliminary analyses (t-tests) indicated possible differential responding with respect to this measure, the results of the ANOVA showed no significant differences in eye opening, $F(3,33) = 1.98$, $MSE = 0.02$, $p > .05$.

There were no significant differences in responsiveness with respect to any of the other measures.

CHAPTER III

EXPERIMENT 1

Since the results of the pilot study indicated that a specific response pattern may be identified for at least two of the emotional expressions being examined, the next experiment was conducted to establish the reliability of these findings. Specifically, the results of the pilot study showed that mouthing behavior (i.e., rhythmical sucking and/or tongue protrusions) occurred more frequently during sad and neutral presentations as compared to happy presentations. Additionally, although the mean scores for eye openings did not differ significantly across emotion conditions, the data was suggestive of a possible trend, in which increased eye openings (or eyes remaining open) were associated with the presentation of happy vocal expressions. Therefore, these particular responses were the behaviors of interest in all subsequent studies.

Method

Subjects

Ten (5 male and 5 female) full-term, healthy newborn infants (24 - 50 hours old, $\underline{M}$ = 34.55) were recruited from the nursery at St. John's Queens hospital, Elmhurst, New York. Data from an additional 19 infants were discarded due to a failure to achieve a quiet alert state (12), excessive crying (6), or experimenter error (1). Only those infants who met the criteria specified in the pilot study were tested. Because the infant's eyes were not clearly visible in 3 of the infants tested, only the data from 7 infants was utilized for judgements of eye openings.

Stimuli

Since the tape used in the previous study did not consist of the same four female speakers using all four intonation patterns, a new stimulus tape was produced. In addition, a new script[1] was used, since the script used by Caron (1988) was more appropriate for infant-directed speech as opposed to adult directed speech. The decision to use an adult directed script was based on the assumption that adult-directed emotional expressions would be more typical during pregnancy, whereas it cannot be assumed that all mothers used infant-directed emotional expressions during this time period.

The tape consisted of four female speakers each reciting the same script four times, using each of the following intonation patterns: happy, sad, angry, and neutral. The speakers were instructed to recall an experience appropriate for each emotion to ensure that they were experiencing each of the three emotions as they were speaking, rather than acting. This technique is referred to as the "relived emotions task" (Levenson, 1992), and it has been used to induce emotions in studies of the physiological concommitants of emotion (Ekman, Levenson & Friesen, 1990; Levenson, Cartensen, Friesen & Ekman, 1991). For the neutral tone of voice, speakers were instructed to speak in an "ordinary conversational tone".

The 16 recorded speech samples were then judged by ten naive adults using a forced choice procedure. An overall 94% accuracy rating of correct identifications was obtained. For the different tones, 100%, 92.5%, 97.5%, and 87.5% accuracy ratings were obtained for the happy, sad, angry and neutral tones respectively.

Because there was a possibility of a carry-over effect in responding when the vocal expressions were presented very closely in succession, the inter-trial intervals were lengthened to 5 s. Stimulus presentations were shortened to approximately 10 s. For the four sad presentations, the first phrase of the recited script was deleted to control for presentation length, since the rate of speech was slower for this vocal expression.

The audio tapes were low-pass filtered by playing the recording on a Denon DR-M24 HX tape deck and passing it through a Krohn-Hite filter (model 3550) set at 500 Hz. A second Denon DR-M24 HX tape deck was used to record the output.

The procedures used to control for presentation order were identical to the pilot study.

Apparatus

Two lightweight Radioshack Realistic mini amplifying speakers (model 40-16) were mounted onto the sides of the bassinet, and were connected to a Marantz PMD 360 stereo cassette tape recorder. A Panasonic Proline (model AG180) videorecorder was used to tape the infants' responses.

Procedure

The procedure used for testing the newborns was identical to that of the pilot study.

Scoring

The infants' videotaped responses were assessed in terms of mouthing behavior (i.e., the incidence of rhythmical sucking movements, tongue protrusions, and/or lip pursing in the absence of oral stimulation from the infant's hand or blanket during a trial was noted) and eye behavior responses. Specifications for eye behavior responses were made according to the following three categories: eyes open (O), eyes closed (C), or eyes transitional towards closed (TTC). TTC is a term being used to describe eye behavior typically observed when an infant is in a drowsy state following a period of eyes open or wakefulness.

The judges were blind to the experimental conditions (i.e., the videotapes were scored with the sound turned off).

Reliability

To assess reliability, a second trained observer also judged the eye behavior responses of all seven of the infants. There was 75.9% agreement between the raters. To determine whether agreement between the raters was significant, the kappa statistic was calculated comparing the judges assignments of infant responses to the three eye behavior categories (ie., open, TTC, or closed). The results indicated significant agreement between the two judges, K = 0.61, $z = 7.84$, $p < .01$.

Results

Eye Behavior Responses

Although every effort was made to test the infants in a quiet-alert state (in which the infants eyes would be open[2]), in many cases, it was difficult to maintain this state throughout the testing session. Additionally, there were differences between the amount of time spent in different states (i.e., awake, drowsy or sleep states). This resulted in considerable variability in the state of the infants just prior to each stimulus presentation. Since it is known that newborn responses to stimuli differ depending on state, and particularly since eye opening/closing or drowsy (i.e., TTC) behavior is the response measure being observed in the present study, it was necessary to take the state of the infant just prior to each stimulus presentation into account for the purposes of data analysis. Therefore, the individual trials were grouped into three separate categories that described the infants eye position just prior to stimulus presentation: initial eye position - open (IEP-O), initial eye position - closed (IEP-C) or initial eye position - transitional towards closed (IEP-TTC). The data collected in each of these three categories was analyzed separately. This procedure allowed for a more clear understanding of any changes in the infants' behavior that occurred following the onset of a stimulus.

Data Conversion

The division of trials into separate data sets dependent upon initial eye position resulted in an unequal distribution of trials among the three sets. For example, in experiment 1, the highest percentage of trials fell into the IEP-C data set (49.1%), whereas smaller percentages of trials fell into the IEP-O (31.2%) and IEP-TTC (19.6%) data sets. In addition, the percentage of trials in any one data set differed for the different emotion conditions and for individual subjects. Therefore, it was necessary to use scores that would take the number of trials into account when determining the frequencies of the different responses in the different emotion conditions.

Although the most obvious way of accomplishing this would be to determine the ratio of the number of responses to the number of opportunities to respond (i.e., the number of trials in the data set for that condition), this is not the method used in this study as it may distort the data (see, however, Appendix F-I). For example, if a subject begins two of the happy presentation trials with eyes open, and then closes his/her eyes during one trial, this would result in a score of 0.5 or 50% for eye closings (in the IEP-O data set for the happy condition). And, although this score would accurately reflect the behavior of this particular infant in this one condition, this formula would yield an equivalent score in the case of two eye closings out of four trials beginning open. Yet, two eye closing responses is 50% greater in frequency than one eye closing response. Likewise, this formula would yield equivalent scores for one eye closing out of one opportunity to respond (i.e., one trial in the IEP-O data set) and for four eye closings out of four opportunities to respond. Distortions of the data such as these made it necessary to develop a formula that was sensitive to both the differences in the frequencies of responses and to the proportion of responses to the number of opportunities to respond in a data set.

One potential formula that is sensitive to both of these considerations involves the addition of a constant (e.g., + 1) to the denominator in the formula just discussed. This would serve to increase the denominator sufficiently to reflect the differences in scores that differ in terms of response frequencies, but which have the same ratio of responses to opportunities to respond. *For example,* one eye *opening* response out of one opportunity to respond would result in a score of 0.5 (1/1+1), whereas four responses out of four opportunities to respond would result in a score of 0.8 (4/4+1). A problem arises with this formula in cases involving zero responses in a response category. A score of zero would be obtained from this formula regardless of the number of opportunities to respond. Since zero responses in a category (e.g., eye openings) when no opportunity to respond (in a particular data set) exists is clearly not equivalent to zero responses when one or more opportunities exist, further modifications of this formula were necessary.

The following formula was used to calculate the subjects scores in each data set. Separate scores were calculated for each response category (open, closed, TTC) in each of the four emotion conditions:

$$\frac{(\text{HIT} \times 4 - \text{MISS})}{\#\text{ of OPPORTUNITIES TO RESPOND} + 1}$$

In this formula, a "HIT" is defined as the frequency of responses in the particular response category for which the score is being calculated (e.g., the number of eye opening responses). A "MISS" is defined as the total number of responses falling into the other response categories (in the present example, the combined total of closed and TTC responses). The "MISSES" were subtracted from the "HITS" in order to obtain negative scores in cases in which there were no responses in a category but when there were one or more opportunities to respond. The value of 4 in the numerator represents the number of presentations of each condition. The rationale for multiplying the number of "hits" by the number of presentations was to increase the numerator to a value greater than zero in those cases in which the number of "misses" was either equal to or greater than the number of "hits". This procedure maintained positive scores in all cases involving one or more responses in the category being measured regardless of the number of the number of "misses".

The value obtained in the numerator was then divided by the number of opportunities to respond (i.e., the total number of trials in the data set for that particular condition) plus 1. One was a constant added to the denominator to increase it sufficiently to reflect the differences in those scores that differed in the frequency of responses but which were proportionally equivalent (i.e., the number of responses was equal to the number of opportunities to respond). For example, according to this formula four responses out of four opportunities would result in a score of 3.2, whereas three responses out of three opportunities would result in a score of 3.0.

This formula satisfies the following criteria: 1) A value of zero would be obtained in cases involving no opportunities to respond (i.e., no trials fell into the particular data set). For example, if infant #1 began all trials in a condition with eyes open, all scores for this infant in the IEP-C and IEP-TTC data set would equal zero for that condition. (See Appendix J-K)

2) A negative value would be obtained in cases involving no responses in a category when an opportunity to respond existed (i.e., at least one trial fell into this particular data set). And, the absolute value of the score increases proportionally to the number of missed opportunities to respond. For example, no eye opening responses in a data set involving four trials would yield a negative score with a greater absolute value (i.e., -0.8) than no eye openings in a data set involving three (-0.75), or less, trials.

3) A positive value would be obtained in cases involving one or more responses in the response category. And, these scores increase proportionally depending on both the absolute frequency of responses and the percentage of responses relative to the number of trials in the data set.

The resulting method of assigning scores takes both the frequency of responding and the percentage of responses relative to the number of opportunities to respond into account. Figure 1 shows the relation of the scores obtained using this method to the scores that would be obtained using both simple frequency scores and percentage scores.

Figure 1. Obtained scores using frequencies of responses, proportions of responses, and the scoring method used in this study as a function of the ratio of responses to opportunities to respond.

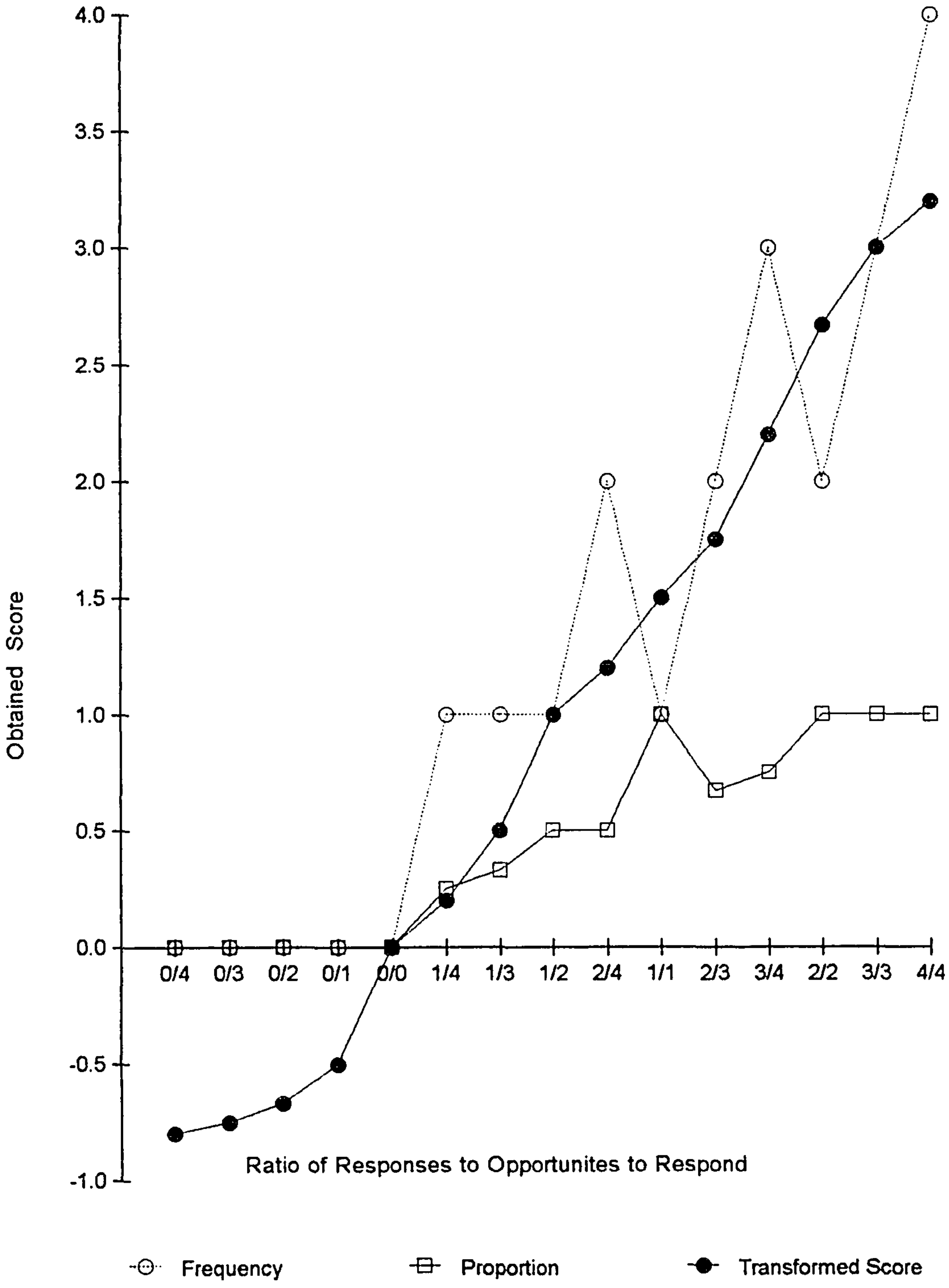
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
Obtained Score
0/4 0/3 0/2 0/1 0/0 1/4 1/3 1/2 2/4 1/1 2/3 3/4 2/2 3/3 4/4
Ratio of Responses to Opportunites to Respond
Frequency
Proportion
Transformed Score

Figure 1

IEP-C Data Set

The results of the data set for IEP-C (i.e., trials involving eyes closed immediately prior to stimulus presentation) will be discussed first since it is expected that an increase in the level of alertness of the infants in response to happy stimulus presentations would be the result of greatest interest based on the results of the data collected in the pilot study. Examination of the mean scores for eye openings revealed a similar pattern of results to those obtained in the pilot study. Figures 2 and 3 show the mean scores for eye openings and eyes remain closed in the data set for IEP-C. The highest mean score for eye openings was observed in the happy condition, followed by the angry, neutral, and sad conditions. Additionally, the percentage of trials during which eye openings were observed in the happy condition (55.6%) was almost twice that of each of the other conditions. The percentages of trials for the angry, sad, and neutral presentations in which eye openings were observed were 30.7%, 21.4%, and 20.0% respectively. Note that the highest mean score for eye openings was observed in the happy condition (M = 1.09), and the

Figure 2. Mean eye opening scores (± *SE*) as a function of emotion condition for the Initial Eye Position-Closed data set for group Eng/Eng (*n* = 7, repeated measures design).

