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I am submitting herewith a dissertation written by Charlotte Ann Hubbard entitled "Infants' Vocalized Emotions: Listener Identification and Acoustical Analysis." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Speech and Hearing Science.

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INFANTS' VOCALIZED EMOTIONS:
LISTENER IDENTIFICATION AND ACOUSTICAL ANALYSIS

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Charlotte Ann Hubbard

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DEDICATION

To Mom and Dad, who through their unconditional love, taught me patience and perseverance to endure "the night before the fair."

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ABSTRACT

Six infants were video recorded during 5 emotional conditions (anger, fear, separation, joy, and elation). The 30 randomized samples were only presented auditorily to a group of 20 listeners (mothers), who identified which of the five emotions they perceived. A significant difference in the auditory identification by the listeners was observed among the 5 emotions. The listeners perceived the positive emotions as the targeted emotion at a higher percent than the negative emotions. Intrajudge, interjudge and test-retest reliabilities were higher for negative/positive identification of the emotions than for specific emotions.

A significant difference among the 6 infants indicated that the vocalized emotions of the group were not homogeneous. Infant 3 (13 months of age) had the highest percent of responses which were the same as the targeted emotions; whereas, Infant 1 (9 months of age) had the lowest percent of responses. All five sampled emotions for Infant 3 met the 70% criterion (14 out of 20 listeners); whereas Infant 1 had only 1 of 5 emotions that satisfied the criterion. These 70% criterion samples were used for the acoustical analysis.

Six acoustic parameters were measured for 43% of the samples (13 out of 30). These were mean fundamental frequency (Fo), mean Fo range, mean Fo inflection, mean Fo

rate, mean relative amplitude range, and mean relative amplitude rate. The positive emotions had the highest values for all the acoustic parameters, except for mean Fo which was highest for anger. This emotional/acoustic relationship suggested a continuum ranging from the most negative to the most positive emotion with increasing values in all acoustic parameters except mean Fo.

A comparison of the perception of infants' emotions with adults' emotions revealed that adult emotions are easier to perceive than infant emotions. The mean fundamental frequency (Fo) inflection and Fo rate of the adults' emotions were higher than those of infants'. Mean Fo rate was similar in the ranking of the three emotions for both the adults and the infants. Emotions have discriminating acoustical characteristics for both infants and adults.

TABLE OF CONTENTS

CHAPTER PAGE

I. INTRODUCTION..... 1

Statement of the Problem..... 1

Purpose..... 5

Rationale..... 6

Hypotheses..... 7

II. REVIEW OF LITERATURE.....10

Introduction.....10

Emotional Development.....11

Facial Expression of Emotions.....17

Suprasegmental Development.....19

Suprasegmental Communication.....21

Suprasegmental Expression in Infant Cry.....23

Vocal Expression of Emotions.....25

Summary.....32

III. METHODS.....33

Subjects.....33

Stimulus Selection.....37

Infant's Vocal Recordings.....37

Auditory Presentation to Listeners.....38

Acoustic Analysis.....41

Descriptive Analysis.....46

IV. RESULTS.....48

Reliability.....48
Perceptual Analysis.....54
Acoustical Analysis.....71
Descriptive Analysis.....83
V. DISCUSSION.....93
Perceptual Analysis.....93
Acoustical Analysis.....99
Descriptive Analysis.....100
VI. SUMMARY AND CONCLUSIONS.....103
Summary.....103
Conclusions.....104
Implications for Future Studies.....105
Limitations of the Study.....106
BIBLIOGRAPHY.....107
APPENDICES.....114
APPENDIX A. INSTRUCTIONS FOR LISTENING TO/ JUDGING EMOTIONS.....115
APPENDIX B. SPECTROGRAMS OF 5 EMOTIONS.....122
APPENDIX C. RAW DATA FOR 20 LISTENERS.....128
APPENDIX D. GRAPHED ACOUSTIC DATA FOR INFANTS.....139
VITA.....144

LIST OF TABLES

TABLE		PAGE
2-1.	The development of basic human emotions determined by Sroufe	14
2-2.	Acoustic parameters of emotional expression by adults	27
3-1.	Demographic information for the video taped infants	34
3-2.	Demographic data for the 20 listeners	36
4-1.	Intrajudge reliability of 20 listeners on negative emotions and on 3 extra emotions	49
4-2.	Probability of interjudge agreement and disagreement among 20 listeners on the perceived emotion	51
4-3.	Specific conditions utilized with each infant to elicit each vocalized emotion	55
4-4.	Kruskal-Wallis test for agreement with targeted emotions by 20 listeners	57
4-5.	Targeted samples of emotion with which each listener's response was the same	58
4-6.	Listener's perception of targeted emotion as negative or positive in percent and raw data	61
4-7.	Response matrix of raw data and percentages for targeted emotions	62
4-8.	Percent of listeners whose response was the same as the targeted emotion for each of the 30 samples	64
4-9.	Demographic data and percent agreement with targeted emotion for 20 listeners	65
4-10.	Listeners' percent of responses that were the same as the targeted emotions	67
4-11.	Kruskal-Wallis test for agreement with 6 infants' expression of emotions by 20 listeners	68

TABLE PAGE

4-12. For 20 listeners, percent of same responses with the targeted emotions of each infant..... 70

4-13. Fundamental frequency data in Hz for Infant 3.... 73

4-14. Relative amplitude data in dB for Infant 3..... 74

4-15. Rank ordering of 5 emotions for each acoustic parameter..... 84

4-16. Percent agreement for the emotions studied by Hubbard (1991) and Fairbanks (1940)..... 85

4-17. Fundamental frequency data for three emotions studied by Hubbard (1991) and Fairbanks (1940) reported in Hertz and tones..... 87

4-18. Fundamental frequency data for three emotions expressed by actors..... 90

4-19. Fundamental frequency data for three emotions expressed by infants..... 91

C-1. Responses of listener 1 to 5 targeted emotions for 6 infants..... 129

C-2. Responses of listener 2 to 5 targeted emotions for 6 infants..... 129

C-3. Responses of listener 3 for the targeted emotions for each infant..... 130

C-4. Responses of listener 4 for the targeted emotions for each infant..... 130

C-5. Responses of listener 5 for the targeted emotions for each infant..... 131

C-6. Responses of listener 6 for the targeted emotions for each infant..... 131

C-7. Responses of listener 7 for the targeted emotions for each infant..... 132

C-8. Responses of listener 8 for the targeted emotions for each infant..... 132

C-9. Responses of listener 9 for the targeted emotions for each infant..... 133

TABLE PAGE

C-10. Responses of listener 10 for the targeted emotions for each infant..... 133

C-11. Responses of listener 11 for the targeted emotions for each infant..... 134

C-12. Responses of listener 12 for the targeted emotions for each infant..... 134

C-13. Responses of listener 13 for the targeted emotions for each infant..... 135

C-14. Responses of listener 14 for the targeted emotions for each infant..... 135

C-15. Responses of listener 15 for the targeted emotions for each infant..... 136

C-16. Responses of listener 16 for the targeted emotions for each infant..... 136

C-17. Responses of listener 17 for the targeted emotions for each infant..... 137

C-18. Responses of listener 18 for the targeted emotions for each infant..... 137

C-19. Responses of listener 19 for the targeted emotions for each infant..... 138

C-20. Responses of listener 20 for the targeted emotions for each infant..... 138

LIST OF FIGURES

FIGURE PAGE

2-1. The approximate age level at which emotions emerge during birth through 24 months of age... 12

2-2. Age periods during which emotions emerge in the first year of life..... 16

3-1. Block diagram of equipment during the presentation of the training and infants' vocal recordings..... 40

3-2. Expanded narrow-band spectrographic display utilized for obtaining acoustic data..... 43

3-3. Expanded narrow-band spectrographic display with cursors showing (a) upward direction in fundamental frequency and (b) downward direction in fundamental frequency..... 45

3-4. Relative amplitude display and waveform with cursors placed at points of change in amplitude for computing relative amplitude rate..... 47

4-1. Sample computation of interjudge reliability for targeted emotion anger of Infant 2..... 53

4-2. Percentage of listeners with the same judgments as the targeted emotions of 6 infants..... 60

4-3. Mean fundamental frequency for five targeted emotions of infants meeting the 70% criterion.. 72

4-4. Mean fundamental frequency of five targeted emotions for Infant 3..... 75

4-5. Fundamental frequency range of five targeted emotions for Infant 3..... 77

4-6. Fundamental frequency inflection of five targeted emotions for Infant 3..... 78

4-7. Mean fundamental frequency rate for Infant 3..... 80

4-8. Mean amplitude rate of 5 targeted emotions for Infant 3..... 82

4-9. Percent agreement for three emotions of infants meeting 70% criterion (Hubbard, 1991) and six adults (Fairbanks, 1940)..... 86

FIGURE PAGE

4-10. Median fundamental frequency for three emotions of infants meeting 70% criterion (Hubbard, 1991) and six adults (Fairbanks, 1940)..... 88

5-1. Acoustic-emotional continuum for 5 emotions and 5 acoustic parameters..... 96

B-1. Narrow-band spectrogram of targeted emotion anger for Infant 3..... 123

B-2. Narrow-band spectrogram of targeted emotion fear for Infant 3..... 124

B-3. Narrow-band spectrogram of targeted emotion separation for Infant 3..... 125

B-4. Narrow-band spectrogram of targeted emotion joy for Infant 3..... 126

B-5. Narrow-band spectrogram of targeted emotion elation for Infant 3..... 127

D-1. Fundamental frequency range of 5 targeted emotions for infants..... 140

D-2. Fundamental frequency inflection of 5 targeted emotions for infants..... 141

D-3. Fundamental frequency rate of 5 targeted emotions for infants..... 142

D-4. Relative amplitude rate of 5 targeted emotions for infants..... 143

CHAPTER I

INTRODUCTION

Statement of the Problem

Emotions are the basis for communicative intent in infants (Emde, Gaensbauer, & Harmon, 1976). Emotional expression is forceful, giving purpose, life, and meaning to communication. The words in a message may represent the true feelings to be conveyed; however, the vocal tone carries the essence of the verbal expression (Collier, 1985). Even hearing impaired individuals, who had difficulty understanding speech, could perceive the emotional content of the verbal message. In a study of hearing impaired and normal hearing children's ability to auditorily identify one of four emotions, Cotterell (1981, p. 36) concluded that "the ability to listen and discriminate among emotions is not related to the detection threshold of hearing."

Speech, as well as nonverbal communication, is an expression of our emotions (Asp, 1991). Emde, Kligman, Reich, & Wade (1978, p. 126) stated "we found that facial expressions and other behaviors that we presumed to call [or define as] emotional regularly communicated 1) feelings and 2) messages for caretaking and social interaction, and that both of these were meaningful for parents."

Emotions may be viewed as a linguistic Universal that affects the meaning in all spoken languages (Asp, 1991). Even though the words of one language are not understood by a listener from a different language, that listener will understand the emotional content of the message. Ekman and Oster, (1979) reported that the majority of judges from nine "literate cultures" labeled a facial expression as the same emotion. They also stated that "there is unambiguous evidence of universality only for the [facial] expressions of happiness, anger, disgust, sadness, and combined fear/surprise" (Ekman & Oster, 1979; p. 531).