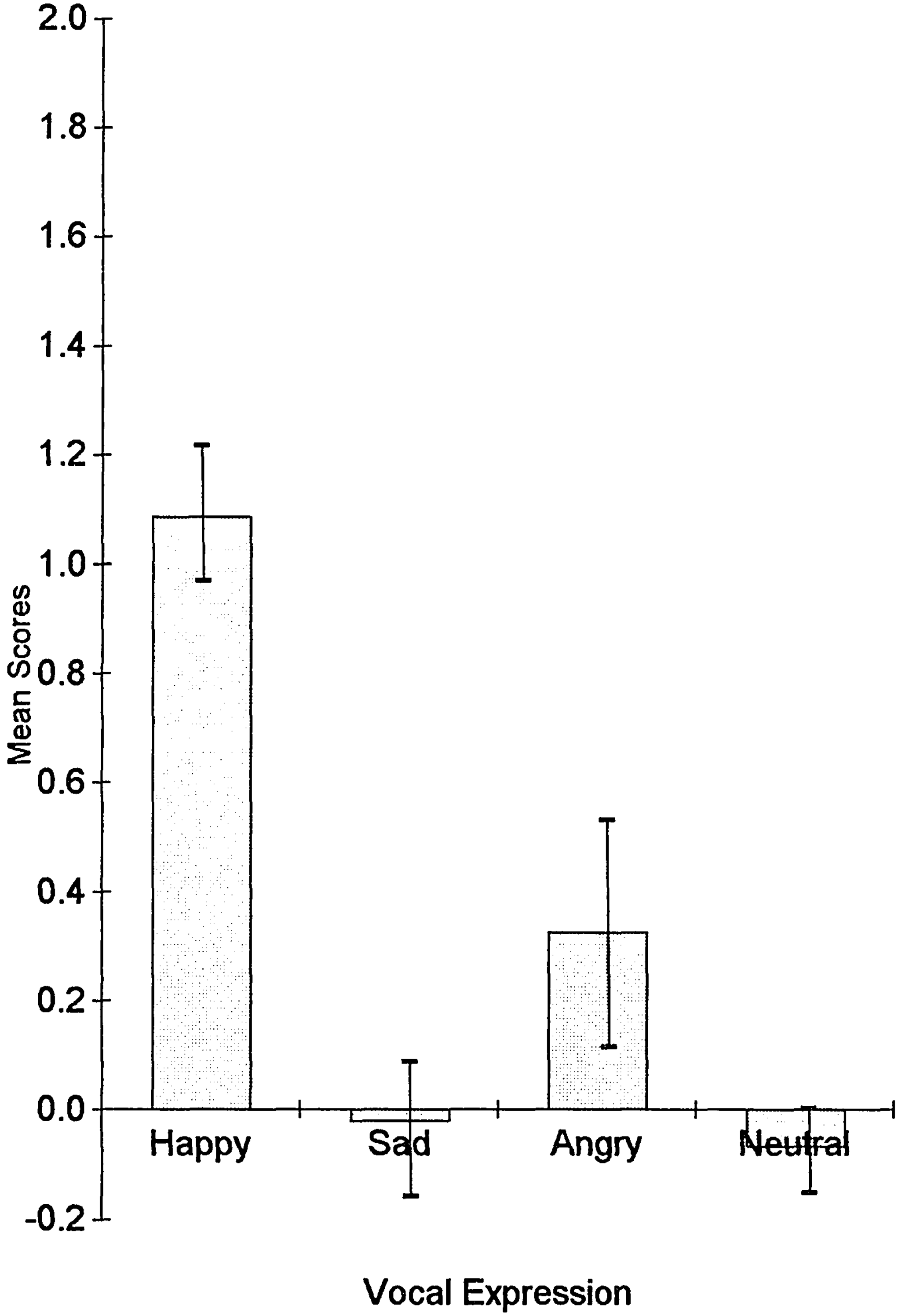
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
Mean Scores
Happy
Sad
Angry
Neutral
Vocal Expression

Figure 2

Figure 3. Mean eye closing scores (± SE) as a function of emotion condition for the Initial Eye Position-Closed data set for group Eng/Eng (n = 7, repeated measures design).

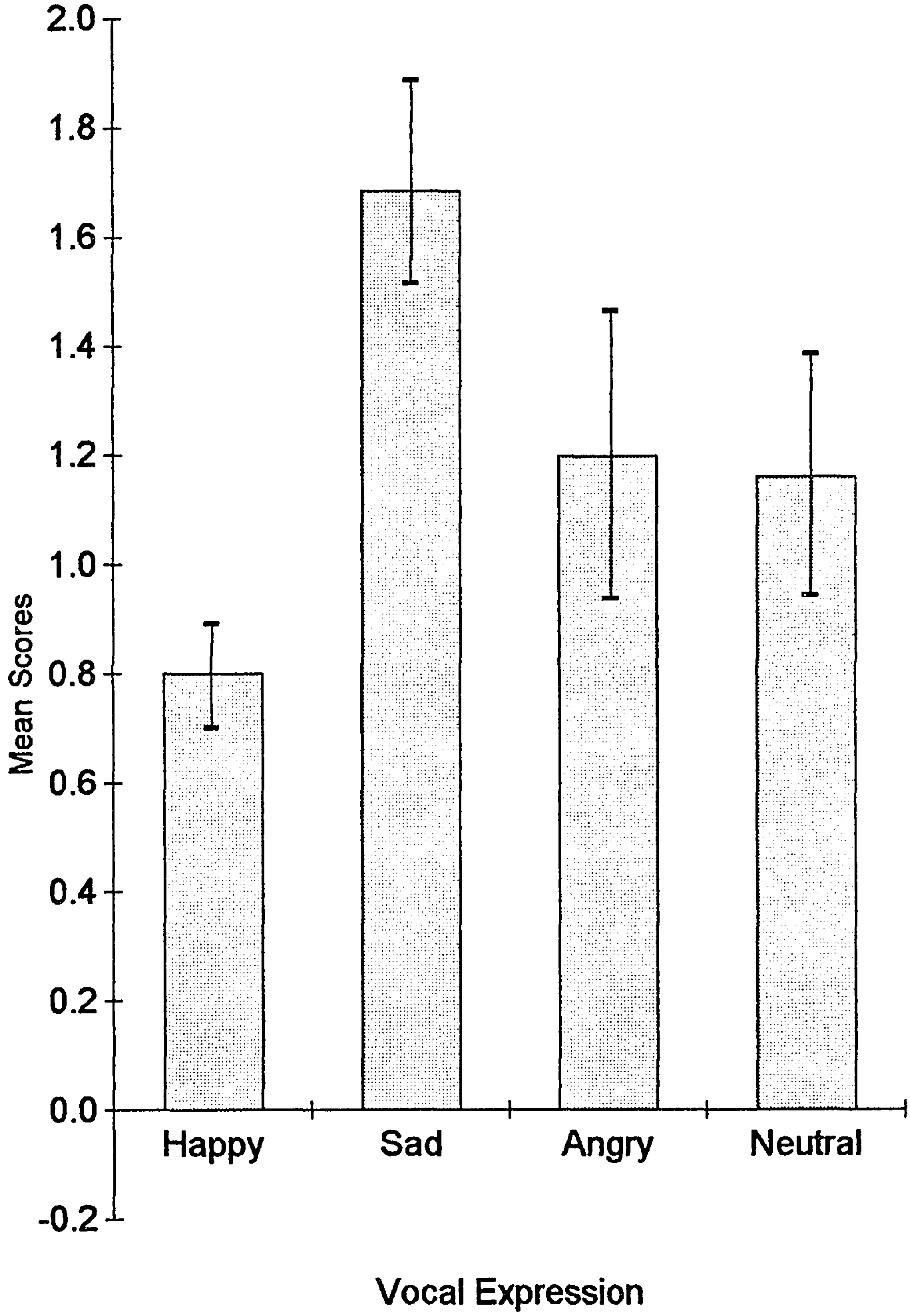
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
Mean Scores
Happy
Sad
Angry
Neutral
Vocal Expression

Figure 3

percentage of trials during which eye openings occurred was almost twice that of each of the other conditions.

Furthermore, the scores for eye openings (O) exceeded scores for eyes remain closed (C) in the happy condition only. All other conditions showed higher C scores as compared to O scores. This suggests that when infants began trials with eyes closed (i.e., prior to stimulus presentation), there was a general tendency for the eyes to remain closed unless a happy stimulus was presented.

A 4 (emotion) X 2 (eye behavior, O or C) repeated measures analysis of variance was performed on this data set to determine whether there was a significant interaction between the emotion (E) and eye behavior (EB) variables. Such an interaction would indicate differential eye behavior responses to the different emotional expressions.

As expected, the E X EB interaction was significant $\underline{F}(3, 18) = 3.70$, $\underline{MSE} = 0.68$, $\underline{p} < .05$. Follow-up comparisons using the Anova multiple F-tests comparisons procedure for planned comparisons were used to compare mean scores for eye openings across the four emotion conditions (CV = 0.78). The results indicated that the infants' eyes opened significantly more often during happy presentations ($\underline{M}$ = 1.09) as compared to the sad ($\underline{M}$ = -0.02) and neutral ($\underline{M}$ = -0.07) presentations. Although the mean eye openings score was higher in the happy as compared to the angry condition ($\underline{M}$ = 0.33), this difference (0.76) only approached the critical value for significant differences(CV = 0.78). Eye opening behavior during angry presentations did not differ significantly from any of the other three conditions.

IEP-O

In contrast, no evidence of differential responsiveness emerged in the data set IEP-O as a result of an overall tendency for the infants' eyes to remain open throughout trials that involved eyes open prior to stimulus presentation, regardless of the particular vocal expression being presented. As shown in Table 1, in all conditions the means for eyes remain open exceeded the means for C and TTC responses. This pattern is reflected in the results of the 4 (emotion) X 3 (eye behavior; O, C, or TTC) Anova of the IEP - O data set, in which the interaction of E X EB was not

Table 1

Mean Eye Behavior Scores in the Initial Eye Position-Open Data Set for Experiment 1 (Eng/Eng)

Condition	Open	TTC	Close
H	1.024	-0.274	-0.274
S	0.619	0.274	-0.203
A	0.679	0.214	-0.156
N	0.993	-0.043	-0.221

Note. H = happy; S = sad; A = angry; N = neutral.

significant, $F < 1$. The main effect of the E variable was also not significant, $F < 1$. Whereas, the main effect of EB approached conventional significance levels, F (2, 12) = 3.50, $p = .06$, as a result of the general pattern of higher mean O scores as compared to mean C and TTC scores.

IEP-TTC

In the IEP-TTC data set, a 4 (emotion) X 3 (eye behavior; O, C, or TTC) Anova was also performed. The significant E X EB interaction, $F(6, 36) = 4.27$, $MSE = 0.50$, $p < .01$, indicated differential eye behavior responses in the different conditions. The means for eye openings, TTC, and eye closing responses for this data set are presented in Table 2. The results of the follow-up comparisons, CV = 0.58, showed that eye openings occurred significantly more in the happy (M = 0.57) as compared to the angry (M = -0.33) and neutral (M = -0.11) conditions. This result further supports the findings obtained in the IEP-C data set, in which an increase in eye opening behavior was also associated with the happy condition.

In contrast, follow-up comparisons also indicated

Table 2

Mean Eye Behavior Scores in the Initial Eye Position-Transitional Towards Closed Data Set for Experiment 1 (Eng/Eng)

Condition	Open	TTC	Close
H	0.571	0.000	-0.239
S	0.786	-0.071	-0.310
A	-0.334	0.667	0.190
N	-0.107	1.000	-0.346

Note. H = happy; S = sad; A = angry; N = neutral.

significantly higher eye openings in the sad condition (M = 0.79) as compared to the angry and neutral conditions. Eye opening in the sad condition did not differ significantly from the happy condition. This pattern of results is different from those obtained in the IEP-C data set, in which the mean eye opening score in the sad condition was lowest as compared to the other three conditions. One possible explanation for this result is that the infants' responses to the sad vocal expressions differed depending on the state of the infant (i.e., drowsy vs. wakefulness). Alternatively, it is also possible that the presentation of sad vocal expressions did not necessarily lead to an increase in eye opening behavior, but that the significant effect observed in this data set was due to an artifact. Since the IEP-TTC data set represented less than 20% (i.e., 19.64%) of the trials in this experiment (whereas the IEP-C data set represented 49.11% of all trials), it is difficult to determine which explanation is more probable.

Conversely, the TTC scores were significantly higher in the neutral (M = 1.00) and angry (M = 0.67) conditions as compared to the happy ($\underline{M}$ = 0.00) and sad ($\underline{M}$ = -0.07) conditions, indicating a general pattern of no change in eye behavior (i.e., eyes remain TTC) following the onset of neutral and angry presentations.

Mouthing Behavior

Although the mean frequency of mouthing behavior was highest during sad presentations ($\underline{M}$ = 1.4) as compared to the mean frequency of mouthing during the neutral ($\underline{M}$ = 0.9), happy ($\underline{M}$ = 0.7), and angry presentations ($\underline{M}$ = 0.5), these differences were not significant, $\underline{F}(3,27) = 2.64$, $\underline{MSE} = 0.57$, $\underline{p} = .07$. Therefore, the results obtained in the pilot study indicating a significant increase in mouthing behavior associated with the presentation of sad vocal expressions was not replicated in this experiment.

Discussion

The results of experiment 1 indicate that newborn infants do respond differentially to different vocal expressions of emotion. The specific pattern of differential responding observed in this study involved an increase in eye opening behavior in response to the presentation of happy vocal expressions as compared to eye openings following the presentations of the other vocal expressions. While it is difficult to speculate about the reasons underlying this particular behavior, it is possible that the infants' responses to the happy vocal expressions may be characterized as an increase in the level of alertness and/or arousal as compared to the level of alertness/arousal seen in the other conditions. However, it is clear that the infants did discriminate the happy presentations from the other vocal expressions. Prior to these findings, the earliest demonstration (in the existing literature) of infant discrimination and/or responsiveness to emotional expressions was 10-weeks of age (Haviland & Lelwica, 1987). Therefore, this demonstration of the newborn's ability to detect the distinctive prosodic features characterizing different expressions of emotion indicates that the ability to differentiate emotion exists earlier in development than previously anticipated.

CHAPTER IV

EXPERIMENTS 2 & 3

Introduction

Although the evidence obtained in the pilot and first experiment indicates that newborns respond differentially to different vocal expressions of emotion, this evidence does not clearly demonstrate that this ability is related specifically to fetal exposure to maternal speech. Therefore, the relevance of this type of experience was tested by examining the responses of infants with different prenatal acoustic experiences. Specifically, the next series of studies were designed to determine whether or not newborns respond in a similar manner to vocal expressions of emotion in a native and a non-native language.

Research by Mehler and his associates (Mehler, Juczyk, Lambertz, Halsted, Bertoncini, and Amiel-Tison, 1988) suggests that newborns may be less responsive to the prosodic cues of speech segments belonging to a non-native language as compared to the prosodic cues typical of their native language. In a series of studies, these researchers (Mehler et. al., 1988) demonstrated that newborns (4-day-olds) are capable of discriminating utterances belonging to their native language from those belonging to a non-native language, and (possibly) show a listening preference for the native language as well.