Emotions are expressed on a continuum (Asp, 1991). Emde, Kligman, Reich, & Wade (1978) reported that infants' facial expressions of emotions could be categorized on a three-dimensional continuum: 1) "hedonic tone" ranging from negative to positive emotions, 2) "activation" ranging from sleep to excitement, and 3) "orientation" ranging from external to internal.

Tronick (1989) explained that the infant and the adult were integral participants in an emotional communication system. This system was critical to the infant in achieving goals, experiencing emotions, and overall development. Emotional development is dependent upon the emotional bonding or attachment between the infant and the main caregivers (mother, father, etc.). Bonding results in a feeling of emotional security for the infant. Infants can

"grow up" regarding their mothers (caregivers) as a secure source from which they can venture forth and explore the environment (Sroufe & Waters, 1977). Infants, who have secure attachments, are usually more socially mature and more apt to interact socially with their peers, using appropriate emotional expression. Intonational patterns, defined as "the gross pitch movement throughout a sentence or part of a sentence" (Helfrich, 1979), are the conveyors of emotional expression, which is the communicative intent of infants.

Infants' emotional development has typically been studied in facial expression (Izard, 1978; Ekman & Oster, 1979), body language, and situational context (Sroufe, 1979) but has not been quantified only by vocal patterns. It has been difficult to control the emotional situation as well as the acoustic conditions for the actual recording of the infants' vocalized emotions (Scherer, 1982).

Approximately seven emotions emerge during the first twelve months of infancy (Bridges, 1932; Izard, 1978; and Sroufe, 1979). These emotions were identified in facial expressions, in body movements, and/or the context of the situation under which vocal expression was a part. These seven emotions were labeled surprise, joy, elation, fear, disgust, anger, and separation.

In studying the facial expressions of infants, Ekman, Friesen, and Ellsworth (1982) concluded that facial

expressions could be judged in at least seven categories (happiness, surprise, fear, anger, sadness, disgust, and interest). Simultaneously, facial measurement systems, e.g. Maximally Discriminative Facial Movement (Izard and Dougherty, 1982), were devised to determine the emotion exhibited by an infant (discussed in Campos, Barrett, Lamb, Goldsmith, & Stenberg, 1983). However, no vocal measurement system has been devised for studying infants' vocalized emotions.

Abe (1980), who discussed several uses of intonation (changes in fundamental frequency) in spoken language, emphasized the role of intonation in the expression of emotion or attitude. He, as well as Helfrich (1979), stated that intonation revealed the emotional intent of the syntactic structure. Whereas, Guberina (1939) placed intonation in the realm of linguistics (specifically syntax) suggesting that it contained the basic meaning in syntactic structures, rather than a superimposed meaning.

A few researchers suggested that communicative intent in language development occurred before lexicon usage (twelve months of age) in the form of intonation contours (Lieberman, 1967; Tonkova-Yampol'skaya, 1973). Tonkova-Yampol'skaya studied intonational development in infants one month up to two years of age (N = 170 infants). The author observed speech sound production at two months of age, but since these sounds had no semantic content, the adult

responded to the intonational pattern rather than the speech sound. Tonkova-Yampol'skaya (1973, p. 137) concluded that "speech development in children begins with development of intonations." Before words develop (around 9-15 months of age), intonational patterns are clearly identified as communicative in nature.

Emotions can be reliably identified through intonational patterns in the voice. Fairbanks (1940) demonstrated this successfully with adults. Several studies conducted by Scherer (1981) and Fairbanks (1940) indicated that changes in pitch, loudness, and duration affect the perception of the emotions that are conveyed by adult speakers. Acoustical analyses of spoken "emotions" have shown differences in the vocal characteristics for each emotion. The same technique can be applied to infants if the context for evoking the emotion is appropriate and controlled.

Purpose

The purpose of this study was to determine if infant emotions could be identified by listening to infants' vocalization patterns and if the acoustical analysis showed distinct intonational patterns for each emotion. Fairbanks (1940) reported different intonational patterns of each emotion for adult speakers. Since intonational patterns are

the basis of spoken language, the intonational patterns of infants and adults may be similar for each emotion.

Rationale

Models of emotional development (Bridges, 1932; Izard, 1978; Sroufe, 1979) have emerged from observations of the infants' body language (in particular facial expression), their cognitive development, the reactions to certain stimuli, and the social context. Vocalizations have been included in some of these investigations, but have not been studied in isolation. Since spoken language is the primary means of communicating ideas, intent, and emotion, it would appear imperative to study the expression and perception of emotions in infants' vocalizations. Scherer (1979, 1981, 1982), Fairbanks (1940), and Williams and Stevens (1972), among others, have investigated the vocal expression of emotions in adults and reported similarities in perceptual and acoustic results. Scherer (1979) identified acoustic parameters which were typically present in the adults' expression of emotion. However, little of this work has been applied to the vocal emotional expression of infants.

It would be valuable to identify the vocal characteristics of infants' emotions at various age levels, and accumulate normative data. Already there is evidence in the literature that some anomalies, such as Cri du Chat Syndrome and Down Syndrome, have distinctly different vocal

cries documented by acoustic analysis (Wasz-Hockert, Lind, Vuorenkoski, Partanen, & Valanne, 1968). For example, the pain cry of a Down Syndrome infant was described by Wasz-Hockert et al. (1968, p. 32) as "tense and often only half voiced" with a flat "melody form" and a pitch level lower than normal infants. If normative data existed, early identification of unusual vocal patterns could result in early intervention and stimulation of more appropriate vocal/intonational patterns.

Hypotheses

In order to determine the role of listening and acoustic analyses in the identification of infants' reactions to emotional situations outlined in Appendix A (henceforth, termed emotions), the following hypotheses were tested:

A. Perceptual Analysis

1. With respect to 9- through 12-month old infants' vocalizations, there is no significant difference in the identification by listening among the following five (5) emotions:
    a) anger
    b) fear
    c) separation

d) joy

e) elation

2. With respect to 9- through 12-month old infants' vocalizations of a given emotion, there is no significant difference among infants in the identification by listening.

B. Acoustical Analysis

1. With respect to 9- through 12-month old infants' vocalizations, there is no significant difference among the five emotions for each of the following acoustic parameters:

a) mean fundamental frequency (Fo)

b) mean Fo range (highest Hz - lowest Hz)

c) mean Fo inflection (highest Hz - lowest Hz in one direction)

d) mean Fo rate (mean Fo inflection divided by the number of seconds)

e) mean relative amplitude range (highest dB - lowest dB)

f) mean relative amplitude rate (highest dB - lowest dB in one direction divided by the number of seconds)

C. Descriptive Analysis

In order to compare infants and adults on the vocal expression of three emotions (anger, fear, and separation/grief), the following question was tested:

1. What are the acoustical differences in tones (T = 19.92 x [log10 x (f1/f0)]) between infants' (Hubbard, 1991) and adults' (Fairbanks, 1940) vocalizations for the following measures:

   a) mean Fo range (highest Fo - lowest Fo)

   b) mean Fo inflection (highest Fo - lowest Fo in one direction)

   c) mean Fo rate (mean Fo inflection divided by number of seconds)

CHAPTER II

REVIEW OF LITERATURE

Introduction

Affective communication is a major component in the infant's development (Tronick, 1989). The infant utilizes emotional expression to reach a goal and to evaluate the effectiveness in accomplishing that goal. If the infant sees that a goal is being reached, then a positive emotion is expressed. If, however, an obstacle gets in the way of reaching that goal, anger is expressed. If the barrier cannot be overcome, then sadness is displayed. Therefore, emotions encourage and organize the infant's responses in a situation.

Emotions are the means by which the preverbal infant regulates self-directed and other-directed behaviors. If the infant wants out of the crib and is not successful at achieving this goal, then a negative emotion is expressed. When the caretaker responds to the infant's vocalized emotion by taking the infant out of the crib, then the caretaker has accomplished two transformations. The failure at reaching a goal has been repaired into a successful event and also a negative emotion has been altered to a positive emotion.

Emotions are one means of conveying cognitive abilities. For example, when the infant initiates the game, "peek-a-boo," the cognitive concept of object permanence is demonstrated, as well as the ability to elicit a particular emotion (Lewis, 1989). The infant now displays a higher level of development than stimulus-response.

In order to study the relationship that emotional communication has with infant development, a better understanding of emotional development is necessary.

Emotional Development

One of the first attempts to identify and define the emotions in infants was conducted by Bridges (1932). In this classic study, she observed infants daily from birth through twenty-four months of age for a period of three to four months. She transcribed their behavioral reactions and noted the surrounding conditions in order to determine the emotion displayed. Her results yielded a developmental diagram of different emotions (See Figure 2-1).

Bridges noted that at birth the infants demonstrated a general emotion of "excitement". By three months of age, infants exhibited three emotions (distress, excitement, and delight). By six months of age, they expressed an additional three emotions (fear, disgust, and anger). She concluded that emotions developed slowly and that the