Moon, Cooper and Fifer (1993) examined newborn listening preferences for the native language in two-day-old infants who were prenatally exposed to either English or Spanish. Using a contingent sucking paradigm, in which the infants could control the length of stimulus presentation by altering the duration of sucking bursts, these researchers found that newborns show a preference for the maternal language.

Furthermore, Mehler et. al. (1988) also found that the newborns (4-day-olds) were capable of discriminating utterances belonging to their native language from those belonging to a non-native language when the speech segments were filtered at 400 Hz, thereby removing segmental cues, while keeping the prosodic cues available. However, when the speech segments were presented backwards, no discrimination was found, suggesting that the direction of the spectral changes was important for recognition of the native language. Additionally, when newborns were tested for discrimination between two non-native languages, no evidence of discrimination was found. This finding is especially relevant to the present study since it suggests that familiarity with the language(s) is necessary for newborns to discriminate between differences in prosody.

Since newborns were unable to discriminate the prosodic differences characterizing two unfamiliar languages, it was expected that newborns would also be unable to discriminate the prosodic differences characterizing different vocal expressions of emotion when spoken in an unfamiliar language.

However, it has been hypothesized that a number of the prosodic modifications used to express different emotions may be culturally universal (Cosmides, 1983; Scherer, 1986). Therefore, it is possible that the newborns could detect some of the similarities in emotion - relevant prosodic cues across different languages and be responsive to them. Such a finding would make it difficult to assess whether the newborns are responding to the emotional tones as a result of prenatal exposure to maternal speech (and stimulus generalization across languages) or if they are simply responding to specific acoustic features (e.g., pitch, pitch range and variability, intensity, etc.) of the different emotional tones that are invariant across the different languages. This latter explanation neither excludes nor necessitates the role of prenatal experience.

Since the aim of this study was to examine the role of prenatal experience in influencing emotional perception after birth, precautions were taken to minimize the potential for stimulus generalization (and the number of shared prosodic modifications) across languages. Therefore selection of the language used for comparison was determined by testing the ability of adult judges to accurately identify emotional tones in their native language and those expressed in a non-native language, in order to test whether the vocal expressions could be accurately identified only by adults who are native speakers of the language, or by adults who are relatively unfamiliar with the language as well. Two comparison languages were considered for the study, Spanish and Korean.

Experiment 2

Method

Adult judges. Ten native Spanish speaking adults served as judges of the recordings of Spanish vocal expressions of emotion and English vocal expressions of emotion. Ten native Korean speaking adults served as judges of the recordings of Korean vocal expressions of emotion and English vocal expressions of emotion. Ten native English speaking adults served as judges of the recordings of English, Spanish and Korean vocal expressions of emotion.

Stimuli. The unfiltered stimulus tapes used in experiment 1 were used for judgements of vocal expressions of emotion in English. For the Spanish and Korean recordings, three adult female native speakers of each language were recorded expressing each of the four tones of voice using the same procedure described in experiment 1. In addition, the same script as in experiment 1 was translated and used for each of the two comparison languages.

Procedure. The three groups of adult judges were asked to label each of the speech samples as a specific emotional or as a nonemotional (i.e., neutral) tone of voice[3].

Results

Table 3 shows the percentages of correctly identified expressions for each group of judges for each language. The native English speaking judges were most accurate in identifying English vocal expressions (82.5% of the expressions were identified correctly), as compared to the percentages of correct identifications of the Spanish (66.7%) and Korean (59.2%) expressions.

In general, the percentages of correct identifications of the Korean expressions was low in comparison to correct identifications of the vocal expressions in the other two languages. In fact, the Korean judges were more accurate when identifying the expressions in English (62.5%) than in Korean (40.7%). Furthermore, the Korean judges identified the Korean vocal expressions less accurately than did the English judges (59.2%). Therefore, Korean was not selected as the comparison language for this study.

Table 3

Percentage of Correct Identifications of Vocal Expressions by Adult Raters

Raters	Expressions	H	S	A	N	Total
English	English	90.0	85.0	85.0	70.0	82.5
	Korean	50.0	63.3	56.7	67.0	59.2
	Spanish	79.2	75.0	66.7	46.1	66.7
Korean	English	83.3	41.7	69.4	55.5	62.5
	Korean	37.0	37.0	37.0	51.9	40.7
Spanish	English	89.3	60.7	89.3	78.6	79.5
	Spanish	71.4	76.2	62.0	76.2	71.4

Note. H = happy; S = sad; A = angry; N = neutral.

The Spanish vocal expressions were identified more accurately by judges who were native speakers of Spanish than by judges who were native speakers of English, making Spanish a potential language to be used as a comparison to English. However, the Spanish judges were also more accurate when identifying the vocal expressions in English (79.5%) than in Spanish (71.4%). There are two possible explanations for this effect. One probable explanation is that since the group of Spanish speaking judges were bilingual (i.e., Spanish/English), it is possible that some or all of the judges were more experienced listening to English vocal expressions of emotion. Alternatively, it is also possible that the native Spanish speakers who recorded the expressions were less emotionally expressive than were the speakers who recorded the English tapes. And, in fact, many of the Spanish judges reported that this was the case. Therefore, new recordings were made using three additional native Spanish speakers. In addition, those vocal expressions on the original Spanish tape that were identified least reliably were re-recorded by the original three speakers.

Method

Ten additional native Spanish speaking judges and ten additional native English speaking judges were then asked to identify the vocal expressions (of both the Spanish and English tapes) using the same procedure described previously, so that the accuracy of correct identifications by native and non-native speakers could be compared.

Results & Conclusions

The four speakers whose expressions were identified most reliably by the native Spanish speaking judges were then selected for the study. The percentages of correctly identified expressions for each group of judges for each language are presented in Table 4.

Examination of the percentages of correct identifications shows that the English judges were not only more accurate in identifying the English expressions overall, but they were also consistently more accurate in the identification of all four of the English vocal expressions as compared to the four Spanish vocal expression. Conversely, the English judges (68.8%) performed relatively poorly in

Table 4

Percentage of Correct Identifications of Vocal Expressions by Adult Raters

Raters	Expressions	H	S	A	N	Total
English	English	92.5	82.5*	95.0*	80.0	87.5*
	Spanish	82.5	70.0*	50.0*	72.5	68.8*
Spanish	English	97.5	85.0	92.5	72.5	86.9
	Spanish	97.5	75.0	70.0	70.0	78.1

Note. Means in the same column marked by an asterisk differ at $p < .05$ in the repeated measures analysis of variance. H = happy; S = sad; A = angry; N = neutral.

comparison to the Spanish judges (78.1%) when identifying the Spanish vocal expressions.

As indicated by the total percentages of correct identifications, the Spanish judges (86.9%) performed comparably to the English judges (87.5%) when identifying the vocal expressions in English, probably as a result of having similar amounts of experience in listening to English vocal expressions. And, a comparison of Tables 3 and 4 shows that the overall percentage of correct identifications of the Spanish expressions improved with the new recordings.

In order to assess whether the judges were significantly more accurate when identifying the vocal expressions in their native language (or, possibly, if both groups were significantly more accurate when identifying the English expressions), a 2 (language) X 4 (emotion) analysis of variance was performed on the frequencies of correct identifications of the four vocal expressions in each language for both the English and Spanish groups of judges.

The results of the analysis of correct identifications by the English judges revealed that this group of judges identified the English expressions

(87.5%) significantly more accurately than the Spanish expressions (68.8%), as indicated by the significant main effect of Language, $F(1,9) = 7.11$, MSE = 1.58, $p < .05$. In addition, the Language X Emotion interaction was also significant, $F(3,27) = 4.46$, MSE = 0.56, $p < .05$, due to the significantly more accurate identifications of both the sad and angry expressions spoken in English as compared to those spoken in Spanish (Anova multiple F-tests comparison procedure, CV = 0.58).

The analysis of correct identifications by the Spanish judges showed that the main effect of Language was not significant, $F(1,9) = 2.58$, MSE = 0.95, $p > .05$, as may be expected since this group of judges was bilingual. So although the percentage of correct identifications of the English expressions (86.9%) was higher than that of the Spanish expressions (78.1%), this difference was not significant.

In summary, while the English expressions were identified with equal accuracy by the monolingual English and bilingual Spanish/English judges, the Spanish vocal expressions were identified more accurately by judges who were native speakers of

Spanish than by judges who were less familiar with the language (native speakers of English). This evidence suggests that these two languages differ in terms of some of the prosodic modifications used to convey emotion. Therefore, Spanish was selected as the language used for comparison with English.

Experiment 3

The next experiment examined:

1) the responses of newborns of English speaking mothers to expressions of emotion in Spanish.

2) the responses of newborns of Spanish speaking mothers to expressions of emotion in Spanish.

3) the responses of newborns of Spanish speaking mothers to expressions of emotion in English.

It was expected that infants listening to the emotional expressions in their native language would respond in a similar manner to the infants studied in experiment 1 (i.e., newborns of English speaking mothers listening to expressions of emotion in English, group Eng/Eng), whereas those infants listening to emotional expressions in a non-native language were expected to be less likely to respond in a similar manner, since the infants were not prenatally exposed to the prosodic modifications used to express emotion in the unfamiliar language.

Method

Subjects

Three additional groups were tested using the same procedures described in experiment 1. Only those infants who met the criteria specified in the pilot study were tested. All infants were recruited from the nursery at St. John's Queens hospital, Elmhurst, New York.

Group 2(Eng/Span) consisted of ten (5 male and 5 female) full-term, healthy newborn infants ($\underline{M}$ = 31.6 hours old) of Spanish (Span) speaking mothers.[4] Data from an additional 9 infants were discarded due to a failure to achieve a quiet alert state (6), or excessive crying (3).

Group 3(Span/Span) consisted of ten (4 male and 6 female) full-term, healthy newborn infants ($\underline{M}$ = 28.2 hours old) of Spanish speaking mothers.[4] Data from an additional 10 infants were discarded due to a failure to achieve a quiet alert state (7), or excessive crying (3).

Group 4(Span/Eng) consisted of ten (3 male and 7 female) full-term, healthy newborn infants (M = 25.8 hours old) of English speaking mothers. Data from an additional 9 infants were discarded due to a failure to achieve a quiet alert state (6), or excessive crying (3).

Procedure

The infants in group 2 (Eng/Span) were videotaped while listening to the tape recording of English vocal expressions. The infants in groups 3 (Span/Span) and 4 (Span/Eng) were videotaped while listening to the tape recording of Spanish vocal expressions. All other procedures used to examine differential responding were the same as that of experiment 1.

In addition, as in the previous experiments, all speech samples were low-pass filtered. This procedure also removes, or at least minimizes, the differences between languages that could be attributed to differences in segmental (i.e., phonemic) acoustic cues rather than to differences in the prosodic modifications used to convey emotion.

Reliability

For experiments 2 - 4, a second trained observer judged the infants' eye behavior responses for ~25% of the trials (i.e., 8 out of 30 infants tested). The inter-rater reliability was 85.3%. The results of the Kappa test, K = 0.66, indicated significant agreement between the raters, $z = 7.86$, $p < .01$.

Results

Eye Behavior Responses - Overall Analyses

In order to test the relevance of prenatal experience on the newborns' ability to discriminate between and respond differentially to these different vocal expressions, an overall analysis of variance was performed on the data sets from the combined data from all four groups. These analyses were used to determine whether differential eye behavior responses to different emotional expressions was present in (1) all of the groups tested, or (2) if this was a behavior demonstrated only in those groups presented with a specific language (e.g., English) with very specific and salient acoustic features, or (3) if this behavior is present only in those infants presented with the language to which they were prenatally exposed.

A mixed (Group X Emotion X Eye Behavior) analysis of variance was performed on each data set. The triple interaction of these three variables was the result of particular interest in the overall analyses, since it would indicate whether or not differential eye behavior (EB) responses to different emotional expressions (E) differed between the groups (Gp) of infants. All analyses were performed on the transformed scores, using the formula described previously.

IEP-C Data Set

Examination of the mean scores indicates that the highest mean scores for eye openings were found in the happy condition in all of the experimental groups with the exception of group Span/Eng, in which the mean score for eye openings was lowest in the happy condition. Additionally, in the happy condition, the scores for eye openings exceeded the scores for eyes remain closed in groups Eng/Eng, Eng/Span, and Span/Span. The mean scores for eye openings for the four groups are presented in figure 4.

Figure 4. Mean eye opening scores (± _SE_) as a function of emotion condition and experimental group for the Initial Eye Position-Closed data sets.

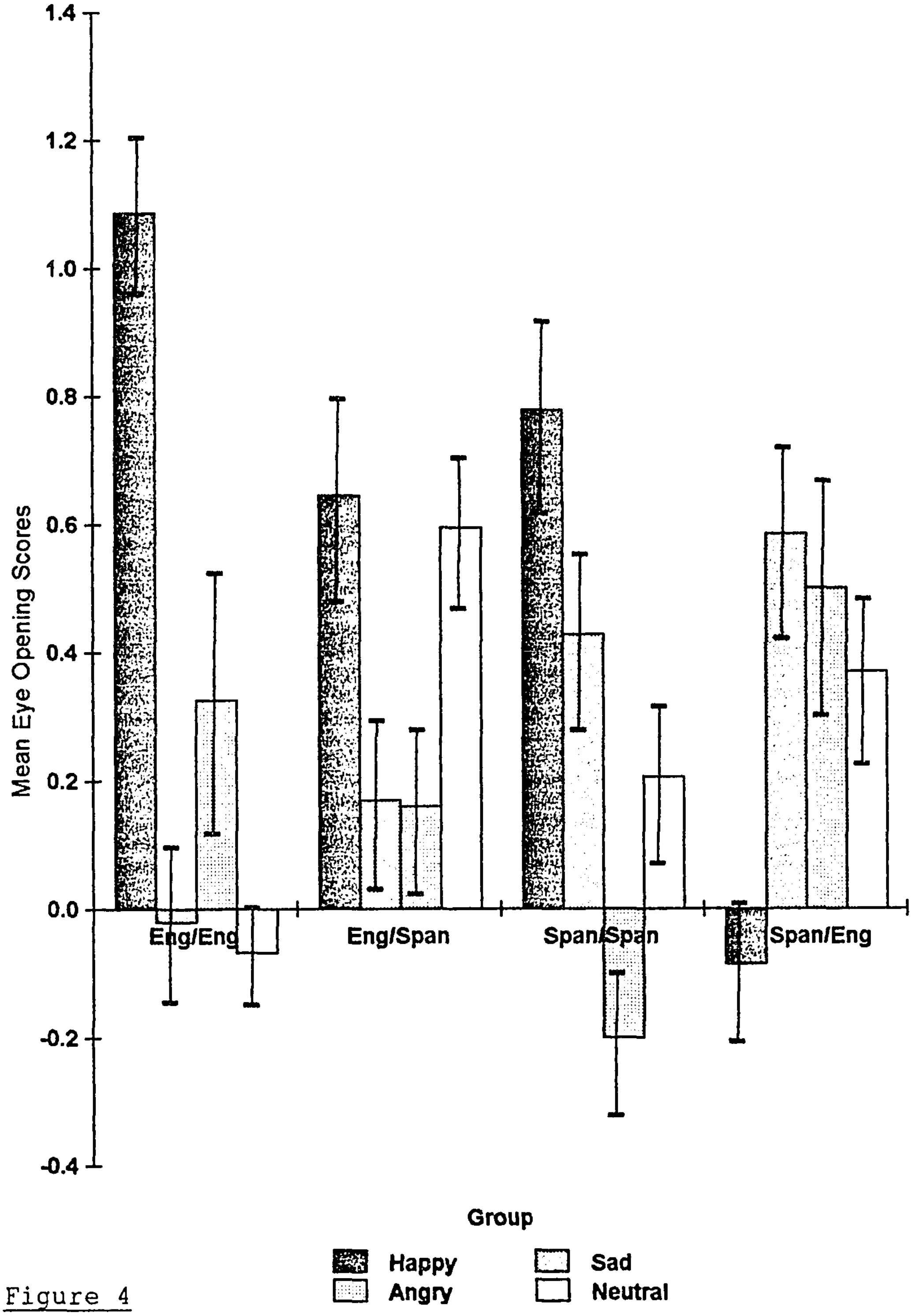
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
Mean Eye Opening Scores
Eng/Eng
Eng/Span
Span/Span
Span/Eng
Group
Happy
Angry
Sad
Neutral

Figure 4

The results obtained in the analysis of variance of the IEP-C data set indicated that differential responsiveness to the emotional expressions varied among the four groups when the infants' eyes were closed prior to stimulus presentation. The three way interaction of 4 (Gp) X 4 (E) X 2 (EB) was significant, $F(9,99) = 2.26$, $MSE = 1.01$, $p < .05$, indicating that differential eye behavior responses to the emotional expressions differed between the groups when the infants' eyes were closed prior to stimulus presentation. In order to determine the basis for this difference, individual analyses were performed on each of the four groups.