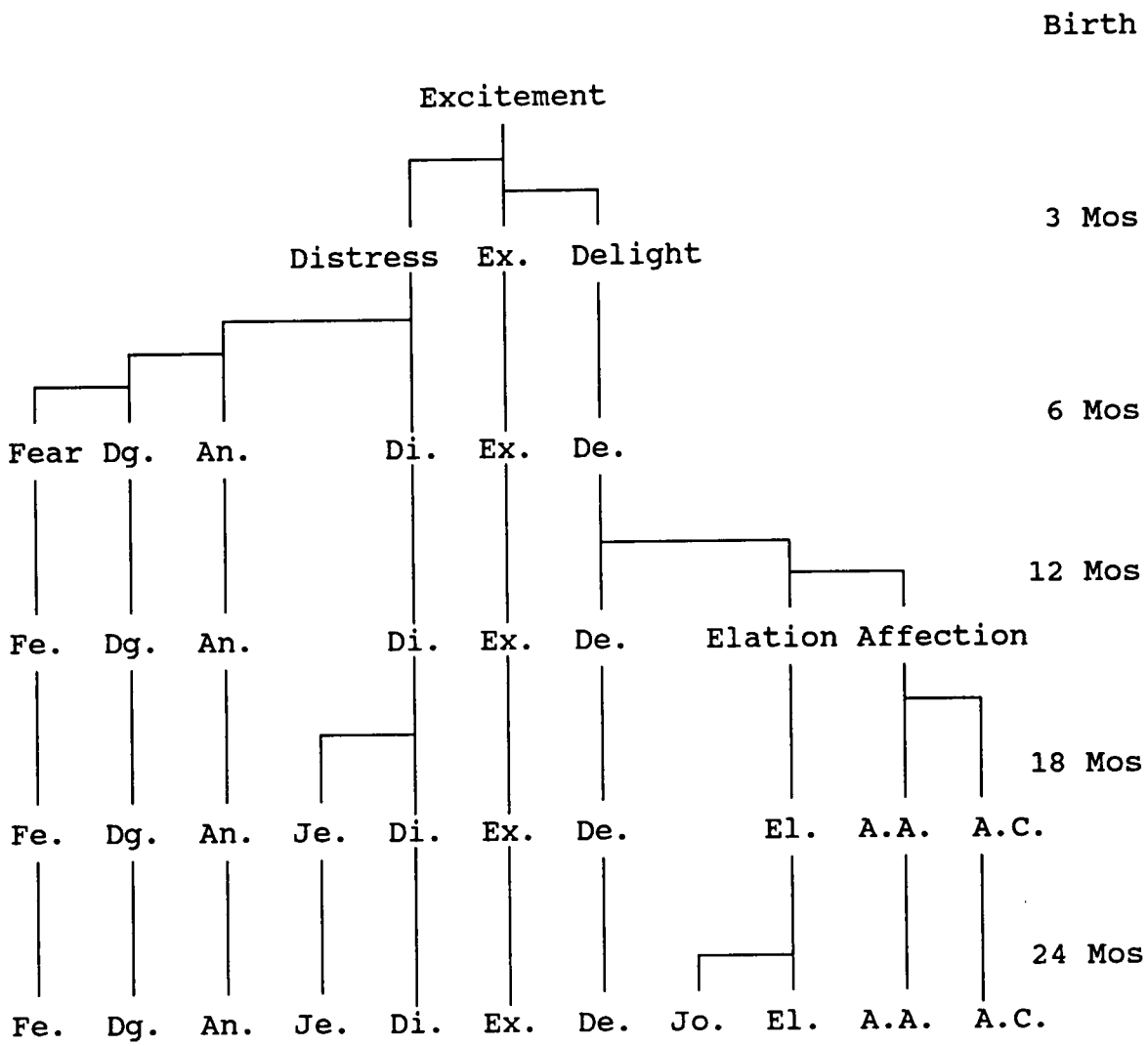

Figure 2-1. The approximate age level at which emotions emerge during birth through 24 months of age (Key: A.A. = Affection for Adults, A.C. = Affection for Children, An. = Anger, De. = Delight, Dg. = Disgust, Di. = Distress, El. = Elation, Ex. = Excitement, Fe. = Fear, Je. = Jealousy, Jo. = Joy) (From K. Bridges, 1932)

specific age at which the emotion emerged was difficult to ascertain. She also reported that the observable behaviors for an emotion became more specific over time for certain stimuli and type of response.

Sroufe (1979) concurred with Bridges (1932) that specific emotions evolved from the general emotion of "excitement," but was concerned that sufficient explanation was not given to justify the labeling of each emotion. Therefore, he proposed that neonates exhibited precursors to three emotional categories (pleasure/joy, wariness/fear, and rage/anger), which evolved into higher levels of emotion as cognitive skills developed (See Table 2-1). For example, the emotion of pleasure/joy evolved into "delight" by five months of age when the emotional developmental period of positive affect emerged. By twelve months of age, elation had evolved from delight when attachment (bonding) of the infant to the mother had taken place.

Sroufe was also concerned about the social aspect of emotional development and studied the infant's recognition of and response to the environment. Attachment of the infant to the caregiver was critical to the organization of infant development (Sroufe and Waters, 1977). If the infant had an attachment to the caregiver, then the baby had a secure base from which to explore among and integrate the cognitive, social, and affective domains.

Table 2-1. The development of basic human emotions determined by Sroufe (From Osofsky, 1979)

Month of Age	Pleasure/Joy	Wariness/Fear	Rage/Anger	Periods of Emotional Development
0	Endogenous smile	Startle/pain	Distress due to covering the face, physical restraint, extreme discomfort	Absolute stimulus barrier
1	Turning toward	Obligatory attention		Turning toward
2				
3	Pleasure		Rage (disappointment)	Positive affect
4	Delight Active laughter	Wariness		
5				
6				Active participation
7	Joy		Anger	
8				
9		Fear (stranger aversion)		Attachment
10				
11				
12	Elation	Anxiety Immediate fear	Angry mood, petulance	Practicing
18	Positive valuation of self-affection	Shame	Defiance	Emergence of self
24		Intentional hurting		
36	Pride, love		Guilt	Play and fantasy

In describing emotional development, Bijou and Baer (1965) postulated that emotional behavior was a response to the environment and was affected strongly by reinforcement and extinction. Initially, the infant has a small repertoire of emotional behaviors which occur following certain situations. As the baby develops, the responses occur in a wider variety of situations. Also, the infant becomes more discriminatory of the extent of the emotional response, depending on the stimuli presented. New behaviors become dependent on the changing physiological structures and capabilities of the infant and were modified by the subsequent consequences displayed by the adult.

Izard's (1978) theory of emotional development asserted three principles. The first principle stated that the neonate displayed several specific emotions (See Figure 2-2) which were identified by particular facial expressions. These early emotions were "interest", "disgust", "distress", and "startle" (a precursor of surprise). The second principle stated that emotions emerged when the infant was exposed to new and various situations. While the third principle stressed that the emergence of emotions was in close proximity to changes in cognitive, perceptual, and motor skills of the infant. For example, "joy" did not emerge until the infant had developed the ability to discriminate social from nonsocial objects in his/her environment.

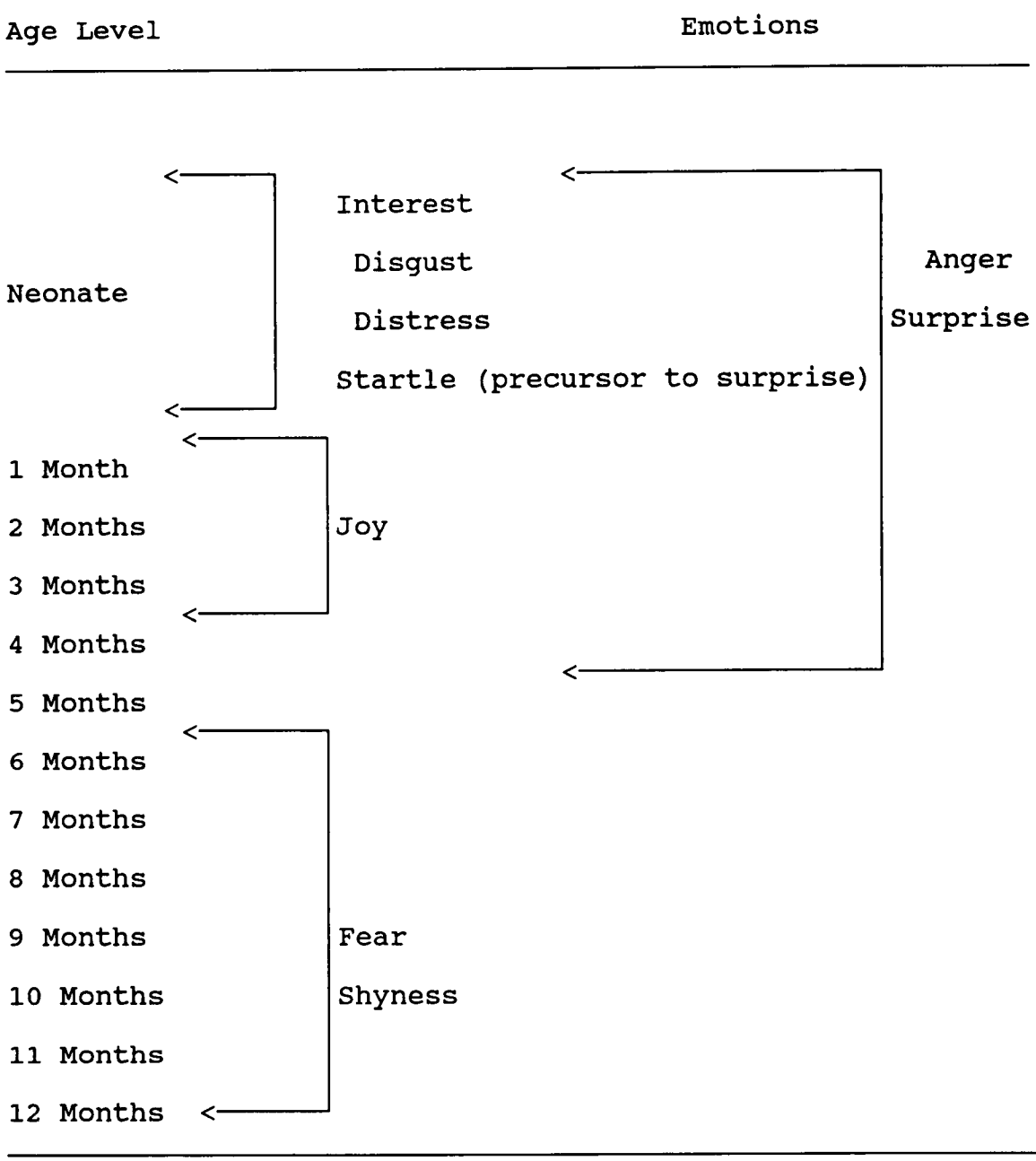

Figure 2-2. Age periods during which emotions emerge in the first year of life (Izard, 1978)

Campos, Barrett, Lamb, Goldsmith, and Stenberg (1983) proposed a theory of emotional development which encompassed several segments from Sroufe, Izard, and others. However, they stressed that changes in the goals of the infant occurred with the development of cognitive, perceptual, and motoric skills. Therefore, these authors proposed seven axioms to emotional development:

1. There is a set of differentiated core emotion states that are present throughout the lifespan.
2. As cognitive development proceeds and as new goals appear in the life of the child, complex intercoordinated emotions become evident.
3. The effectiveness of specific eliciting circumstances changes as the organism develops.
4. The relationship between emotional expression and emotional experience changes as the organism develops.
5. Coping responses to emotions change as the organism develops.
6. Emotions become socialized as the organism develops.
7. Receptivity to others' emotional expressions changes as the organism develops. (Campos et al., 1983, p. 818)

Facial Expression of Emotions

In an attempt to objectively observe emotions, studies of facial expression of emotions emerged. Facial expression studies in infants were conducted to investigate emotional development because 1) certain facial expressions were typically labeled as the same emotion universally (Ekman & Oster, 1979) and 2) facial expressions similar to those of

adults could be observed in neonates (Ekman, Friesen, & Ellsworth, 1982).

In order to further study the effect of the adult facial expression on the infant's expression, Field (1982) observed the newborn's alertness and visual fixation on the adult's face. An habituation-dishabituation paradigm was utilized to measure the amount of infant observation on the adult during each facial expression. As expected, the visual fixation time decreased from the middle to the end of the expression presented. However, the length of fixation increased significantly between the end of one expression and the beginning of the next expression. Not only did these neonates discriminate between changes in the adult's model, but they also imitated the lip and eye positioning for each of the three emotions (happy, sad, and surprised) expressed.

In studying two and three-week-old infants, Meltzoff and Moore (1977) concluded that infants could discriminatively imitate motor movements, such as protrusion of tongue and lips and opening the mouth. Other studies reported in Ekman & Oster (1979) indicated that 3- to 4-month-olds responded differentially to various facial expressions.

Malatesta, Grigoryev, Lamb, Albin, and Culver (1986) investigated 2 1/2-, 5-, and 7 1/2-month-old preterm and full-term infants in order to determine changes in emotion

with increased age. Results indicated that positive emotions, e.g. "joy", increased with age, while negative emotions, e.g. "pain", decreased as age increased. These researchers concluded that learning was taking place from the models and contingencies of the mothers. Malatesta et al. (1986) also reported that mothers of preterm infants 1) demonstrated less imitation of their infant's facial expressions, 2) more often ignored their infant's anger, and 3) displayed inconsistent responses to their infant's sadness than did mother's of full-term infants. These differences appeared related to differences in negative emotion and gazing patterns in the preterm infants. Therefore, a breakdown in affective communication apparently occurred, as the infant must have had difficulty in the regulation of mother's behavior.

Suprasegmental Development

Before directly discussing the verbal expression of emotions, it is important to understand suprasegmental development as the conveyor of emotional expression. Acquisition of the parameters of suprasegmentals are highly dependent upon the physiological capabilities of the infant, as well as auditory sensitivity and auditory perceptual skills. Lieberman (1986) discussed the development of intonation as it was affected by physiological and neural control. In order to express differentiating cries in

infancy, such as hunger or pain, the infant had to demonstrate control of such vocal parameters as: 1) fundamental frequency, 2) duration, and 3) amplitude.

Changing the duration involved control over the breath-group which was the basic element for dividing speech into sentence-like segments. The neural transmissions to the laryngeal and thoracic muscles were not refined in the neonate, therefore, not allowing for control over an expiration during vocalization (breath-group). After three months of age, the infant demonstrated skill in prolonging the phonation during vocalization. Infants who had been deaf since birth usually exhibited very poor control of air flow and laryngeal muscles (Lieberman, 1986). By three months of age normal infants imitated the duration and fundamental frequency of their mother's vocalization (Sandner, 1981, as reported in Lieberman, 1986). By eight to ten months of age, the infant imitated the fundamental frequency and intonation contour (Rabson, Lieberman, & Ryalls, 1982). In addition, similar results were reported for ten- and thirteen-month-olds (Lieberman, 1967), in which higher fundamental frequency of infants' cries occurred during mother-infant interactions than during father-infant interactions.

Crystal (1973) concurred with Lieberman when citing prior research that reported spectrographic differences between infants' vocalizations and adults' attempts to

imitate the infants. Differences of formant frequencies were reported. At the emergence of cooing, adult-like formants were observed in infants' vocalizations. A comparison of infants' and adults' intonation patterns was made by Tonkova-Yampol'skaya (1973). Between one and six months of age, the intonational pattern for "discomfort" was similar for both the infants and the adults. From two to seven months of age, the "indifference" pattern of infants was similar to the "assertion", "enumeration", and "comparison" patterns of adults.

Suprasegmental Communication

Infants begin to imitate intonational patterns of adults at an early age (Crystal, 1973). Crystal (1973, p. 16) stated that "...non-segmental patterning in general, and intonation in particular, seemed to be the earliest kind of linguistic structuring in the vocalization of the child..." He continued by reporting that most researchers determined that these patterns emerge between six and twelve months of age. More recent research by Guberina (1991), suggested that infants communicated with each other by their intonational patterns and nonverbal skills.

Garnica (1977) investigated the differences in fundamental frequency, duration, and intensity within a syllable produced by mothers as they interacted with their children and adults. Recordings were made in a variety of

settings (storytelling, reading aloud, and giving instructions). The recordings were analyzed with the Pitch Extractor and were transcribed phonetically and by accentual pattern using form levels of stress. Results indicated that the mothers' fundamental frequency (Fo) was significantly higher and had a wider range with their children (2-5 years of age) than with adults. When interacting with the 2-year-olds, the mothers' Fo range was greatly expanded in the higher frequencies; whereas, with older children (5 years of age) the range expanded at both the high and low ends of the frequency range.

Garnica (1977) also reported that final falling pitch contours were observed in all speaking conditions with adults. Whereas, final rising pitch contours were utilized with the children, especially during presentation of instructions.

Garnica concluded that higher pitch, rising final pitch, and whispering served as a social marker used for the 2-year-old children. It would appear that the rising pitch was a means to sustain the child's attention. As a child matures, his attention span increases and thus the need for rising pitch and whispering decreases; therefore, the function of these markers are greatly reduced or eliminated as the child develops.

For 13-month olds, Kent and Bauer (1985) reported the most frequent intonational contours as the fall and rise-

fall contours. Delack and Fowlow (1978) reported the rise-fall contour as occurring more often showing the greatest increase (40 to 55 %) during the first year. They studied 19 infants for 12 months, starting at one month of age.

Robinson (1984) audio taped the utterances of 3-, 4-, and 5-year-old children in a play situation with the researcher. These utterances were analyzed to obtain the pitch contours. Each contour was classified and analyzed descriptively to determine any difference in type or frequency of occurrence of the pitch patterns according to age, sex, and utterance length. Results revealed seven distinct "pitch-prosody patterns" (single-hump, double-hump, triple-hump, initial-hump with gentle slope or flat contour, initial-gentle-slope or flat-contour with final-hump, initial-gentle-slope or flat-contour with final-rise, initial-hump with gentle slope or flat contour with final rise). There were no changes in the number or occurrence of pitch patterns across age. However, there appeared to be potential differences in the patterns across sex and age which could be associated with semantics and pragmatics.

Suprasegmental Expression in Infant Cry

According to Lester and Boukydis (1985), crying is the basic manner in which the infant communicates intent or expresses needs. Infant cry studies have been emphasized due to the ability to determine the intent of the cry, e.g.

pain and hunger. The conditions in which these cries are elicited can be controlled. By creating sudden changes in pitch and loudness, such as in crying, infants communicate their emotions during discomfort, hunger, or pain. Infants are physiologically capable of vocal changes for the expression of different communicative intents by two months of age. Lester (1985) reported that at different age levels infants cry for various reasons, related to physiological, cognitive, social, and emotional development. In the first few weeks, the cry is reflex-like, giving the infant a chance to express that the external stimuli are too demanding for the internal system. Within the first few months, the amount as well as the type of crying changes. The infant begins to communicate needs, e.g. hunger, through crying. Since listeners can perceive differences in cry to indicate intent of communication, i.e. hunger, pain, or discomfort (Wasz-Hockert, Lind, Vuorenkoski, Partanen, & Valanne, 1968), fundamental frequency and amplitude form the acoustical and perceptual patterns which distinguish one type of cry from another. Vocal parameters of the infant cry include the following: length of cry, voice height, height of a voice shift, latency of the cry, voicing, melody type (a pitch level change that exceeds 10% of the pitch for more than 10% of the cry duration), continuity of the signal (whether continuous or interrupted), glottal plosives within or between cries, vocal fry, vibrato, and subharmonic breaks

(Lester & Boukydis, 1985). Prior research has indicated that infants have a higher mean fundamental frequency (400-600 Hz) when crying, and (a lower one (300-500 Hz) when babbling (Robb & Saxman, 1985, and Wasz-Hockert, et al., 1968).

Murry, Hoit-Dalgaard, and Gracco (1983) conducted a longitudinal study of infant vocalizations. Cry and non-distress vocalizations were observed biweekly from two to twelve weeks of age. Fundamental frequency (mean, standard deviation, and range) and duration were analyzed. For both cry and nondistress vocalizations, the vocalic duration increased with age. There was no apparent relationship between the Fo of the cry and nondistress vocalization. The rising-falling intonation contour was the most common for the infant cries, whereas falling-rising was common for nondistress vocalizations. Rising and flat intonation contours occurred twice as often as nondistress crying. The rising-falling contour was expected because of the initial laryngeal tension of the cry and the subsequent relaxation of the muscles. This created a falling pitch pattern as the muscles return to the natural state.

Vocal Expression of Emotions

Adult Studies: In order to study the perception of vocally expressed emotions, adults were initially selected as subjects because they could more easily assimilate the

requested emotions than could children. Campos et al., (1983) described several research methods which were utilized to "capture" the emotion and control the variables. The use of singing resulted in the identification of the emotions of "surprise", "fear", "sorrow", and "anger". When reading the letters of the alphabet with different emotions, ten emotions were perceived above chance level. The use of filtered speech yielded much lower accuracy ratings than did the other methods.

Scherer (1979, 1982, & 1986) observed the neglected area of vocal expression of emotions and therefore focused his research endeavors toward the identification of emotions perceptually and through acoustic analysis. He began by establishing a theoretical foundation for conducting research on the vocal expression of emotions (Scherer, 1979). His first step was a review of the literature to determine which vocal parameters were essential in the identification of different emotions. From this review, he concluded that there was no one parameter which was critical to an emotion. Rather, he concluded that it was the pattern established by five vocal parameters which facilitated the identification of an emotion. Scherer utilized the following five vocal parameters to describe vocally expressed emotions: loudness, tempo, pitch level, pitch range, and pitch variability (See Table 2-2). For example, the emotion of "happiness/joy" was vocally expressed with a

Table 2-2. Acoustic parameters of emotional expression by adults (Scherer, 1979) (? = data missing or inconclusive)

Emotion	Pitch level	Pitch range	Pitch variability	Loudness	Tempo
Happiness/ Joy	High	?	Large	Loud	Fast
Confidence	High	?	?	Loud	Fast
Anger	High	Wide	Large	Loud	Fast
Fear	High	Wide	Large	?	Fast
Indifference	Low	Narrow	Small	?	Fast
Contempt	Low	Wide	?	Loud	Slow
Boredom	Low	Narrow	?	Soft	Slow
Grief/ Sadness	Low	Narrow	Small	Soft	Slow
Evaluation	?	?	?	Loud	?
Activation	High	Wide	?	Loud	Fast
Potency	?	?	?	Loud	?

level, large pitch variability, increased loudness, and a fast tempo; whereas, "grief/sadness" was expressed with a low pitch level, a narrow pitch range, small pitch variability, decreased loudness, and a slow tempo.

Fairbanks (1940) conducted a study of the vocal expression of emotions by adults. He had six adult male actors simulate five emotions ("contempt", "anger", "fear", "grief", and "indifference") within a scenario. These scenarios were repeated by the actors until the experimenters judged them as being representative of each emotion. Sixty-four advanced students of speech categorized each sample into one of twelve emotions. Results indicated that "indifference" was perceptually identified by the listeners with 88% agreement, "contempt" with 84% agreement, "anger" with 78% agreement, "grief" with 78% agreement, and "fear" with 66% agreement.

The samples were analyzed acoustically and compared for differences among the emotions. There were some pitch patterns observed within the different emotions. For the emotion, "grief", there were few wide downward inflections. Wide, rapid inflections were noted with "anger;" whereas, there were irregular inflections in "fear". Vibrato was characteristic of "grief" and there were no distinct pattern with "indifference". Median fundamental frequency was similar for "anger" and "fear" (229 Hz and 254 Hz), but different from "contempt" (124 Hz), "grief" (136 Hz), and

"indifference" (108 Hz). The mean total pitch range in tones was similar for "contempt" (10.5 tones), "anger" (10.3 tones), and "fear" (11.2 tones), but different from "grief" (9.0 tones) and "indifference" (7.8 tones). Four of the emotions were similar in mean extent of inflections: "contempt" (2.2 tones), "anger" (2.6 tones), "fear" (2.3 tones), and "indifference" (2.0 tones). Mean extent of shifts were reported as 2.3 tones for "contempt" and "anger", 2.7 for "fear", 2.0 for "grief", and 1.6 for "indifference". Mean rate of pitch change was 25.6 tones/sec. for "anger" and 19.0 tones/sec for "fear". It was lower for "contempt" (16.8 tones/sec.), "indifference" (16.6 tones/sec.), and "grief" (15.6 tones/sec).