For each experiment, a 4 (E) X 2 (EB) repeated measures analysis of variance was used to detect the presence of differential eye behavior across the different emotion conditions. Again, a significant interaction between the E and EB variables would be an indication of this behavior. The results showed that eye behavior (i.e., eye openings vs. eyes remain closed) differed across emotion conditions in the two groups of infants (i.e., groups Eng/Eng & Span/Span) presented with the mother's native language, whereas the two groups of infants (i.e., groups Eng/Span & Span/Eng) presented with a nonnative language did not show significant differences in eye behavior across the different emotion conditions (see Table 5). Therefore, discrimination and differential responsiveness to different emotional tones of voice was found only in those groups of infants who were presented with emotional expressions in the language experienced prenatally, whereas no evidence of significant differences in responding was found in infants listening to vocal expressions in a novel language. Clearly, this result indicates that prenatal experience plays an important role in the newborn's differential response to emotional speech.

Within Group Comparisons. Further analyses were aimed at determining whether the patterns of differential responding to the vocal expressions were similar in the two groups of infants who demonstrated differential responsiveness (those presented with the language to which they were prenatally exposed). Planned comparisons using the Anova multiple *F*-tests procedure were done to compare mean scores for eye openings across the four emotion conditions within each

Table 5

Analyses of Variance Results for the Interaction of Emotion X Eye Behavior for each Group

Group	df	*F*	*MSE*	*p*
Eng/Eng	3,18	3.70*	0.68	.031
Eng/Span	3,27	1.19	1.12	.333
Span/Span	3,27	3.94*	0.73	.019
Span/Eng	3,27	1.15	1.41	.348

Note. A significant interaction of the Emotion and Eye Behavior variables indicates differential eye behavior responses to the different emotional expressions.

of the two native language experimental groups.

The results for group 1 (Eng/Eng), presented previously (see page 77), revealed higher mean scores for eye openings in the happy condition as compared to the other three conditions, with significantly higher scores in the happy ($\underline{M}$ = 1.09) as compared to the sad ($\underline{M}$ = -0.02) and neutral ($\underline{M}$ = -0.07) conditions.

Similarly, in group 3 (Span/Span) the highest mean score for eye openings was also found in the happy condition ($\underline{M}$ = 0.78), and, again, this was the only condition in which the scores for eyes remain closed did not exceed the scores for eye openings (see figures 5-10). Eye opening scores were significantly higher in the happy ($\underline{M}$ = 0.78) as compared to the angry ($\underline{M}$ = -0.02) condition (CV = 0.66). The sad ($\underline{M}$ = 0.43) and neutral ($\underline{M}$ = 0.21) eye opening scores did not differ significantly from any of the other conditions.

Therefore, although the pattern of significant differences between the different emotion conditions in each of the two native language experimental groups was not identical, the results of these two experiments were consistent in terms of higher eye opening scores associated with the presentation of happy vocal expressions of emotion.

Figure 5. Mean eye opening scores ($\pm$ SE) as a function of emotion condition for the Initial Eye Position-Closed data set for group Eng/Span (n = 10, repeated measures design).

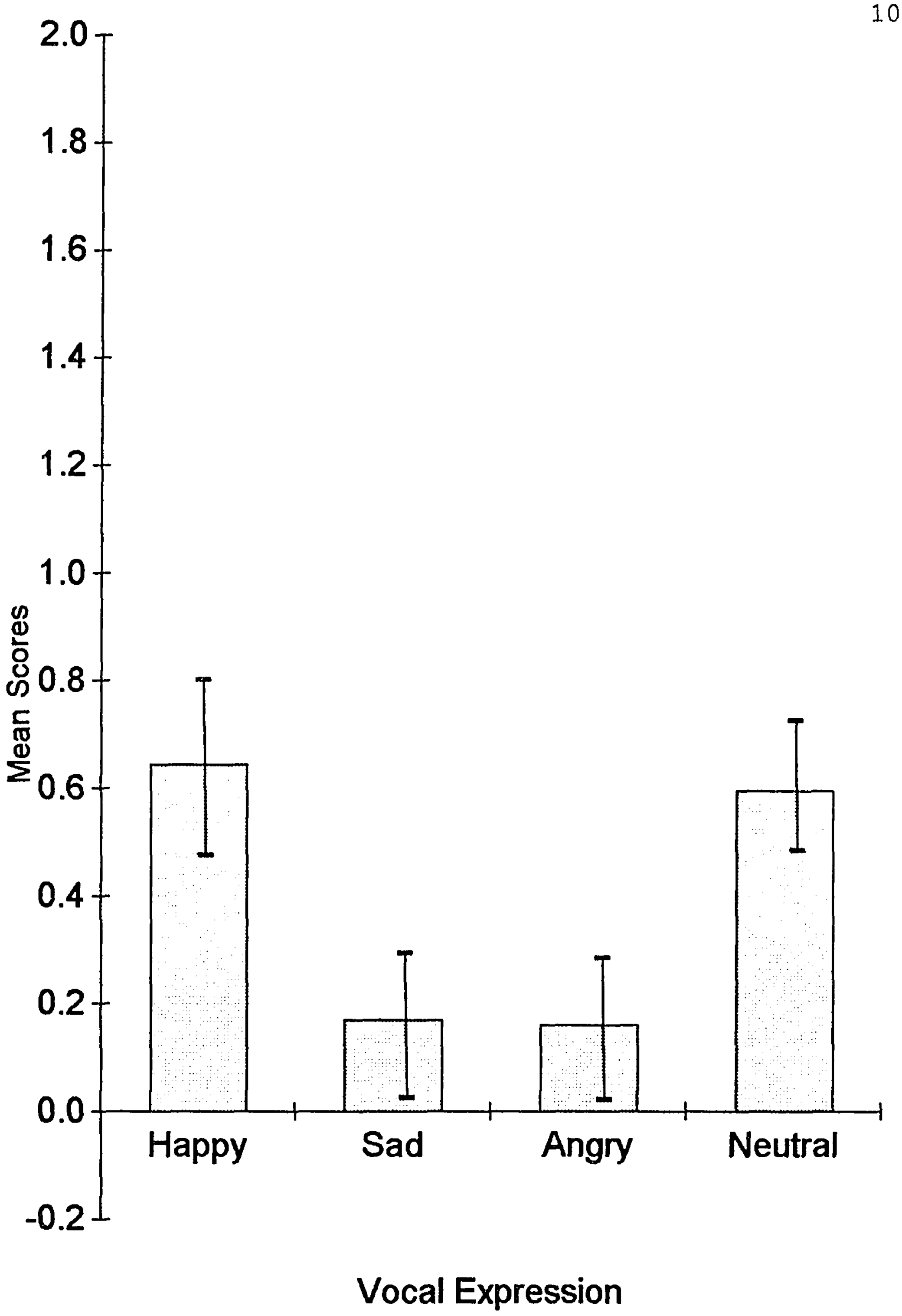
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
Mean Scores
Happy
Sad
Angry
Neutral
Vocal Expression

Figure 5

Figure 6. Mean eye closing scores (± SE) as a function of emotion condition for the Initial Eye Position-Closed data set for group Eng/Span (n = 10, repeated measures design).

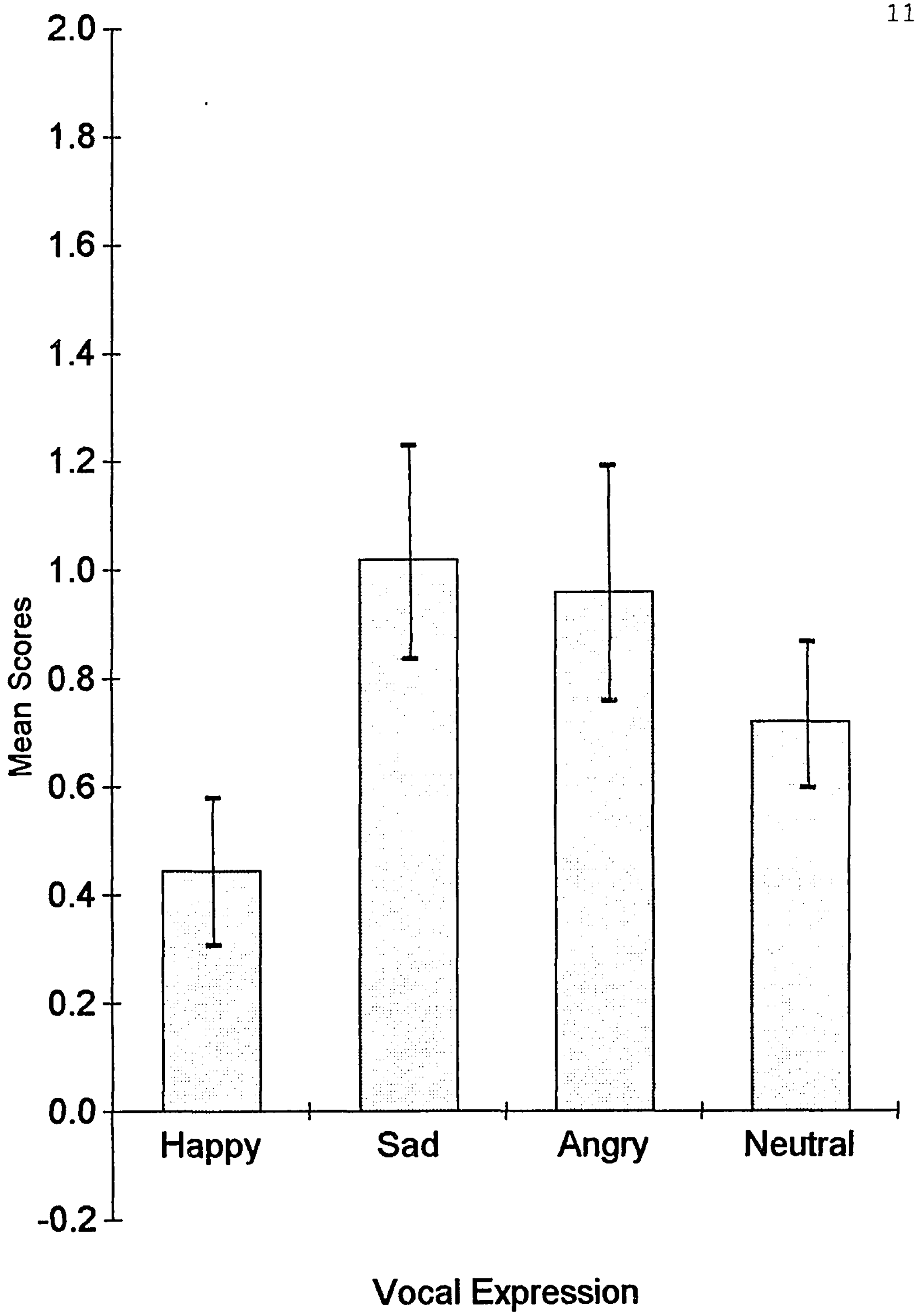
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
Mean Scores
Happy
Sad
Angry
Neutral
Vocal Expression

Figure 6

Figure 7. Mean eye opening scores (± SE) as a function of emotion condition for the Initial Eye Position-Closed data set for group Span/Span (n = 10, repeated measures design).

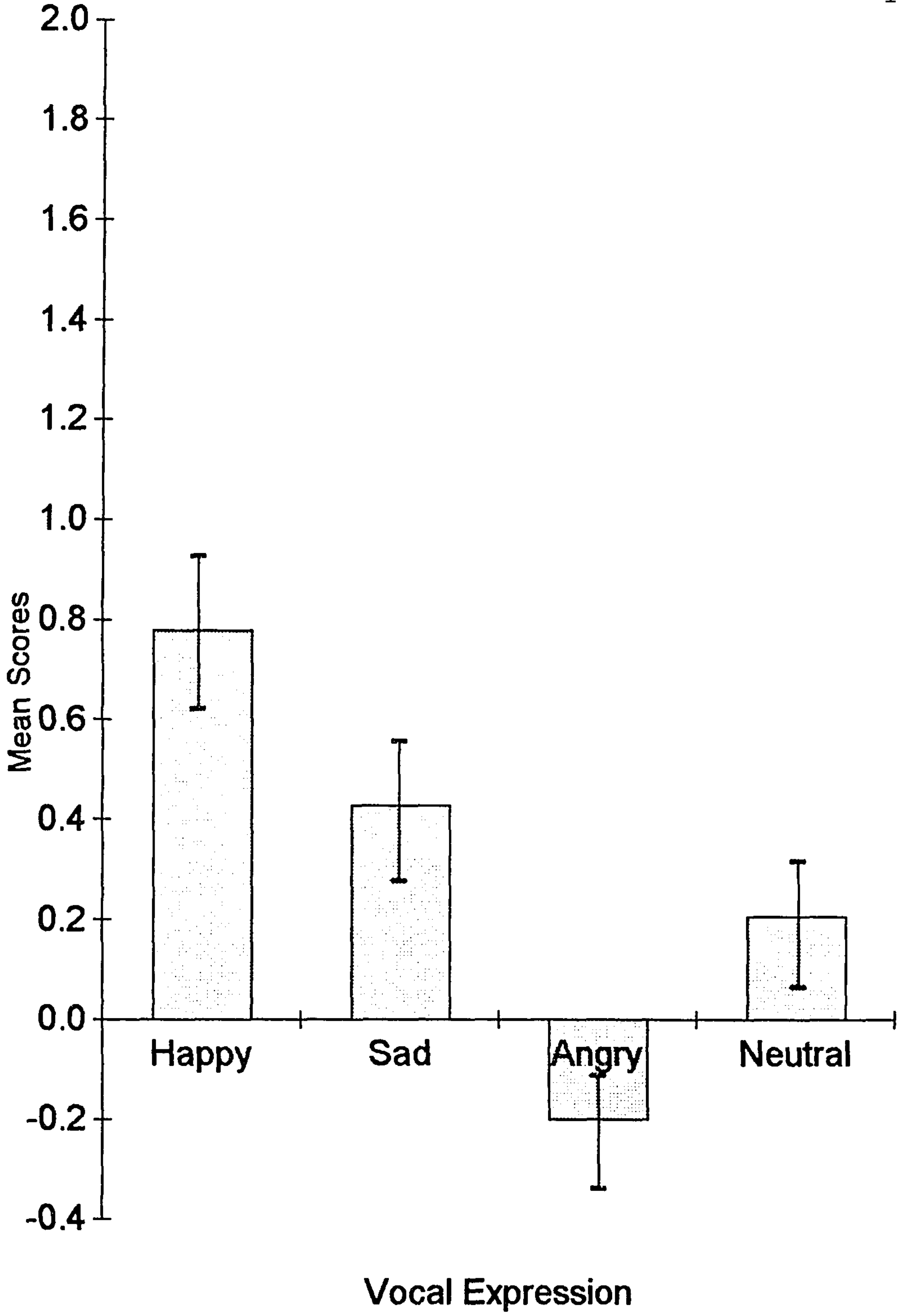
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
Mean Scores
Happy
Sad
Angry
Neutral
Vocal Expression

Figure 7

Figure 8. Mean eye closing scores (± SE) as a function of emotion condition for the Initial Eye Position-Closed data set for group Span/Span (n = 10, repeated measures design).

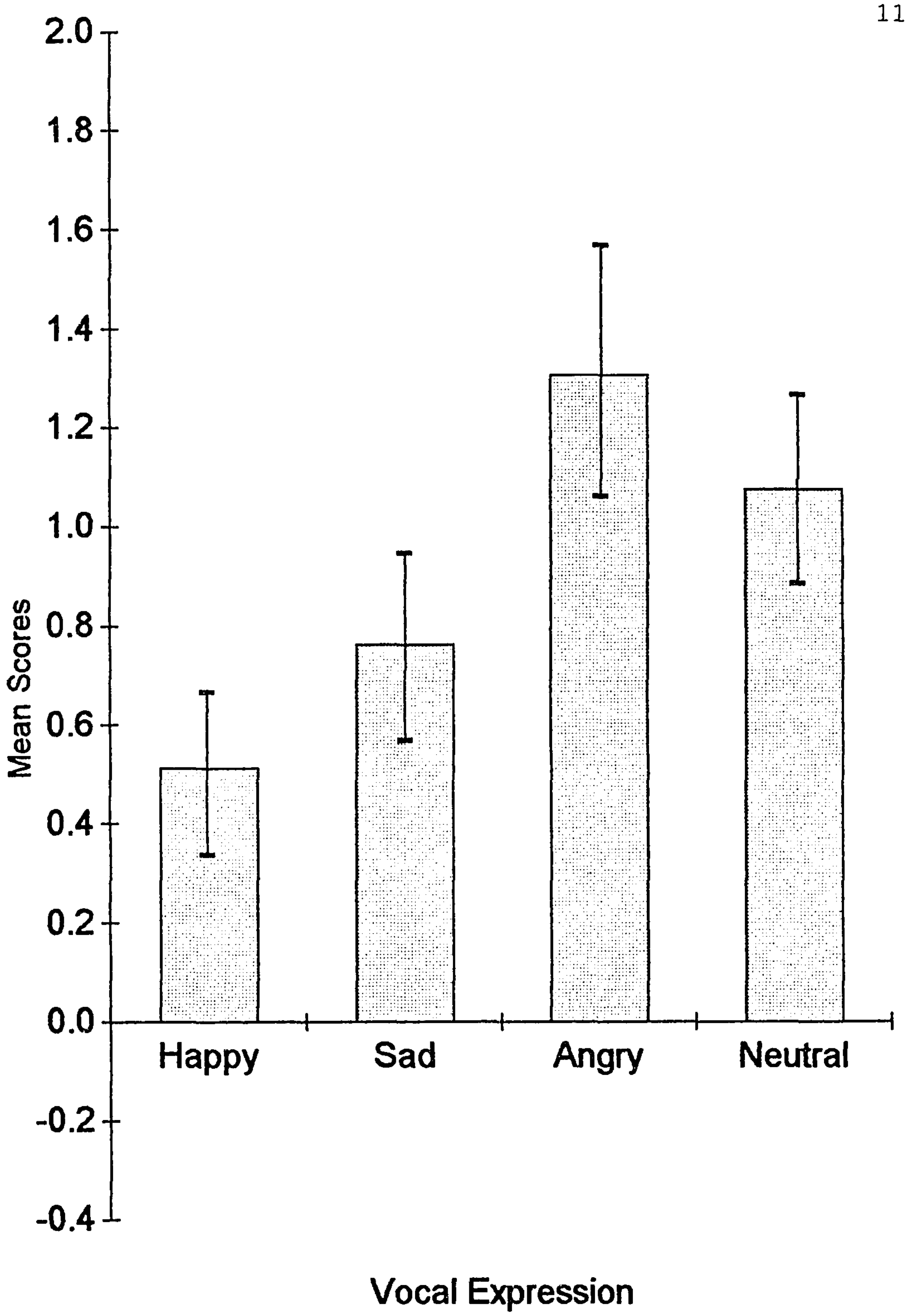
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
Mean Scores
Happy
Sad
Angry
Neutral
Vocal Expression

Figure 8

Figure 9. Mean eye opening scores (± *SE*) as a function of emotion condition for the Initial Eye Position-Closed data set for group Span/Eng (*n* = 10, repeated measures design).

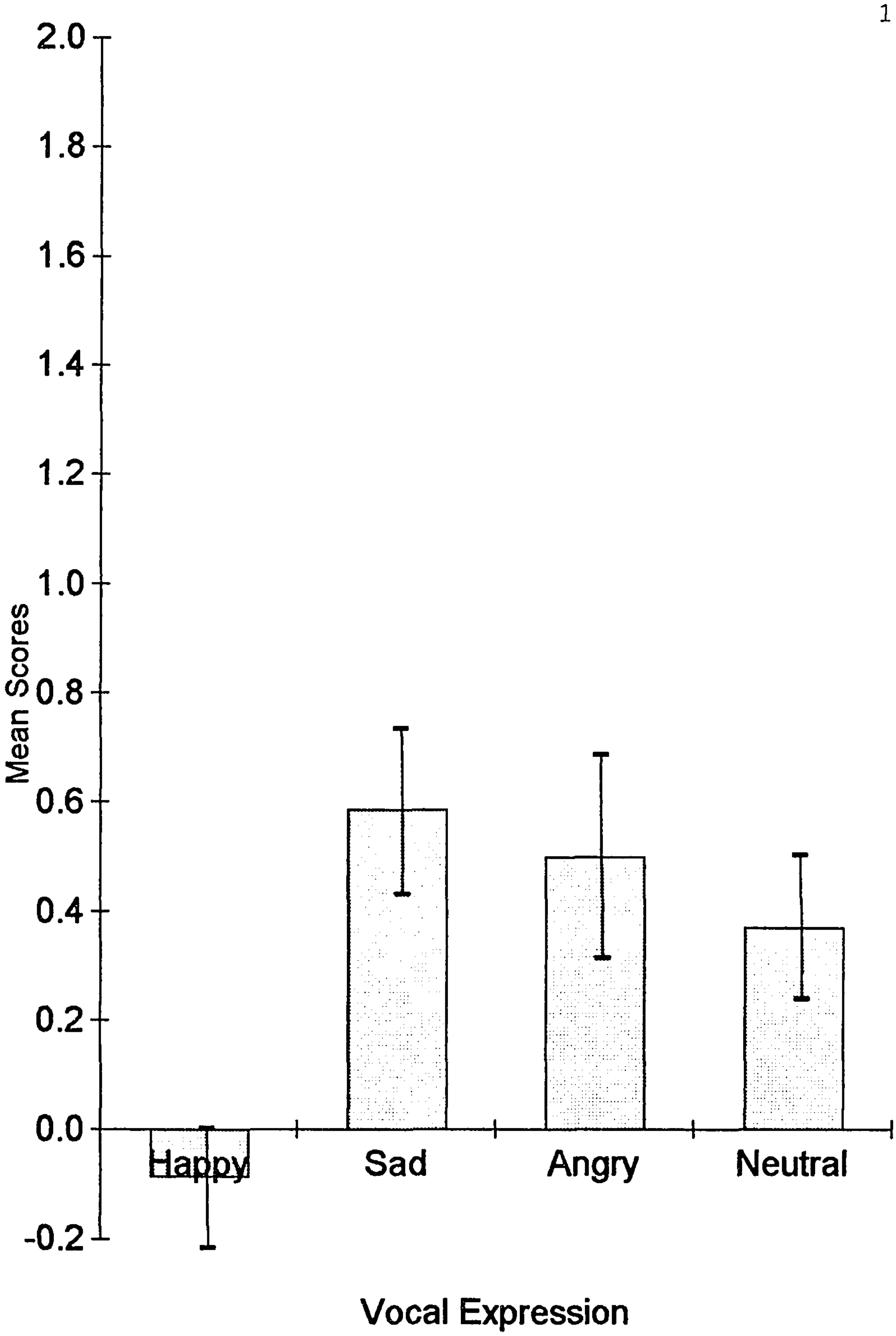
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
Mean Scores
Happy
Sad
Angry
Neutral
Vocal Expression

Figure 9

Figure 10. Mean eye closing scores ($\pm$ *SE*) as a function of emotion condition for the Initial Eye Position-Closed data set for group Span/Eng (*n* = 10, repeated measures design).

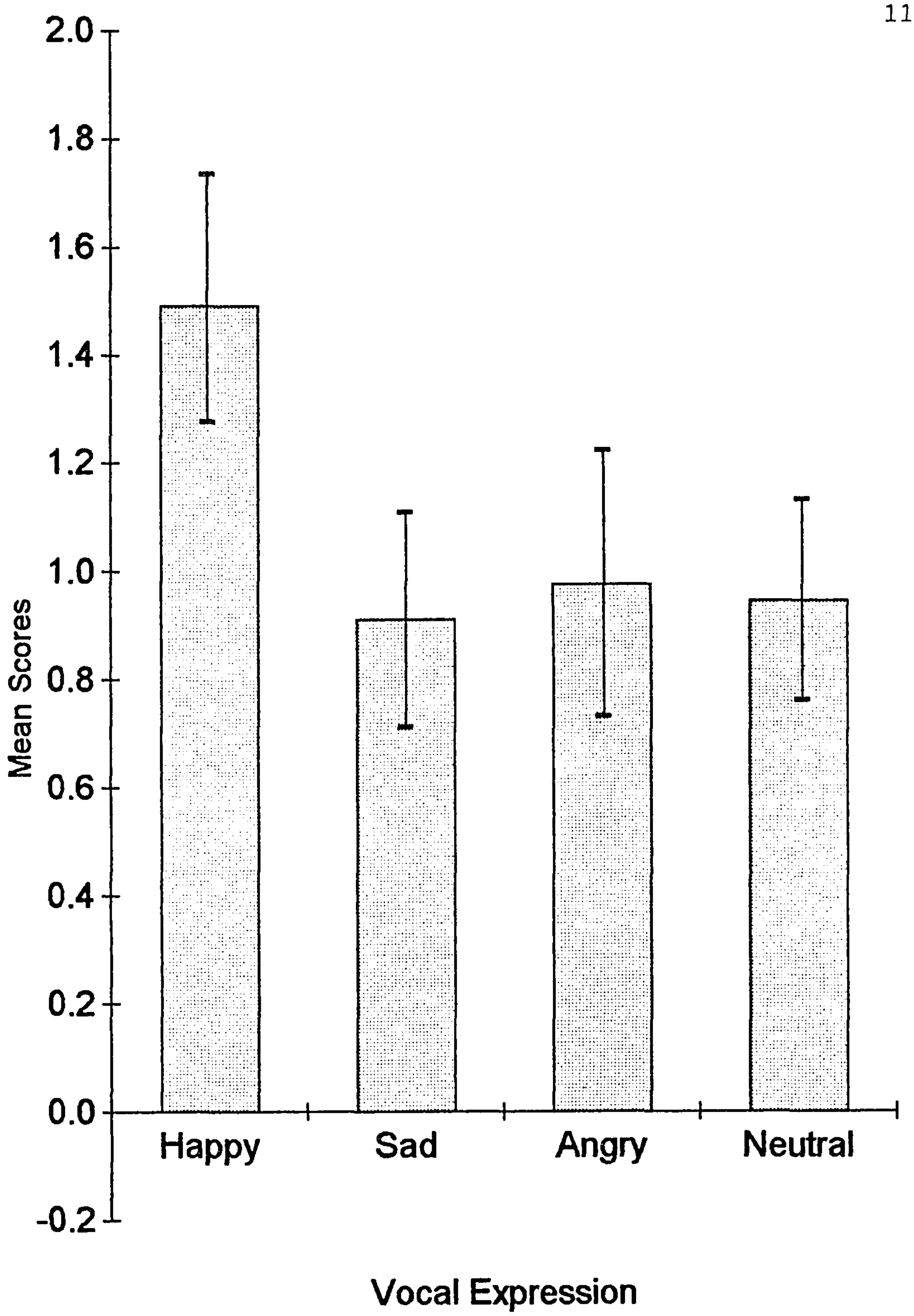
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
Mean Scores
Happy
Sad
Angry
Neutral
Vocal Expression

Figure 10

Between Group Comparisons. The next set of follow-up analyses performed was a comparison between the different groups on the eye opening scores in the happy condition. This was done to determine whether there were significantly higher eye openings in the native language presented groups (groups Eng/Eng & Span/Span) as compared to the non-native language presented groups (groups Eng/Span & Span/Eng).

The overall combined Anova error term (Gp X E X EB) was used to determine the critical value of the Anova multiple *F*-tests comparison procedure for these between group comparisons (CV = 0.33). The eye opening scores for the happy condition were significantly higher in the Eng/Eng group (*M* = 1.09) as compared to the two non-native groups, Eng/Span (*M* = 0.65) and Span/Eng (*M* = -0.86). The scores for the Span/Span group (*M* = 0.78) were significantly higher than the scores for the Span/Eng group (*M* = -0.86), but did not differ significantly from the other group of Spanish infants, Eng/Span (*M* = 0.65). Additionally, the two native language groups did not differ significantly from each other, nor did the two non-native groups. (See Figure 4 on page 103.)

In addition to the results obtained in the analyses indicating differential eye opening behavior in groups 1 (Eng/Eng) and 3 (Span/Span), there was a significant main effect of the EB variable in the overall analysis, $F(1,33) = 9.01$, $MSE = 3.44$, $p < .01$, as a result of a general tendency for the infants eyes to remain closed. Therefore the increase in eye opening behavior observed in the happy condition in both of the native language-presented groups was an exception to this tendency.