In a study by Johnson, Emde, Scherer, and Klinnert (1986), natural voice was compared with synthesized voice in the identification of emotions. Using a forced-choice method with only the four emotions, the judges identified the natural voices with 100% agreement for "joy", "sadness", and "anger", and 99% with "fear". The agreements were decreased with the synthesized voice: 93% with "sadness", 66% with "joy", and 32% with "anger" and "fear".

Cotterell (1981) investigated the perception of emotions by hearing impaired and normal hearing children ages 6-12 years. She devised a Test of Emotion Discrimination which required the children to select a photo of a facial expression that corresponded with the adult's

of a facial expression that corresponded with the adult's vocalized expression of anger, sorrow, joy, or fear. The normal hearing children scored significantly higher on the test than the hearing impaired children. Anger was the easiest identified emotion, while fear was the most difficult for both groups of children. Both groups scored similarly on sorrow, but the normal hearing group scored significantly higher on joy than the hearing impaired group. Cotterell (1981, p. 36) concluded that "...the level of oral communication skills may be the most important factor in the ability to discriminate among these four emotions for the hearing impaired children."

Infant Studies: There has been minimal research on the vocal expression of infant emotions. Several studies, such as Fuller and Horii (1986) and Stark, Rose, and Benson (1978), investigated the infant's vocalization during either particular physiological states (e.g., pain or hunger), behavioral situations (e.g., speech play), or type of sound (e.g., cry or vegetative).

Fuller and Horii (1986) studied some acoustic parameters of 2- to 6-month-old infants in four situations ("pain", "hunger", "fussy", and "cooing"). The acoustic analyses revealed a significant difference in fundamental frequency among "cooing" (355 Hz), "hunger" (490 Hz), and either "fussy" (443 Hz) or "pain" (450 Hz). There was no significant difference between "fussy" or "pain".

Bretherton, Fritz, Zahn-Waxler, and Ridgeway (1986) discussed the ability of preverbal infants through adolescents to express their emotions. The authors suggested that even though infants did not have a word to communicate their emotions, they could express their emotions by other means. For example, they avoid eye contact to express fear of strangers or smile indicating joy at playing "peek-a-boo." Bretherton et al. stated that by nine months of age the infant is emotionally expressive in vocalizations, as well as in body language.

Stark et al. (1978) conducted a longitudinal study of infants' vocalizations in which tape recordings were obtained at nine different age levels between two and forty weeks of age. Six classifications of infant vocalizations (cry sound, discomfort sound, vegetative sound, laugh sound, comfort sound, and vocal play sound) were observed. The judges listened to the tapes of the infants accompanied by a narrative of the ongoing activities which could not be heard on the tape. Then they classified the vocalizations into the six categories. The agreement among the judges was better than 70%. The researchers reported the frequency of occurrence of each of the six classifications according to age level and noted some developmental changes, such as vegetative sounds declining after twelve weeks of age. The authors stated that the auditory features of the vocalizations were important for identifying the type of

sound, such as "cooing", but that contextual information was necessary in order to classify the vocalization into one of the six categories.

They concluded that vocal behaviors could not be easily categorized for young infants unless the situational information was considered. It appeared that if the vocalizations had been classified into emotional categories (e.g., anger or separation), rather than situational categories, the intent of the vocalization, as expressed through intonational patterns, would have yielded more consistent information for the classification of the infant's vocalizations.

Summary

Research in the infants' vocal expression of emotion is needed, as emotions appear to be intertwined in the infant's development. Emotional expression is the means by which the infant manipulates his environment to obtain goals and achieve success. Through emotions, levels of cognitive and social development can be observed. Emotions are critical to self-regulation of behaviors and development of self-esteem (Campos et al., 1983).

CHAPTER III

METHODS

This study was designed to investigate listeners' identification and acoustical analysis of infants' vocalized emotions. A panel of listeners identified the emotions, and then six acoustical parameters were measured and compared.

Subjects

Infants: Six infants, ages 9 through 12 months, from Standard English speaking homes were selected for video taping the Infant's Vocal Recordings according to the following criteria (See Table 3-1):

1. An APGAR score of 7 or higher at 5 minutes.
2. Hearing acuity within normal limits as determined by the HEAR Kit.
3. Age-appropriate development as measured by the Denver Developmental Screening Test.
4. The birth mother was major caretaker of her infant, working no more than half-time outside the home.
5. The birth mother was willing to elicit the designated emotions.

The vocalized emotions of these six infants were utilized for the Infant's Vocal Recordings. Two additional infants

Table 3-1. Demographic information for the video taped infants

Infant #	Infant Age (mos.)	Apgar Score 1 min.	Apgar Score 5 min.	Hearing Screening	Developmental Screening
Infant's Vocal Recordings					
1	9	7	9	Passed	Passed
2	12	9	9	Passed	Passed
3	12	8	9	Passed	Passed
4	11	6	8	Passed	Passed
5	12	8	10	Passed	Passed
6	11.5	9	9	Passed	Passed
Training Recordings					
A	12.5	3	9	Passed	Passed
B	12	8	9	Passed	Passed

(A and B in Table 3-1) who satisfied the same criteria were used for the Training Recordings.

Daycare Workers: After recording each infant, the investigator and the infant's mother reviewed the vocalized emotions to determine if they were elicited and recorded properly. Then, five female daycare workers with more than two years experience with nine- to thirteen-month-old infants verified the taped infants' emotions. The video samples were presented both visually and auditorily. If four of the five (80%) daycare workers agreed with the targeted emotion, the sample was accepted for the study. Initially, 90% of the samples were verified. The remaining 10% were retaped and verified later by the daycare workers. For the final Stimulus Tape, all 30 samples satisfied the above criteria for verification.

Listeners: Twenty mothers, who were not parents of the 6 infants in the study, listened and judged these verified samples. Demographic information on the listeners is shown in Table 3-2. Fifteen listeners had infants between seven and thirteen months of age, and five listeners had infants less than seven months of age. Ten listeners had only one infant, four had two infants, four had three infants, and two had six infants. Fourteen of the listeners worked less than half time and six worked more than half time. All twenty listeners passed a normal hearing screening at 15 dB HTL for the frequencies 250, 500, 1000, and 2000 Hz.

Table 3-2. Demographic data for the 20 listeners

Listener # (Mothers)	Infant Age (mos.)	Birth Order of Infant	Mother Works < 1/2 Time
1	10.0	1	No
2	10.0	6	Yes
3	7.0	2	Yes
4	2.0	6	Yes
5	12.0	2	Yes
6	3.0	2	Yes
7	3.0	1	Yes
8	12.0	3	Yes
9	8.5	1	Yes
10	7.5	1	No
11	12.0	1	Yes
12	13.0	1	No
13	10.5	1	Yes
14	6.0	1	Yes
15	7.5	1	No
16	13.0	2	Yes
17	8.0	3	No
18	2.0	3	Yes
19	9.0	3	Yes
20	7.0	1	No

Stimulus Selection

Five emotions, three negative (anger, fear, and separation/grief) and two positive (joy and elation) were selected for this study. The selection was based on listeners' identification of actors' emotions (Fairbanks, 1940) and the emotional development of infants (Bridges, 1932; Sroufe and Waters, 1977); Izard, 1978; and Sroufe, 1979). All five emotions had emerged by 9 months of age, according to the previously listed researchers in emotional development.

Infant's Vocal Recordings

The 6 infants were individually video taped in their homes. Each mother elicited her infant's vocalized emotional response utilizing verbal and nonverbal cues, such as gestures, facial expressions, and objects/toys. She attempted to cease verbalization during the infant's vocal response. The video recordings were obtained one-half hour before or after the infant's usual eating or sleeping times to reduce any emotional reactions to physiological needs.

Specific situations were dramatized by the parent for the elicitation of the five targeted emotions. In order to elicit "separation," the mother walked out of the room or the house, leaving her infant alone with the investigator, who ignored the infant. Fear was elicited either with the presence of a Halloween mask, a dog, or a vacuum cleaner. A

desired object, food, or toy was withheld to elicit "anger." "Joy" was evoked by playing with a toy, while "elation" was elicited by tickling or chasing the infant.

Video recordings were made utilizing a video camera (Panasonic VHS Camcorder, model AG-170) and 1/2-inch video tapes (Scotch VHS EG T-120). A miniature electret condenser microphone (Philmore, model CM50A) was placed within six inches of the infant's mouth to insure a favorable signal-to-noise ratio.

Thirty verified samples (five emotions by six infants) were randomly dubbed onto the Stimulus Video Tape utilizing a video cassette recorder (Emerson, model VCR953). A three-second silent period was placed between each of the 30 samples to allow time for the listener's judgment.

For evaluating reliability, three of the thirty samples were randomly selected and dubbed after the thirty samples. This made a total of 33 samples that were judged by the listeners.

Auditory Presentation To Listeners

All 20 listeners completed a 75 minute session, either individually or in groups of two. The session was divided into: (1) 40 minutes for training, (2) 25 minutes for judging the 33 samples, and (3) 10 minutes for individual hearing screening.

Training: For the 40-minute training session, each mother read typed descriptions and instructions (See Appendix A) for judging the targeted emotions. The descriptions explained the situation utilized to elicit each of the five emotions and the auditory cues for each emotion. These listening cues were determined by the investigator after reviewing the literature and listening to the tapes. Then, the listeners judged only the audio portion of the Training Recordings of five targeted emotions for two training infants (A and B; See Table 3-1). The investigator identified and discussed the targeted emotions, so that the listeners had a guideline for identifying the infant's vocalized emotion. Each listener reviewed the practice tape until she was satisfied; this usually took 2-5 repetitions.

Only the audio portion of the video tape was played from a video cassette recorder (Panasonic, model PV-1330) through two loudspeakers (Advent Legacy, model A-1010) placed 6 feet apart on a table (See Figure 3-1). The experimenter set the most comfortable loudness level (MCL), while seated at the table. This level was 70 dB SPL; whereas, the ambient room noise level was less than 50 dB SPL. This created a +20 dB signal-to-noise ratio (Quest Electronics sound level meter, model 208L) for all the presentations. The listener(s) was/were seated within three feet of the two loudspeakers. This was the distance for

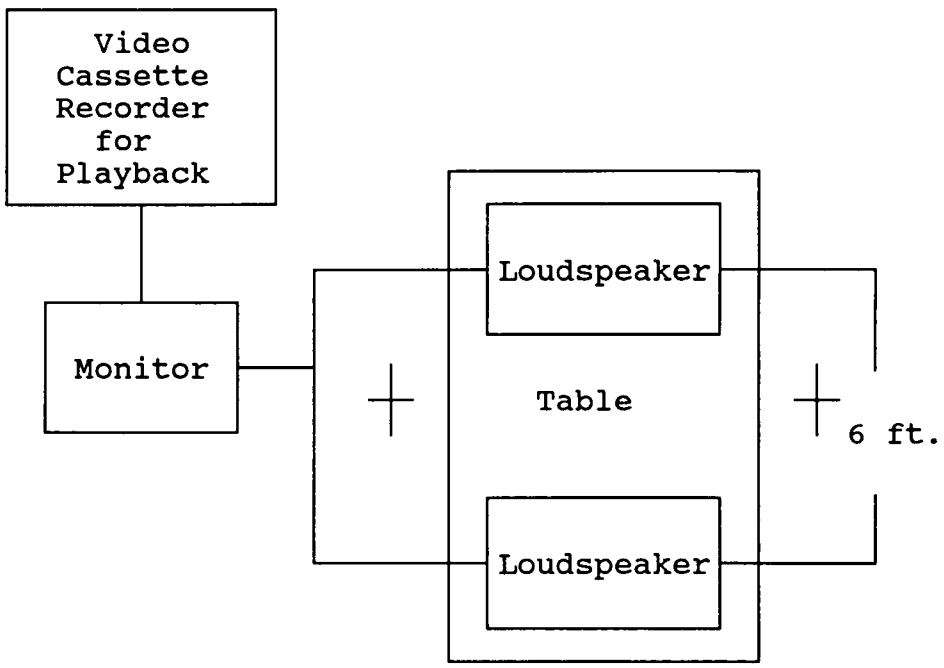

Figure 3-1. Block diagram of equipment during the presentation of the training and infants' vocal recordings (+ = position of listeners)

setting the 70 dB SPL. The experimenter monitored the sample using a video monitor (Mitsubishi, Model CM-1901).