IEP-O Data Set

As in experiment 1, there was a general tendency in all groups for the infants' eyes to remain open throughout presentations when the infants began trials in this alert condition, rather than becoming drowsy or closing their eyes. Examination of the mean eye behavior scores reflects this tendency, in that mean eye open scores were higher than mean eye closing and TTC scores in all conditions. (See Table 6)

The results of the combined analysis of this data set indicated that eye behavior responses did not differ among the four groups, Gp(4) X E(4) X EB(3)

Table 6

Mean Eye Behavior Scores in the Initial Eye Position-Open Data Set

Group	Condition	Open	TTC	Close
Eng/Eng	H	1.024	-0.274	-0.274
	S	0.619	0.274	-0.203
	A	0.679	0.214	-0.156
	N	0.993	-0.043	-0.221
Eng/Span	H	1.626	-0.568	-0.076
	S	0.798	0.248	-0.027
	A	1.087	0.003	-0.397
	N	1.162	-0.397	0.028
Span/Span	H	1.617	-0.417	-0.417
	S	1.329	-0.139	-0.364
	A	1.415	-0.010	-0.419
	N	0.770	0.094	0.028
Span/Eng	H	1.148	-0.377	0.082
	S	1.050	-0.150	-0.100
	A	1.529	-0.231	-0.356
	N	1.874	-0.544	-.0344

Note. H = happy; S = sad; A = angry; N = neutral.

interaction, $F(18, 198) = 0.91$, $p > .05$, or across emotion conditions, E X EB interaction, $F(6, 198) = 1.63$, $p > .05$, in trials in which the infants' eyes were open prior to stimulus presentation. There was, however, a significant main effect of the EB variable, $F(2, 66) = 31.56$, $MSE = 2.76$, $p < .001$, resulting from the significantly higher eyes remain open scores as compared to eye closing and TTC scores in all conditions in all groups.

IEP-TTC

In the IEP-TTC data set, differential responsiveness to the emotional expressions varied among the four groups, Gp(4) X E(4) X EB(3), $F(18,198) = 2.19$, $MSE = 0.53$, $p < .01$, as a result of the differential eye opening scores seen in the group of English infants listening to English speech (experiment 1, presented earlier in this paper). No other groups of infants demonstrated differential responsiveness in this data set. As in the IEP-O data set, there was a tendency for the infants to maintain prestimulus eye behavior in the IEP-TTC data set, such that the majority of infants who began trials with an initial eye position - TTC showed TTC behavior during stimulus presentations as well (See table 7). This effect is reflected in the significant main effect of the EB variable, $F(2,66) = 5.87$, $p < .01$. There were no other significant effects in this data set.

Table 7

Mean Eye Behavior Scores in the IEP-TTC Data Set

Group	Condition	Open	TTC	Close
Eng/Eng	H	0.571	0.000	-0.239
	S	0.786	-0.071	-0.310
	A	-0.334	0.667	0.190
	N	-0.107	1.000	-0.346
Eng/Span	H	0.580	0.767	-0.342
	S	-0.184	0.517	-0.017
	A	-0.284	0.675	0.175
	N	-0.242	0.617	0.008
Span/Span	H	0.383	0.150	0.016
	S	1.183	0.517	-0.184
	A	0.550	-0.217	-0.050
	N	0.567	0.033	-0.134
Span/Eng	H	-0.200	0.400	0.000
	S	0.400	0.000	-0.200
	A	0.300	0.300	-0.234
	N	0.250	0.050	-0.150

Note. H = happy; S = sad; A = angry; N = neutral.

Mouthing

No significant differences in mouthing behavior were observed across stimulus conditions in group 2 (Eng/Span), $F(3,27) = 0.94$, $p > .05$, group 3 (Span/Span), $F(3,27) = 1.23$, $p > .05$, or group 4 (Span/Eng), $F(3,27) = 1.18$, $p > .05$.

CHAPTER V

DISCUSSION

The results of these studies indicate that newborn infants do, in fact, respond differentially to different vocal expressions of emotion. And, perhaps more importantly, the results suggest that the origin of differential responsiveness to emotional speech is based upon learning that occurs during the fetal period. Evidence to support this conclusion comes from the finding that differential responding to vocal expressions of emotion was observed only in those infants listening to emotional speech in the language that they had experienced prenatally, while no evidence of differential responding across emotion conditions was observed in the two groups of infants listening to the same vocal expressions when they were presented in an unfamiliar language.

In all three data sets, initial eye position - open, initial eye position - closed and initial eye position - transitional towards closed, there was a general tendency for the infants to maintain prestimulus eye behavior throughout stimulus presentations. The only exceptions to this general tendency were the patterns of differential eye opening behavior observed in the two groups of infants who were presented the vocal expressions in the language experienced prenatally.

Initial Eye Position - Closed data set

In the IEP-C data set, this pattern involved an increase in eye opening responses following the onset of the presentation of happy vocal stimuli as compared to eye opening responses in the other stimulus conditions. This form of differential responding was observed in both the English and Spanish groups of infants listening to vocal expressions in their native language. No evidence of significant differences in responding across emotion conditions were observed in the Eng/Span and Span/Eng groups of infants.

However, it should be noted that the pattern of responding observed in the IEP-C data set for group Eng/Span was similar to that of the two native language groups (Eng/Eng and Span/Span) in that an increase in eye opening behavior was observed in response to the presentation of happy vocal stimuli. Although the eye opening scores in the happy condition did not differ significantly from that of the other conditions for this group, comparisons between groups showed that the eye opening scores for the happy condition in group Eng/Span did not differ significantly from the eye opening scores for the happy condition in group Span/Span. (The scores did, however, differ significantly from group Eng/Eng.) Additionally, the mean score for eye openings exceeded the mean for eyes remaining closed in the happy condition for this group as well. Therefore, it is necessary to give some consideration to the possibility that a significant level of differential responding may have been observed in group Eng/Span if the sample size (n) was increased.

This possibility, however, is not necessarily inconsistent with the proposed hypothesis. Although the infants in group Eng/Span (i.e., Spanish infants listening to English speech samples) were presented the vocal expressions in a language that was not the primary maternal language, all of the mothers of the infants in this group reported that they were bilingual (i.e., Spanish/English), in that they spoke English at least on occasion. As a result, the infants in group Eng/Span did have at least some prenatal exposure to the language presented in this experiment. And, although the specific amounts of prenatal exposure to English emotional expressions for this group is unknown, it should be noted that the eye opening responses to the English happy expressions was significantly higher in the group of infants born to mothers for whom English was the native language (group Eng/Eng).

Initial Eye Position - TTC data set

A similar pattern of differential responding was observed in the IEP-TTC data set for the group of English infants presented with the English vocal expressions (group Eng/Eng). A significant increase in eye openings was observed following the onset of the presentation of happy vocal stimuli (and possibly sad vocal stimuli) as compared to eye openings in response to the other vocal stimuli. No evidence of significant differences in eye opening, TTC, or eye closing responses across emotion conditions were observed in the IEP-TTC data sets for groups Eng/Span, Span/Span and Span/Eng.

The patterns of differential eye opening behavior observed in these experiments suggest an increase in the level of alertness and/or arousal in response to the presentation of joyful speech as compared to the level of alertness/arousal seen in the other conditions. Considering the acoustic features that characterize joyful speech (i.e., increase in fundamental frequency, increase in fundamental frequency range and variability, increased mean intensity, and an increase in speech rate; Scherer, 1986), such an increase in the infants' level of alertness/arousal might be expected in response to the presentation of stimuli with these acoustic properties.

However, if the infants were simply responding to the stimuli on the basis of specific acoustic features, then we would expect that all four groups of infants would show a similar pattern of differential responding to the different vocal expressions. This was not the case. Only the two groups of newborns that were presented with vocal expressions in the language to which they were prenatally exposed exhibited significant differences in eye opening behavior across emotion conditions. This evidence suggests that the differences in the physical properties of the stimuli are not, by themselves and independent of their prior history, sufficient to elicit this form of differential responding to emotional speech.

However, considering the similar increase in eye opening observed in group Eng/Span, it is possible that the acoustic features of the English vocal expressions are particularly salient as compared to the acoustic features of the Spanish expressions. As a result, the infants of bilingual Spanish/English mothers may have been more responsive to the English happy expressions. Yet, as stated previously, the English infants (group Eng/Eng) were more responsive to the English vocal expressions than were the infants in group Eng/Span. In addition to demonstrating differential responsiveness across emotion conditions, the eye opening responses of group Eng/Eng were significantly higher than the eye opening responses of group Eng/Span. Again, this difference is likely to be due to the differences in amount of prenatal exposure to English expressions of emotion.

Additional evidence to support the conclusion that the differences in the acoustic features of the stimuli are not, by themselves and independent of their prior history, sufficient to elicit this form of differential responding to emotional speech is based on the results obtained in the group of Spanish background infants presented with the expressions in their native language (group Span/Span). Although joy and anger have been shown to share many acoustic features (Scherer, 1986), this group of infants exhibited differential responding to these two expressions. Therefore, it is clear that infants listening to expressions in the language experienced prenatally were capable of detecting some of the very subtle differences in the acoustic features characterizing the different expressions, and discriminating among them.

The evidence obtained also indicates that the basis for the differential responding observed was due to the detection of differences in the prosodic features characterizing the different vocal expressions, rather than to the detection of other acoustic differences between the vocal expressions, such as differences in segmental cues or semantic content. Both segmental cues and semantic content were held constant by using the same script across emotion conditions. Additionally, the use of low-pass filtering also served to remove, or at least minimize, the differences between languages that could be attributed to differences in segmental (i.e., phonemic) acoustic cues rather than to differences in the prosodic modifications used to convey emotion.

While newborn sensitivity to prosodic aspects of speech has been demonstrated previously (Mehler, Bertoncini, Barriere, & Jassik-Gerschenfeld, 1978; Moon and Fifer, 1990, cited in Fifer & Moon, 1995; Panneton, 1985, cited in Cooper & Aslin, 1989; Spence & DeCasper, 1987), the present demonstration of this ability extends these findings to include the ability of newborns to detect the distinctive prosodic features characterizing different expressions of emotion in their native language.

These results also further highlight the importance of the auditory modality in perceptual development in early infancy. Since responding to vocal expressions of emotion apparently precedes the emergence of responding to facial expressions, it is possible that the processing of emotional information conveyed vocally may facilitate the development of processing of emotional information conveyed in facial expressions. Additionally, there is evidence for deficits in emotion recognition of facial displays in deaf children (Bachara, Raphael, & Phelan, 1980), lending support to this hypothesis.

However, the most important finding that emerged in this series of experiments is the evidence indicating that newborn differentiation of emotion is influenced by prenatal experience. Yet, in addition to further supporting the importance of the role of prenatal auditory experience in influencing neonatal auditory responsiveness, the results of this study also suggest that the role of other prenatal experiences, in addition to auditory experiences, are important as well.

A potential mechanism - temporal contiguity between the prosodic acoustic characteristics of emotional speech and associated maternal physiologic changes - has been proposed to account for this influence of prenatal experience on newborn behavior. Although these studies have provided no direct evidence in support of this mechanism, the obtained findings clearly increase its plausibility. Previous research examining the role of prenatal exposure to maternal speech has focused primarily upon the ability of newborns to differentiate familiar (i.e., prenatally experienced) from novel speech sounds. Whereas, the results of this study indicate that newborns are also capable of differentiating among familiar sounds with the distinctive prosodic features that characterize different emotional expressions. That the newborns were capable of differentiating among the different sounds experienced prenatally (while infants in this study without prior experience could not), suggests that the presence of other stimuli in the fetal environment are important in serving to make the distinctive prosodic speech patterns even more distinguishable.

Several potential sources of stimuli available to the fetus as a consequence of being physiologically linked to the mother as she experiences emotion were discussed earlier in this paper. Examples include heart rate accelerations and decelerations (Ekman, Levenson and Friesen, 1983), which the fetus is likely to hear (DeCasper and Sigafoos, 1983), respiratory changes (Averill, 1969) and mild uterine contractions

(Huszar & Walsh, 1989; Moawad, 1973), which may provide tactile and/or vestibular stimulation for the fetus, and possibly other sounds, such as those created by digestive disturbances, etc.

The availability of such stimuli would provide a unique opportunity for learning during the fetal period. The proffered explanation entails a highly predictable link between two distinct classes of environmental stimuli, emotional speech and stimuli generated by maternal physiologic responses, both of which could be detected by the fetus. In that at no other stage of development would there be such a direct connection between one individual (the infant or child) and another, this mechanism would be unique to the fetal period. Such a linkage may make possible, or at least facilitate, neonatal responses to the initial postnatal presentation of emotional stimuli. This mechanism would provide a means for the naive organism to be coupled to an already experienced and sophisticated organism so that its processing of environmental events would not have to be developed solely within the framework of its own experiences. This would make it possible for the infant to respond to ecologically meaningful stimuli in a differentiated and meaningful way.

This model of prenatal associative learning would not necessarily be unique to the development of emotional perception, but could extend to other circumstances involving classes of distinctive stimuli that share regular and consistent temporal contiguity with detectable maternal physiologic change. Further research is necessary to understand the opportunities for fetal learning provided by the unique features of the fetal environment. And, while many potential sources of associative stimuli arising as a consequence of maternal physiological responses concomitant on emotion have been proposed, the precise mechanisms by which these transient maternal physiological responses influence fetal behavior and development remain to be explored.

In addition to the possible implications of these findings for fetal development, the findings of this study also has implications for socioemotional development after birth. Our ability to detect the emotional state of others is an important part of social interactions and social competence. The ability of the newborn to respond differentially to vocal expressions of emotion experienced prenatally may have important consequences for early mother-infant interactions and later social and emotional development as well. Further research would be necessary to determine the possible implications of these findings for normal socioemotional development, as well as for atypical developmental circumstances, such as premature infants, deaf infants, and atypical emotional conditions during pregnancy.

Notes

1. The following script (presented in either English or Spanish) was used for all presentations:

It's time to get ready for the party. I wonder if my sister will be there. She probably will. She never misses a party. In fact, she's always the first to arrive and the last to go home.

2. Since overhead lighting was used, on many occasions the infants' eyes may have been closed temporarily although the infant was in an awake state.

3. Since a forced choice procedure was not used when the judges were asked to label the vocal expressions, a wide variety of descriptive terms were used by the judges to label the vocal stimuli. A list of all the descriptive terms given is presented in Appendix A.

In order to determine which of the terms given could be reliably categorized as descriptive terms for happy, sad, angry or neutral vocal expressions, 12 additional adult judges were recruited. The 12 judges were asked to categorize each descriptive term as belonging to one of the following five categories: happy, sad, angry, neutral or other.

Chi-square for goodness of fit tests were used to determine the descriptive terms that were reliably classified as belonging to a specific emotion category. To ensure clear differentiation between the emotion categories, the judges ratings of all terms were analyzed using the .001 alpha level. Lists of the descriptive terms reliably classified as belonging to the happy, sad, angry, or neutral categories are presented in Appendix B-E.

4. The mothers of the infants in groups 2 (Eng/Span) and 3 (Span/Span) all reported that Spanish was their native language, and that they spoke Spanish 50% of the time or more during their pregnancy.

Appendix

Appendix A

Terms used by the adult judges to describe the vocal stimuli

a little excited
aggravated
aggressive
agitated
annoyed
anxious
assertive
assured
bickering
bitter
bored
bouncy
calm
calm/kind/nice
calm/soothing
careless
caring
cheap
cheery
concerned
concerned about trouble
confident
confident/firm
confused
contempt
content
crass
curious
defiant
depressed
depressed/jealousy
despair
determined
disappointed
disgusted
dislike
dismayed
distressed
domineering
doubtful
down
drained
dread
dull
ecstatic
elated
emotional
emotionless
energetic
enthusiastic
envious
exasperated
exasperated/drained
excited
excited/expectant
exhausted
expectant
exuberant
factual/pragmatic
fake
fearful
firm
forced
forceful
friendly
frightened
fun
funny
furious
glad
gleeful
glum
happy but a little jealous
hard/rushed
hasty
hateful
hatred
heavy
heavy/unhappy
hesitant
hopeful
hurried

hurried/annoyed
hyper
hyper-nervous
impatient
indifferent
informative
informing/newscasting
inquisitive
inquisitive/undecided
instructive
interested
intimidated
jealous
joking
jumping to conclusion
kind/warm/soft/calm
lackadaisical
like reading
like an answering machine
love
mad
masculine
maternal/nurturant
matter of fact
mean
mellow
mild excitement
moody
negative
nervous
no energy
normal
not happy
not happy/tired
not emotional
not enthusiastic
not caring about anything
optimistic
overly anxious
painful
pissed off
pressured
proud
pushing
questioning/wondering
reluctant
resentful
revengeful
rough/complaining
rushed
sad/angry
sad/tired
sarcastic
scornful
scared
serious
shocked
sick
sincere
sing-song/concerned
skeptical
sleepy
sluggish
soft
soft but rushed
soft/soothing
soft/warm
soft-spoken/hesitant
solemn
somber
soothing
sorry
sorry/sincere
spiteful
strong
subdued
suggestive
talking to elders
talking to young
ticked off
timid
timid/no confidence
timid/slightly nervous
tired
tired/depressed
tiresome/noninterest
uncaring
uncertainty
undecided
unexcited
unexcited/uninterested
unhappy
uninterested
unsure

upset
worried
worried/troubled
frantic, but nice -like at weddings
like teaching or making a speech
tired/labored/difficulty talking

Appendix B

Words reliably classified as descriptive terms for happy vocal expressions

a little excited
assured
bouncy
calm/kind/nice
caring
cheery
confident
content
ecstatic
elated
energetic
enthusiastic
excited
excited/expectant
exuberant
friendly
fun
funny
glad
gleeful
hopeful
joking
kind/warm/soft/calm
love
maternal/nurturant
optimistic
proud

Appendix C

Words reliably classified as descriptive terms for sad vocal expressions

depressed
despair
disappointed
distressed
down
glum
heavy/unhappy
solemn
somber
sorry
tired/depressed
unhappy
worried/troubled

Appendix D

Words reliably classified as descriptive terms for angry vocal expressions

aggravated
aggressive
agitated
annoyed
bickering
bitter
contempt
crass
defiant
domineering
envious
forceful
furious
hateful
hatred
hurried/annoyed
impatient
mad
pissed off
resentful
revengeful
rough/complaining
sarcastic
scornful
spiteful
ticked off

Appendix E

Words reliably classified as descriptive terms for neutral vocal expressions

factual/pragmatic
like reading
matter of fact
normal
not emotional
serious

Appendix F

Analyses of proportion scores for the Initial Eye Position - Closed data set.

The addition of a constant (i.e., 1) to the denominator of the formula used to calculate scores for eye responses resulted in a non-linear relationship between obtained scores that differed in terms of the number of opportunities to respond. In order to ensure that this non-linearity did not distort the data in such a way that it would effect the pattern of results obtained in the analyses of variance, the analyses were also performed on proportion scores (i.e., the number of responses divided by the number of opportunities to respond) for the eye behavior responses in the IEP-C data set. The mean proportion scores are presented in Appendix G.

The results of an overall 4 (group) X 4 (E) X 2 (EB) analysis of variance (ANOVA) of the combined data from all four groups showed a significant three way interaction of the variables, $F(9,99) = 2.30$, $MSE = 0.12$, $p < .05$, indicating that differential eye behavior responses to the emotional expressions differed between the groups when the infants' eyes were closed prior to stimulus presentation.

This analysis was followed by individual 4 (E) X 2 (EB) repeated measures ANOVAs of the IEP-C data sets for each group. The pattern of results of these analyses was identical to the pattern of results obtained in the analyses performed on the transformed scores calculated using the formula described on page 66.

For group Eng/Eng, the interaction of E X EB was significant, $F(3,18) = 3.25$, $MSE = 0.08$, $p < .05$, indicating differential eye behavior across the different emotion conditions. Planned comparisons using the Anova multiple F-tests comparison procedure (CV = 0.27) showed significantly higher eye opening scores in the happy (M = 0.46) as compared to the sad (M = 0.15) and neutral (M = 0.08) conditions.

Similarly, for group Span/Span, the interaction of E X EB was also significant, $F(3,27) = 3.43$, $MSE = 0.09$, $p < .05$. The results of the planned comparisons (CV = 0.23) indicated significantly higher eye opening scores in the happy (M = 0.44) as compared to the angry (M = 0.10) condition.

The interaction of E X EB was not significant in group Eng/Span, $F(3,27) = 1.04$, $MSE = 0.10$, $p > .05$, or in group Span/Eng, $F(3,27) = 1.37$, $MSE = 0.18$, $p > .05$.

Appendix G

Mean Proportion Scores for Eye Behavior in the IEP-C Data Set

Group	Condition	Open		Close	
		M	SD	M	SD
Eng/Eng	H	0.46	0.23	0.39	0.20
	S	0.15	0.21	0.70	0.37
	A	0.31	0.41	0.55	0.46
	N	0.08	0.14	0.49	0.47
Eng/Span	H	0.38	0.44	0.33	0.42
	S	0.17	0.27	0.43	0.44
	A	0.20	0.35	0.40	0.46
	N	0.33	0.34	0.37	0.36
Span/Span	H	0.44	0.42	0.28	0.35
	S	0.33	0.42	0.38	0.44
	A	0.10	0.32	0.50	0.53
	N	0.23	0.34	0.48	0.45
Span/Eng	H	0.15	0.32	0.55	0.48
	S	0.33	0.36	0.37	0.38
	A	0.55	0.85	0.42	0.47
	N	0.28	0.35	0.43	0.42

Note. H = happy; S = sad; A = angry; N = neutral.

Appendix H

Analyses of proportion scores for the Initial Eye Position - Transitional Towards Closed data set for group Eng/Eng.

An analysis of variance of the proportion scores was also performed on the eye behavior responses of group 1 (Eng/Eng) in the IEP-TTC data set to verify that the significant results obtained in the analyses of the transformed scores were accurate. The mean proportion scores are presented in Appendix I.

The results of a 4 (E) X 3 (EB) repeated measures ANOVA showed a significant interaction of the E and EB variables, $F(6,36) = 4.40$, $MSE = 0.02$, $p < .05$, indicating differential eye behavior across the different emotion conditions. Planned comparisons using the Anova multiple F-tests comparison procedure (CV = 0.12) showed significantly higher eye opening scores in the happy (M = 0.19) and sad (M = 0.26) conditions as compared to the angry (M = 0.00) and neutral (M = 0.05) conditions.

Therefore the pattern of results obtained in this analysis was identical to the pattern of results obtained in the analysis performed on the transformed scores.

Appendix I

Mean Proportion Scores in the Initial Eye Position-Transitional Towards Closed Data Set for Experiment 1 (Eng/Eng)

Condition		Open	TTC	Close
H	*M*	0.19	0.05	0.00
	SD	0.25	0.13	0.00
S	*M*	0.26	0.05	0.00
	SD	0.25	0.13	0.00
A	*M*	0.00	0.19	0.12
	SD	0.00	0.25	0.21
N	*M*	0.05	0.26	0.00
	SD	0.13	0.25	0.00

Note. H = happy; S = sad; A = angry; N = neutral.

Appendix J

Analyses of transformed scores in the Initial Eye Position - Closed data set excluding subjects with 0 scores.

Since the assignment of a score of 0 to conditions involving no opportunities to respond had an effect on the overall means for each condition, a separate set of analyses was performed on the IEP-C data set to ensure that the pattern of results obtained in this data set was not distorted by the use of this procedure. This was accomplished by dropping all subjects with 0 scores from the analyses. This caused the total number of subjects (n) to be reduced to 20. The mean scores are presented in Appendix K.

As a result of the reduction of the n, the three way interaction of the Group X Emotion X Eye Behavior variables in the overall ANOVA (combined data from all four groups) only approached conventional significance levels, $F(9,48) = 2.01$, $MSE = 1.52$, $p = .059$.

However, the pattern of results obtained in the individual analyses was not changed. The 4 (E) X 2 (EB) repeated measures ANOVA for group Eng/Eng ($n = 4$) showed a significant interaction of Emotion X Eye Behavior, $F(3,9) = 6.17$, $MSE = 0.61$, $p < .05$. Planned comparisons using the Anova multiple F-tests comparison procedure (CV = 1.08) showed significantly higher eye opening scores in the happy ($\underline{M}$ = 1.40) as compared to the sad ($\underline{M}$ = -0.16), angry ($\underline{M}$ = -0.06) and neutral ($\underline{M}$ = -0.12) conditions.

The 4 (E) X 2 (EB) repeated measures ANOVA for group Span/Span ($\underline{n}$ = 5) also showed a significant interaction of Emotion X Eye Behavior, $\underline{F}(3,12) = 5.07$, $\underline{MSE} = 0.85$, $\underline{p} < .05$. Planned comparisons (CV = 1.09) indicated significantly higher eye opening scores in the happy ($\underline{M}$ = 0.96) as compared to the angry ($\underline{M}$ = -0.70) condition.

There were no significant interactions in the analyses of the data for group Eng/Span ($\underline{n}$ = 5), $\underline{F} < 1$, or Span/Eng ($\underline{n}$ = 6), $\underline{F}(3,15) = 1.19$, $\underline{MSE} = 2.05$, $\underline{p} > .05$.

Appendix K

Mean Transformed Scores for Eye Behavior in the IEP-C Data Set excluding subjects with 0 scores

Group	Condition	Open		Close	
		M	SD	M	SD
Eng/Eng	H	1.40	0.54	0.90	0.48
	S	-0.16	0.60	2.32	0.44
	A	-0.55	1.21	1.97	1.21
	N	-0.12	0.56	2.03	0.52
Eng/Span	H	0.69	1.25	1.09	0.69
	S	0.14	1.16	1.84	1.21
	A	0.02	1.00	2.02	1.09
	N	0.69	0.85	1.34	0.52
Span/Span	H	0.96	1.12	1.22	1.00
	S	0.26	0.97	1.72	0.82
	A	-0.70	0.13	2.71	0.71
	N	-0.09	0.81	2.05	0.67
Span/Eng	H	-0.39	0.46	2.57	0.31
	S	0.73	1.09	1.60	1.11
	A	0.14	1.00	1.82	1.38
	N	0.37	0.93	1.66	0.88

Note. H = happy; S = sad; A = angry; N = neutral.

Appendix L

Opportunities to Respond per Condition in the Initial Eye Position - Closed Data Set

Group	H	S	A	N	Total
			Condition		
Eng/Eng[a]					
M	2.6	2.0	1.9	1.4	2.0
f	18	14	13	10	55
Eng/Span[b]					
M	1.4	1.5	1.6	1.7	1.5
f	14	15	16	17	62
Span/Span[b]					
M	1.6	1.5	1.5	1.6	1.5
f	16	15	15	16	62
Span/Eng[b]					
M	1.8	2.2	1.7	1.7	1.9
f	18	22	17	17	74

Note. H = happy; S = sad; A = angry; N = neutral.
[a]n = 7, total number of trials = 112, total number of trials per condition = 28. [b]n = 10, total number of trials = 160, total number of trials per condition = 40.

Appendix M

Opportunities to Respond per Condition in the Initial Eye Position - Open Data Set

Group	H	S	A	N	Total
			Condition		
Eng/Eng[a]					
M	0.9	1.3	1.3	1.6	1.3
f	6	9	9	11	35
Eng/Span[b]					
M	1.7	2.0	1.4	1.6	1.7
f	17	20	14	16	67
Span/Span[b]					
M	1.5	1.6	2.0	1.6	1.7
f	15	16	20	16	67
Span/Eng[b]					
M	1.8	1.4	1.7	2.0	1.7
f	18	14	17	20	69

Note. H = happy; S = sad; A = angry; N = neutral.
[a]n = 7, total number of trials = 112, total number of trials per condition = 28. [b]n = 10, total number of trials = 160, total number of trials per condition = 40.

Appendix N

Opportunities to Respond per Condition in the Initial Eye Position - TTC Data Set

Group	H	S	A	N	Total
			Condition		
Eng/Eng[a]					
M	0.6	0.7	0.9	1.0	0.8
f	4	5	6	7	22
Eng/Span[b]					
M	0.9	0.5	1.0	0.7	0.8
f	9	5	10	7	31
Span/Span[b]					
M	0.9	0.9	0.5	0.8	0.8
f	9	9	5	8	31
Span/Eng[b]					
M	0.4	0.4	0.6	0.3	0.4
f	4	4	6	3	17

Note. H = happy; S = sad; A = angry; N = neutral.
[a]n = 7, total number of trials = 112, total number of trials per condition = 28. [b]n = 10, total number of trials = 160, total number of trials per condition = 40.

Appendix O

Friedman Two-Way Analyses of Variance by Ranks of the Transformed Eye Opening Scores for the Initial Eye Position - Closed data set.

The scores for eye opening responses in the IEP-C data set (obtained using the scoring method described on page 66) were ranked across emotion conditions. For each group, a Friedman two-way analysis of variance by ranks (with correction for ties) was performed on the scores. For these analyses, all infants who did not begin any of the trials in the IEP-C data set (i.e., the scores for all four conditions equaled zero) were omitted. The mean ranks for the four groups are presented in Appendix P.

For group Eng/Eng (n = 6), the mean rank was highest in the happy condition. The results of the Friedman two-way analysis of variance by ranks indicated significant differences in the ranked scores across emotion conditions, $F_r(3) = 9.34$, $p < .05$. Follow-up comparisons showed the rank scores for the happy and sad conditions differed significantly (CV = 1.78).

Similarly, for group Span/Span (n = 8), the mean rank was highest in the happy condition. The ranked scores also differed significantly across emotion conditions, $F_r(3) = 18.53$, $p < .05$, for this group. Follow-up comparisons showed the rank scores for the happy and angry conditions differed significantly (CV = 1.55).

In group Eng/Span ($n = 8$), the highest mean ranks were observed in the happy and neutral conditions. However, for this group, the mean ranks did not differ significantly across emotion conditions, $F_r(3) = 3.86$, $p > .05$.

And, in group Span/Eng ($n = 8$) the mean ranks did not differ significantly across emotion conditions, $F_r(3) = 3.58$, $p > .05$.

Therefore the pattern of results obtained using ranked scores across emotion conditions was the same as that observed in the analyses of variance of the transformed scores for eye openings in the IEP-C data set.

Appendix P

Mean Ranked Scores for Eye Openings in the Initial Eye Position - Closed Data Set

Group	Condition H	S	A	N
Eng/Eng[a]				
M	3.67	1.75	2.67	1.92
Eng/Span[b]				
M	2.75	2.38	2.13	2.75
Span/Span[b]				
M	3.31	2.63	1.69	2.38
Span/Eng[b]				
M	1.81	2.75	2.56	2.88

Note. H = happy; S = sad; A = angry; N = neutral.

[a]n = 6. [b]n = 8.

Appendix Q

Figure A-Q. Mean eye closed scores (± SE) as a function of emotion condition and experimental group for the Initial Eye Position-Closed data sets.