Fifteen samples from the two practice infants were randomly presented for the training. Following the first practice, the mothers were encouraged to ask questions concerning the five emotions before completing a second practice of the same fifteen items.

Infant's Vocal Recordings: After successful completion of the training session, the investigator read the following instruction to the listeners:

> "You will be listening to thirty-three vocalization patterns of infants. On the answer sheet in front of you there are five (5) emotions listed. After each vocalization, you need to decide which of the five emotions you heard and circle it on your answer sheet. You will be given 3 seconds to choose your response; however, you may have longer to decide. You may also listen to the sample as many times as you wish before making a choice."

The Infant's Vocal Recording containing thirty-three samples was presented. The listeners referred to the typed description of the emotional situations and the auditory cues as needed.

Acoustic Analysis

The 13 samples, which met the 70% criterion, were viewed on a monitor (Zenith, model ZCM-1490), analyzed on a spectrograph (Kay Elemetrics, Model 5500), and printed out on a gray scale printer (Kay Elemetrics, model 5510). From the acoustic measures used in Fairbanks' study (1940), six

measures were selected for this study. Four were measures of fundamental frequency and two were measures of amplitude measures. These were obtained from narrow-band and amplitude displays of the spectrograph. They were:

Fundamental Frequency

1) mean fundamental frequency (Fo),

2) mean Fo range,

3) mean Fo range inflection

4) mean Fo rate,

Amplitude

1) mean relative amplitude (dB) range, and

2) mean dB rate in one direction.

Mean Fundamental Frequency: For each sample, the mean fundamental frequency (Fo) was determined by expanding the narrow-band display so that each division along the time axis was 25 msec. Using the third or fourth harmonic of the sample and the frequency cursors, the frequency was measured every 25 msec for each sample and divided by three (for the third harmonic) or four (for the fourth harmonic) to obtain the Fo (See Figure 3-2). The Fo values obtained within a sample were averaged to determine the mean Fo. The mean Fo for each sample was computed separately and the data tabled.

Mean Fundamental Frequency Range: The mean fundamental frequency range was determined by using the cursors on the narrow-band display of the sample to locate the lowest and

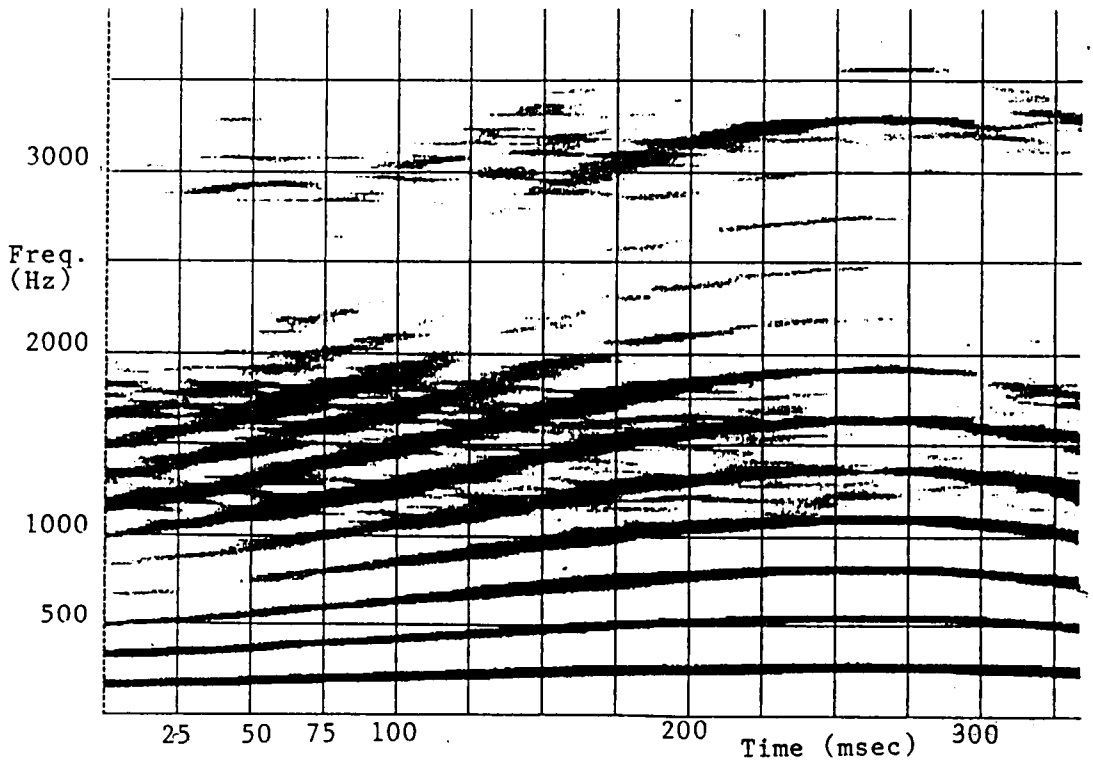

Figure 3-2. Expanded narrow-band spectrographic display utilized for obtaining acoustic data

the highest frequency along the third or fourth harmonic, which was divided by either three or four to obtain the Fo. The mathematical difference between the highest and the lowest Fo for each sample was computed to give the Fo range for that sample. The ranges were averaged to determine the mean fundamental frequency range for each emotion.

Mean Fundamental Frequency Inflection: The mean fundamental frequency inflection was the average of the highest Fo minus the lowest Fo during a change in direction of frequency, either upward or downward. These means were determined from a narrow-band display by setting the cursors at the beginning and end of each inflection within a sample (See Figure 3-3). The frequency changes for each sample of an emotion were averaged to yield a mean fundamental frequency change for that emotion.

Mean Fundamental Frequency Rate: The mean rate (Hz/msec) of fundamental frequency was the rate at which the fundamental frequency (Hz) changed over time (msec). The mean rate was computed by dividing the fundamental frequency inflection (Hz) by time (msec) for each segment of the sample. The mean was computed for each emotion.

Mean Relative Amplitude Range: The mean relative amplitude range was determined by measures from the amplitude display during voiced portions of the utterance. The lowest amplitude (in dB) was subtracted from the highest amplitude (in dB) within one emotion. The relative

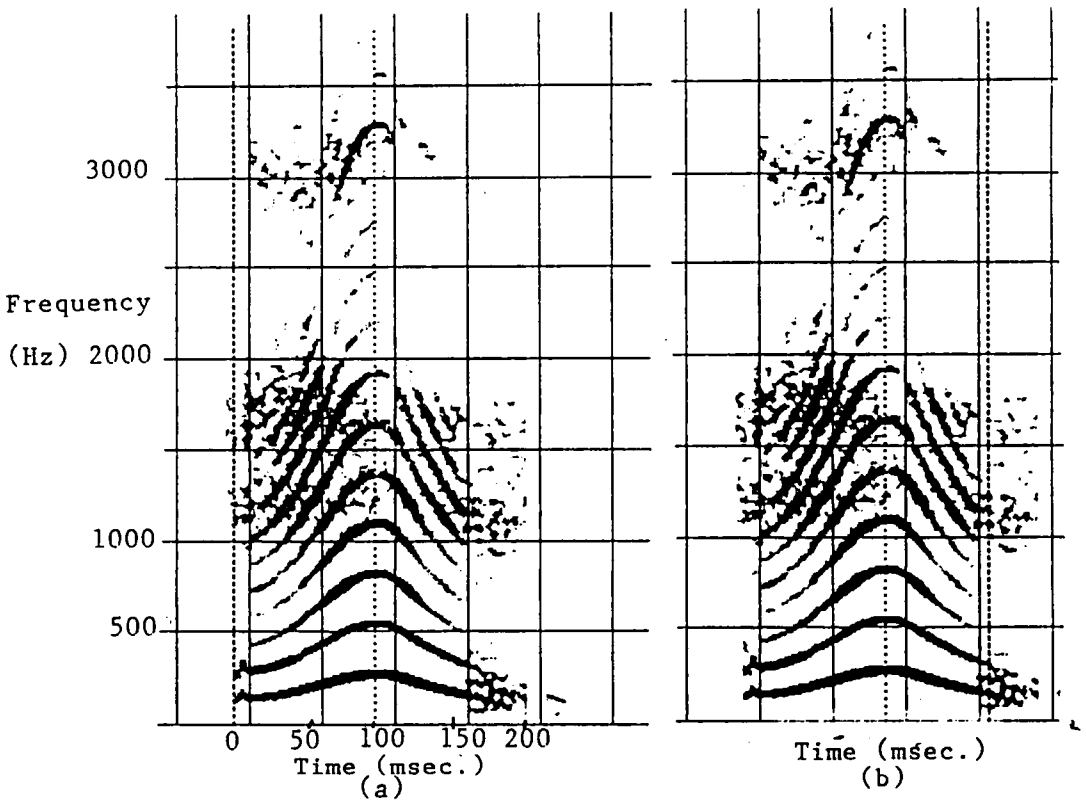

Figure 3-3. Expanded narrow-band spectrographic display with cursors showing (a) upward direction in fundamental frequency and (b) downward direction in fundamental frequency

amplitudes for each sample were determined and then averaged for each emotion to obtain the mean relative amplitude range.

Mean Relative Amplitude Rate: The mean rate of relative amplitude was the highest amplitude (in dB) minus the lowest amplitude (in dB) in one direction divided by the time in that direction (msec) (Figure 3-4). This was determined for each direction and then averaged for each sample. All the samples for one emotion were averaged to determine the mean rate of relative amplitude for a particular emotion.

Descriptive Analysis

The following fundamental frequency (Fo) measures obtained in the current study were compared with those in Fairbanks (1940):

(a) mean Fo range

(b) mean Fo inflection

(c) mean Fo rate

In order to compare both of these experiments, the fundamental frequency (Hz) measures were converted to tones. The conversion formula was N tones = 19.92 X log10 (f1/f0), where f1 is the higher frequency and f0 is the lower frequency. The median Fo was not converted to tones, but was compared in Hertz.

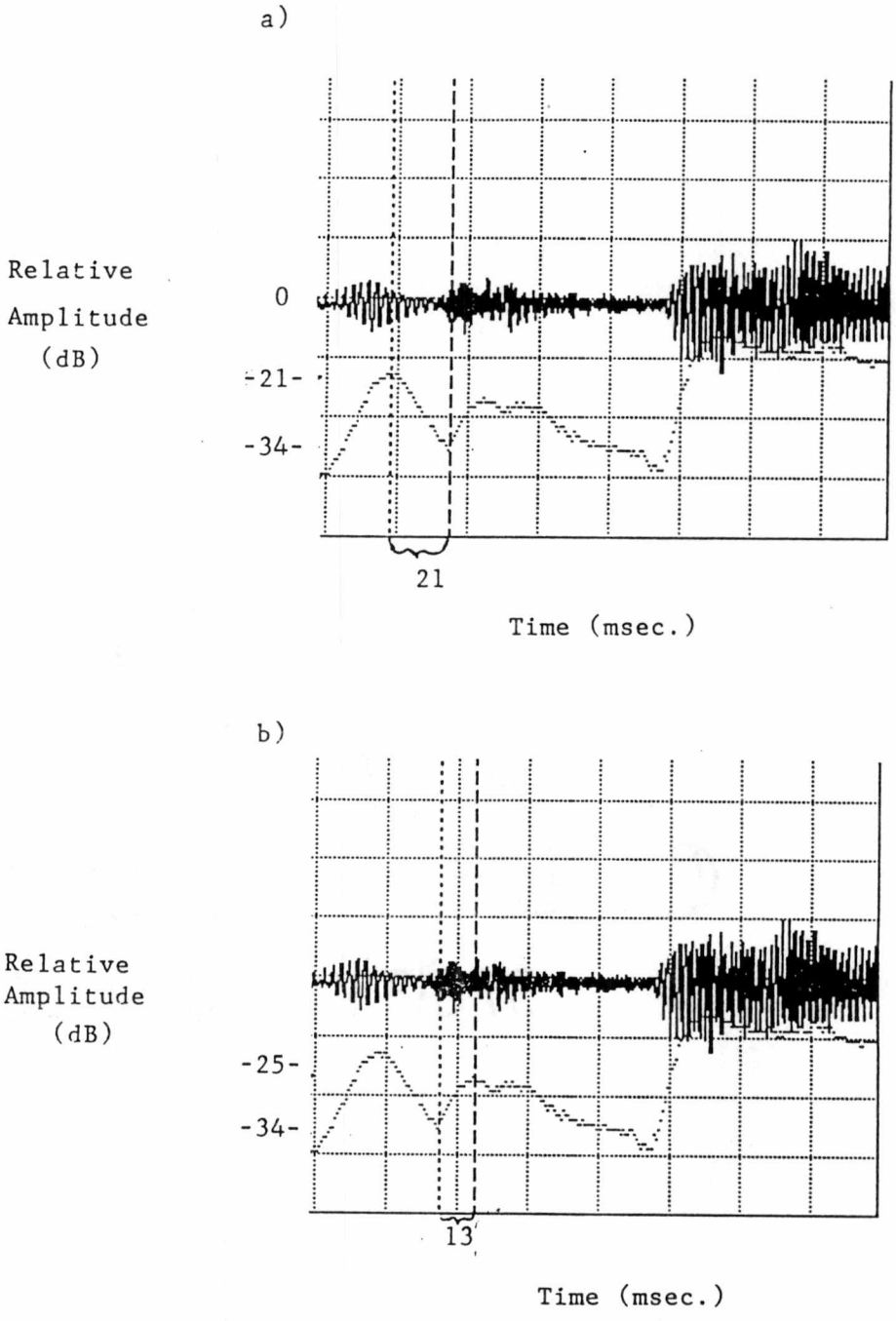

Figure 3-4. Relative amplitude display and waveform (A = waveform, B = relative amplitude) with cursors placed at points of change in amplitude for computing relative amplitude rate (dB/msec)

CHAPTER IV

RESULTS

Reliability

Intrajudge reliability (agreement) was evaluated by having the 20 listeners judge three infant emotions (anger, fear, and joy) a second time. When the judgments for both the first and second presentations agreed, the number of agreements was added and then divided by three for each listener. For example, 2 of 3 agreements was 67% (See Table 4-1). For these 3 emotions, the percentages of agreement were four listeners at 100%, eight at 67%, five at 33%, and three at 0%. The mean judgment was 55% (median = 67%).

For the negative/positive agreements (See Table 4-1), a response (judgment) was considered an agreement when a negative targeted sample was judged as a negative emotion, e.g., the emotion fear could be judged as fear, anger, or separation and it was an agreement. When it was judged as a positive emotion, it was not considered an agreement. The 20 listeners had a mean reliability of 98% (median = 100%) for negative/positive judgments. Nineteen of the 20 listeners had 100% agreement and one had 67% agreement.

Test-retest reliability was conducted by having one listener return three weeks later and complete the entire listening task (Training and Infants' Vocal Recordings).

Table 4-1. Intrajudge reliability of 20 listeners on negative (anger, fear, and separation)/positive (joy and elation) emotions and on 3 extra emotions (anger, fear, and joy). (Key: 3/3 = 100%, 2/3 = 67%, 1/3 = 33%, 0/3 = 0%)

	Intrajudge Agreement	
Listener #	Negative/Positive Emotions	3 Emotions (Anger, Fear, and Joy)
1	100	33
2	100	100
3	100	33
4	100	67
5	100	33
6	100	33
7	67	33
8	100	0
9	100	67
10	100	0
11	100	0
12	100	67
13	100	67
14	100	67
15	100	100
16	100	67
17	100	100
18	100	67
19	100	100
20	100	67
Mean	98	55
Median	100	67

Through random selection and listener consent, listener 7 participated in the test-retest reliability. On an item-by-item analysis, listener 7 selected the same response on the second session as she did the first session for 20 out of 30 samples, yielding a test-retest reliability of 67%.

When the same data were analyzed item-by-item on a negative/positive criterion, as explained earlier, listener 7 had a 90% (27 out of 30) test-retest agreement on the 30 targeted samples.

Interjudge reliability was determined by a modification (Sylwester, 1991) of the Kappa statistic (Siegel & Castellan, 1956). For each of the 5 targeted emotions, three values were computed: 1) the probability of agreement with another listener on the targeted emotion, 2) the probability of agreement with another listener having the same response which was not the targeted emotion, and 3) the probability of disagreement with another listener on a response. For example, in Table 4-2 the probability of agreement with another listener on the targeted emotion anger was 29%. In other words, there was 29% probability that two listeners chose anger for anger. However, some listeners perceived anger as separation or fear. The probability that two listeners chose separation for anger or fear for anger was 21% (4.5% + 16.5%, respectively), yielding the second value (the probability of agreement with another listener having the same response which was not the

Table 4-2. Probability of interjudge agreement and disagreement among 20 listeners on the perceived emotion

Targeted Emotion	Probability of Agreement (%)					Probability of Disagreement (%)
	Negative			Positive		
	Anger	Fear	Separation	Joy	Elation	
Anger	**29**	4.5	16.5	0	0	50
Fear	9.5	**30.7**	3.0	0.2	0.8	55.8
Separation	9.7	5.3	**36.2**	0	0	48.8
Negative	16	13.5	18.6	0.1	0.3	51.5
Joy	0	0	0	**46.2**	8.5	45.3
Elation	0.8	3.3	0.2	0.5	**68.7**	26.5
Positive	0.4	1.6	0.1	23.4	38.6	35.9

targeted emotion). The third value determined for anger was the probability of disagreement with another listener on a response, which was 50% probability that no two listeners would select the same emotion.

The following formulas (Sylwester, 1991) were utilized for the computations of the three interjudge reliability values for each emotion of each infant (See Figure 4-1 for a sample computation):

(1) probability of agreement with targeted emotion, where n = # listeners who agree on targeted emotion and N = total # listeners

$$(PAT) = \frac{n \times (n-1)}{N \times (N-1)}$$

(2) probability of agreement with another listener on emotion other than target, where e = # listeners who agree on emotion other than targeted emotion

$$(PAL) = \frac{e \times (e-1)}{N \times (N-1)}$$

(3) probability of disagreement = 1 - (PAT + PAL)

Table 4-2 contains the probability of interjudge agreement and interjudge disagreement among the 20 listeners on each targeted emotion. The probability for each emotion was averaged for the 6 infants. The highest probability of interjudge agreement on the targeted emotion occurred with elation (68.7%) and the lowest with anger (29%). However, the highest probability of disagreement was observed with fear (55.8%), which reflected confusion of fear with positive (1%), as well as negative (12.5%), emotions. There was 1% probability that a positive emotion was selected for

total listeners = 20 = N

listeners who agree that anger is anger = 12 = n

listeners who agree that anger is fear = 4 = e

listeners who agree that anger is separation = 4 = e

Probability for first value (that anger is anger):

$$PAT = \frac{n \times (n - 1)}{N \times (N - 1)} = \frac{12 \times 11}{20 \times 19} = \frac{132}{380} = .35 = 35\%$$

Probability for second value (that anger is fear):

$$PALa = \frac{e \times (e - 1)}{N \times (N - 1)} = \frac{4 \times 3}{20 \times 19} = \frac{12}{380} = .03 = 3\%$$

Probability for second value (that anger is separation):

$$PALb = \frac{e \times (e - 1)}{N \times (N - 1)} = \frac{4 \times 3}{20 \times 19} = \frac{12}{380} = .03 = 3\%$$

Probability for third value (no two listeners agree on same emotion):

$$= 1 - (PAT + PALa + PALb) = 1 - (35 + 3 + 3) = 1 - 41 = 59$$

Figure 4-1. Sample computation of interjudge reliability for targeted emotion anger of Infant 2

fear, and 4.3% probability that a negative emotion was chosen for elation.

In interjudge reliability the overall probability that a negative emotion was perceived for a positive emotion or a positive emotion for a negative emotion was very small (0.4% or 2.1%, respectively).

In summary, results from intrajudge reliability indicated high (98%) negative/positive agreement, and lower agreement for the 5 emotions ($\bar{X}$ = 55%; Mdn = 67%). This lower agreement suggested more difficulty in identifying specific emotions than in selecting positive or negative emotions. The test-retest reliability was higher (90%) for the negative/positive agreement and lower (67%) for the item-by-item comparison. Interjudge reliability indicated higher agreement with positive emotions (64.1%) than negative emotions (48.5%). In general, the reliability was considered adequate for this study, with the strongest agreements when 1) listener 7 had high test-retest reliability (90%) for negative/positive emotions and 2) all listeners had 98% intrajudge reliability negative/positive emotions.