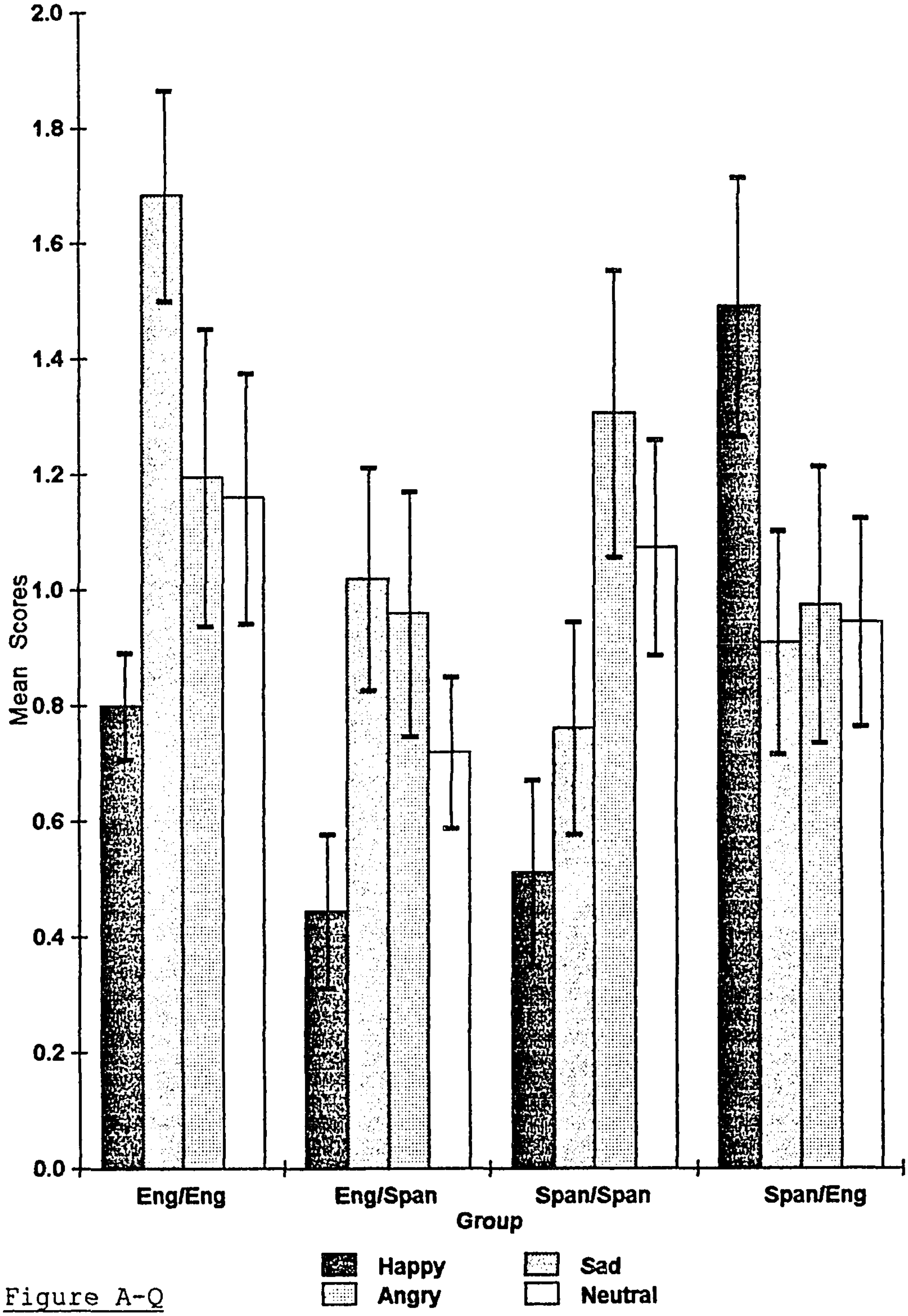
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Mean Scores
Eng/Eng
Eng/Span
Span/Span
Span/Eng
Group
Happy
Angry
Sad
Neutral

Figure A-Q

REFERENCES

Aslin, R. N. (1987). Visual and auditory development in infancy. In J. D. Osofsky (Ed.), Handbook of infant development (2nd ed.). New York: Wiley.

Averill, J. R. (1969). Autonomic response patterns in sadness and mirth. Psychophysiology, 5, 399-414.

Ax, A. F. (1953). Physiological differentiation of fear and anger. Psychosomatic Medicine, 15, 433-442.

Bachara, G. H., Raphael, M. S., & Phelan, W. J. (1980). Empathy development in deaf preadolescents. American Annals of the Deaf, 125, 38-41.

Barrett, K. C. & Campos, J. J. (1987). Perspectives on emotional development II: A functionalist approach to emotions. In J. D. Osofsky (Ed.) Handbook of Infant Development (2nd ed.). New York: Wiley.

Best, C. T., McRoberts, G. W., & Sithole, N. M. (1988). Examination of perceptual reorganization for nonnative speech contrasts: Zulu click discrimination by English-speaking adults and infants. Journal of Experimental Psychology, 14, 345-360.

Campos, J. J., Barrett, K. C. , Lamb, M. E., Goldsmith, H. H. & Sternberg, C. (1983). Socioemotional development. In M. M. Haith & J. J. Campos (Eds.) Infancy and Developmental Psychobiology: Vol. 2 of P. H. Mussen, Handbook of Child Psychology. New York: Wiley.

Cannon, W. B. (1927). The James-Lange theory of emotions: A critical examination and an alternative. American Journal of Psychology, 39, 106-124.

Caron, A. J. (1988, April). The role of face and voice in infant discrimination of naturalistic emotional expressions. Sensory dominance in early development. Symposium presentation at the Sixth International Conference on Infant Studies, Washington D. C.

Clarke A. S. & Schneider M. L. (1993). Prenatal stress has long-term effects on behavioral responses to stress in juvenile rhesus monkeys. Developmental Psychobiology, 26, 293-304.

Cooper, R. P., & Aslin, R. N. (1989). The language environment of the young infant: Implications for early perceptual development. Canadian Journal of Psychology, 43, 247-265.

Cooper, R. P., & Aslin, R. N. (1990). Preference for infant-directed speech in the first month after birth. Child Development, 61, 1584-1595.

Cosmides, L. (1983). Invariance in the acoustic expression of emotion during speech. Journal of Experimental Psychology: Human Performance and Perception, 9, 864-881.

Davidson, R. J., & Fox, N. A. (1982). Asymmetrical brain activity discriminates between positive and negative affective stimuli in human infants. Science, 218, 1235-1237.

DeCasper, A. J., & Fifer, W. P. (1980). Of human bonding: Newborns prefer their mother's voice. Science, 208, 1174-1176.

DeCasper, A. J., & Prescott, P. A. (1984). Human newborns' perception of male voices: Preference, discrimination, and reinforcing value. Developmental Psychobiology, 17, 481-491.

DeCasper, A. J. & Sigafoos, A. D. (1983). The intrauterine heartbeat: A potent reinforcer for newborns. Infant Behavior and Development, 6, 19-25.

DeCasper, A. J. & Spence, M. J. (1986). Prenatal maternal speech influences newborns' perception of speech sounds. Infant Behavior and Development, 9, 133-150.

DeCasper, A. J. & Spence, M. J. (1991). Auditorily-mediated behavior during the perinatal period: A cognitive view. In M. Weiss & P. Zelazo (Eds.) Newborn attention: Biological constraints and the influence of experience, (pp. 142-176). Norwood, New Jersey: Ablex.

Ekman, P., Levenson, R. W., & Friesen, W. V. (1983). Autonomic nervous system activity distinguishes between different emotions. Science, 221, 1208-1210.

Ekman, P. (1984). Expression and the nature of emotion. In K. R. Scherer & P. Ekman (Eds.), Approaches to Emotion, (pp. 319-343). New Jersey: Lawrence Erlbaum Associates.

Erdmann, G., & van Lindern, B. (1980). The effects of beta adrenergic stimulation and blockade on emotional reactions. Psychophysiology, 17, 332-338.

Fernald, A. (1984). The perceptual and affective salience of mothers' speech to infants. In L. Feagans, C. Garvey, & R. Golinkoff (Eds.), The Origins and Growth of Communication, (pp. 5-29). Norwood, New Jersey: Ablex.

Fernald, A. (1985). Four-month-old infants prefer to listen to motherese. Infant Behavior and Development, 8, 181-195.

Fernald, A., & Kuhl, P. (1987). Acoustic determinants of infant preference for motherese speech. Infant Behavior and Development, 10, 279-293.

Fernald, A., & Simon, T. (1984). Expanded intonation contours in mothers speech to newborns. Developmental Psychology, 20, 104-113.

Fernald, A., Taeschner, T., Dunn, J., Papousek, M., de Boysson-Bordies, B., & Fukui, T. (1989). A cross language study of prosodic modifications in mothers' and fathers speech to preverbal infants. Journal of Child Language, 16, 477-501.

Fifer, W., & Moon, C. (1995). The effects of fetal experience with sound. In J.-P. LeCanuet, W. P. Fifer, N. A. Krasnegor, & W. P. Smotherman (Eds.) Fetal Development: A Psychobiological Perspective, (pp.351-366) Hillsdale, New Jersey: Lawrence Ehrlbaum.

Fox, N. A., & Davidson, R. J. (1986a). Taste-elicited changes in facial signs of emotion and the asymmetry of brain electrical activity in newborn infants. Neuropsychologia, 24, 417-422.

Fox, N. A., & Davidson, R. J. (1986b). Psychophysiological measures of emotion: New directions in developmental research. In C. E. Izard & P. Read (Eds.) Measuring Emotions in Infants and Children, (Vol. 11, pp.13-47). New York: Cambridge University Press.

Fox, N. A., & Davidson, R. J. (1988). Patterns of brain electrical activity during facial signs of emotion in 10-month-old infants. Developmental Psychology, 24, 230-236.

Gellhorn, E. (1964). The role of proprioception in the physiology and psychopathology of emotion. Psychology Review, 71, 457-472.

Gottlieb, G. (1971). Ontogenesis of sensory function in birds and mammals. In E. Tobach, L. Aronson & E. Shaw (Eds.), The biopsychology of development (pp. 67-128). New York: Academic Press.

Grieser, D. L. & Kuhl, P.K. (1988). Maternal speech to infants in a tonal language: Support for universal features in motherese. Developmental Psychology, 24, 14-20.

Haviland, J. M. & Lelwica, M. (1987). The induced affective response: 10-week-old infants' responses to three emotion expressions. Developmental Psychology, 23, 97-104.

Hofer, M. A. (1988). On the nature and function of prenatal behavior. In W. R. Smotherman & S. R. Robertson (Eds.) Behavior of the fetus, (pp. 3-18). Caldwell, New Jersey: Telford Press.

Huszar, G., & Walsh, M. P. (1989). Biochemistry of the myometrium and cervix. In R. M. Wynn & Jollie (Eds.) Biology of the Uterus (2nd ed.)(pp 354-382). New York: Plenum Press.

Izard, C. E. (1979). The maximally discriminative facial movement coding system (MAX). Newark, DE: University of Delaware Instructional Resources Center.

Izard, C. E. (1980). The young infant's ability to produce discrete emotion expression. Developmental Psychology, 16, 132-140.

James, W. (1884). What is an emotion? Mind, 9, 188-205.

Kemper, T. D. (1987). How many emotions are there? Wedding the social and autonomic components. American Journal of Sociology, 93, 263-289.

Kuhl, P. K., Williams, K. A., Lacerda, F. Stevens, K. N., & Lindblom, B. (1991). Linguistic experience alters phonetic perception in infants by 6 months of age. Science, 255, 606-608.

Lacey, J. I., Bateman, D. E. & Van Lehn, R. (1953). Autonomic response specificity. Psychosomatic Medicine, 15, 8-21.

Lacey, J. I. & Lacey, B. C. (1958). Verification and extension of the principal of autonomic response stereotypy. American Journal of Psychology, 71, 50-73.

Lange, C. G. (1967, originally published in 1885). The emotions: A physiological study. In C. G. Lange & W. James (Eds.), The Emotions. New York: Hafner.

LeCanuet, J.-P., Granier-Defeыre, C., & Busnel, M.-C. (1988). Fetal cardiac and motor responses to octave band noises as a function of central frequency, intensity, and heart rate variability. Early Human Development, 18, 81-93.

Levenson, R. W. (1992). Autonomic nervous system differences among emotions. Psychological Science, 3, 23-27.

Levenson, R. W., Cartenson, L. L., Friesen, W. V., & Ekman, P. (1991). Emotion, physiology, and expression in old age. Psychology and Aging, 6, 28-33.

Lewkowitz, D. J. (1988). Sensory dominance in infants 1: Six-month-old infants' response to auditory - visual compounds. Developmental Psychology, 24, 155-171.

Lewkowitz, D. J. (1988). Sensory dominance in infants 2: Ten-month-old infants' response to auditory - visual compounds. Developmental Psychology, 24, 171-182.

McNaughton, N. (1989). Problems in the Behavioral Sciences: Biology and Emotion. New York: Cambridge University Press.

Mehler, J., Bertoncini, M., Barriere, M., & Jassik-Gerschenfeld, D. (1978). Infant recognition of mother's voice. Perception, 7, 491-497.

Mehler, J., Juczyk, P., Lambertz, G., Halsted, N., Bertoncini, J., & Amiel-Tison, C. (1988). A precursor of language acquisition. Cognition, 29, 143-178.

Moawad, A. H. (1973). The sympathetic nervous system and the uterus. In J.B. Josimivich (Ed.) Problems of human reproduction: Vol 1. Uterine contractions - side effects of steroidal contraceptives (pp 65-82). New York: Wiley.

Moon, C., Cooper, R. P., Fifer, W. (1993). Two-day-olds prefer their native language. Infant Behavior and Development, 16, 495-500.

Morgan, C. T. (1965). Physiological psychology (3rd ed.). New York: McGraw Hill.

Nathanielsz, P. W. (1995). The effects of myometrial activity during the last third of gestation on fetal behavior. In J.-P. LeCanuet, W. P. Fifer, N. A. Av , & W. P. Smotherman (Eds.) Fetal Development: A Psychobiological Perspective, (pp.369-382) Hillsdale, New Jersey: Lawrence Ehrlbaum.

Oster, H. (1981). "Recognition" of emotional expression in infancy? In M. E. Lamb and L. R. Sherrod (Eds.), Infant Social Cognition: Empirical and Theoretical Considerations. Hillsdale, New Jersey: Lawrence Ehrlbaum.

Safer, M. A. & Leventhal, H. (1977). Ear differences in evaluating emotional tones of voice and verbal content. Journal of Experimental Psychology: Human Perception and Performance 3 75-82.

Segal, L. B., Oster, H., Cohen, M., Caspi, B., Myers, M., & Brown, D. (1995). Smiling and fussing in seven-month-old preterm and full-term black infants in the still face situation. Child Development, 66, 1829-1843.

Schacter, S. & Singer, J. E. (1962). Cognitive, social, and physiological determinants of emotional state. Psychological Review, 69, 379-399.

Scherer, K. R. (1974). Acoustic concommitants of emotional dimensions: Judging affect from synthesized tone sequences. In S. Weitz (Ed.), Nonverbal Communication, (pp 105-111). New York: Oxford University Press.

Scherer, K. R. (1986). Vocal affect expression: Review. Psychology Bulletin, 99, 143-165.