Perceptual Analysis

For the presentation of the Infants' Vocalized Recordings, the panel of 20 listeners judged the infants' vocalized emotions (See Table 4-3) by choosing one of five

Table 4-3. Specific conditions utilized with each infant to elicit each vocalized emotion

Infant #	Targeted Emotions				
	Anger	Fear	Separation	Joy	Elation
1	Took away cookie	Halloween mask plus noises	Mom left room	Playing with toy	Tickling
2	Removed infant from toy	Stranger picked up infant	Mom left room	Playing with toy	Playing peek-a-boo
3	Took away toy	Barking dog	Mom left house	Playing with toy	Tickling
4	Took away cookie	Vacuum cleaner	Mom left house	Playing with toy	Tickling
5	Withheld toy	Halloween mask	Mom left room	Playing ball	Tickling
6	Took away toy	Mom popped balloon	Mom left room	Given new toy	Tickling

emotions. There was a 20% level of chance (1 out of 5 choices) for each judgment being the same as the targeted emotion. Thus, the scores above 30% indicated that the judges identified the targeted emotions, and scores below 30% suggested the judgments were misdirected.

Hypothesis A.1:

Statistical and Descriptive Analysis. A Kruskal-Wallis Test (Chi-Square Approximation; Hays, 1981) was used to test Hypothesis A.1, which stated that there was no significant difference in the identification by listening among the five targeted emotions. Results from the statistical analysis, presented in Table 4-4, revealed a chi-square value of 32.45 ($p < 0.0001$). This indicated a significant difference among the judgments of the five emotions, and that the perceived emotions were selected above the level of chance.

The percent was computed for each listener based on when the judgment (response) was the same as the targeted emotion. This was computed on each sample for all 6 infants (See Table 4-5). Eighty percent of the infants' vocal emotions (24 out of 30) were perceived above the 20% chance level (33%-100%). For the emotion anger, e.g. listener 1 had 50% (3 out of 6 infants) which meant that three of the judgments were the same as the target and three were not (See the raw data in Appendix C). For all 20 listeners (See

Table 4-4. Kruskal-Wallis test (Chi-Square approximation) for agreement with targeted emotions by 20 listeners

Emotion	Sum of Scores	df	Mean Score	CHISQ	p <
Anger	31500.0		262.5		
Fear	33300.0		277.5		
Separation	34200.0		285.0		
Joy	38400.0		320.0		
Elation	42900.0		357.5		
		4		32.45	0.0001

Table 4-5. Targeted samples of emotion with which each listener's response was the same (in percent) (Key: 17% = 1/6, 33% = 2/6, 50% = 3/6, 67% = 4/6, 83% = 5/6, 100% = 6/6 infants; and * = below 20% level of chance)

	Emotions					
Listener	Negative			Positive		
	Anger (%)	Fear (%)	Separation (%)	Joy (%)	Elation (%)	Agreement (%)
1	50	17*	50	83	83	57 (17/30)
2	67	67	67	100	83	77 (23/30)
3	67	67	83	67	83	73 (22/30)
4	33	50	83	33	83	57 (17/30)
5	50	100	33	83	83	70 (21/30
6	50	50	50	67	67	57 (17/30)
7	17*	50	17*	100	100	57 (17/30)
8	50	67	50	67	67	60 (18/30)
9	67	17*	17*	33	83	43 (13/30)
10	50	83	50	67	83	67 (20/30)
11	50	33	67	50	67	53 (16/30)
12	33	67	33	50	67	50 (15/30)
13	50	67	50	50	67	57 (17/30)
14	50	50	83	67	50	60 (18/30)
15	33	33	67	50	100	57 (17/30)
16	50	83	50	100	50	67 (20/30)
17	33	33	67	83	83	60 (18/30)
18	50	50	67	83	100	70 (21/30)
19	50	50	67	83	100	70 (21/30)
20	50	17*	50	33	83	47 (14/30)
Mean	48 (57/120)	53 (63/120)	55 (66/120)	68 (81/129)	79 (95/129)	61 (366/600)
Median	50	50	50	67	83	57
Range	7-67	17-100	17-83	33-100	50-100	43-77
Rank (Highest to Lowest)	5	4	3	2	1	
Neg. Mean	52% (196/360)					
Pos. Mean				74% (176/240)		

Figure 4-2), the rank order for the five emotions was 79% (median = 83%) for elation, 68% (median = 67%) for joy, 55% (median = 50%) for separation, 53% (median = 50%) for fear, and for anger 48% (median = 50%). The overall mean was 61%.

The averaged positive judgments were 74% (68% and 79%); whereas the averaged negative judgments were 52% (48%, 53%, and 55%). The positive emotions were ranked one and two, and were 22% higher than the negative emotions (See Table 4-5).

Post-Hoc Analysis.

Emotions: When the judgments for the negative targeted emotions were combined, 97% (N = 348/360) of the judgments were identified as a negative emotion (anger, fear, or separation); whereas, 88% (N = 211/240) of the targeted positive emotions (joy or elation) were identified as positive (See Table 4-6 and 4-7). For the negative targeted emotions, the perceived negative emotions were 100% for separation, 97% for anger, and 93% for fear. The the negative/positive category were selected other than the targeted emotion (See Table 4-7). For separation, responses different from the targeted emotion were anger (26%) and fear (19%). For the targeted emotion fear, anger was selected for 23% of the responses and separation for 17%. For anger, separation was perceived for 32% of the responses and fear for 17%. Of the positive emotions, elation was

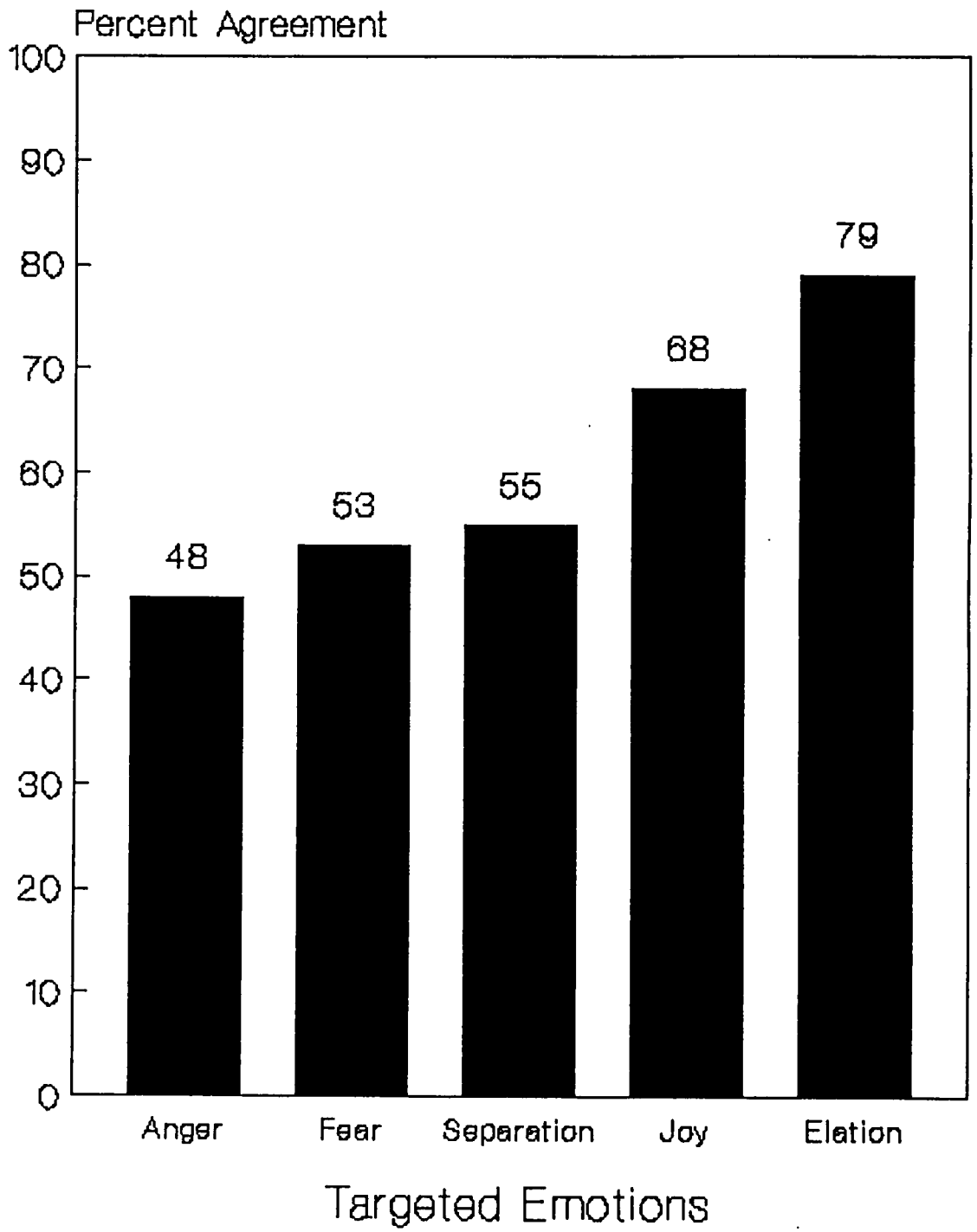

Figure 4-2. Percentage of listeners with the same judgments as the targeted emotions of 6 infants (level of chance = 20%)

Table 4-6. Listener's perception of targeted emotion as negative or positive in percent and raw data (N=120)

Targeted Emotion	Perceived Emotion		
	Negative(A,F,S) n(%)	Positive(J,E) n (%)	Total Possible
Negative:			
Anger	117 (97)	3 (3)	120
Fear	111 (93)	9 (7)	120
Separation	120 (100)	0 (0)	120
Positive:			
Joy	9 (7)	111 (93)	120
Elation	20 (17)	100 (83)	120
Negative Perceived	348 (97)	12 (3)	360
Positive Perceived	29 (12)	211 (88)	240
Total Perceived	377 (63)	223 (37)	600

Table 4-7. Response matrix of raw data and percentages for targeted emotions (N=120)

Targeted Emotion	Perceived Emotion					Total
	Negative			Positive		
	Anger	Fear	Separ.	Joy	Elation	
	n (%)	n (%)	n (%)	n (%)	n (%)	N (%)
Negative						
Anger	57(**48**)	21(17)	39(32)	0(0)	3(3)	120(100)
Fear	27(23)	63(**53**)	21(17)	4(3)	5(4)	120(100)
Separ.	31(26)	23(19)	66(**55**)	0(0)	0(0)	120(100)
Positive						
Joy	0(0)	9(7)	0(0)	81(**68**)	30(25)	120(100)
Elation	7(6)	11(9)	2(2)	5(4)	95(**79**)	120(100)
Negative Subtotal	115(97)	127(89)	126(104)	4(3)	8(7)	360(300)
Positive Subtotal	7(6)	20(16)	2(2)	86(72)	125(104)	240(200)
Total Negative & Positive	122(103)	107(105)	128(106)	90(75)	133(111)	600(500)

perceived as joy for 25% of the responses, and joy was perceived as elation for 17%.

Infants: A response analysis was completed for the 6 infants and the five emotions (6 X 5 = 30) (See Table 4-8). There were 10% of the targeted emotions (3 out of 30) where the perceived emotions were at or below chance (0%, 15%, and 20 %). However, on all three of these negative targets, 100% of the time a negative emotion was perceived. For example, anger for Infant 1 was perceived by 70% of the listeners as separation and by 30% of the listeners as fear. Separation for Infant 2 was 60% as anger 20% as fear, and 20% as separation. Fear for Infant 5 was perceived 65% as anger, 20% as separation, and 15% as fear.

Listeners: In order to further understand the listeners' judgments, the 20 listeners were ranked by overall percent from highest (77%) to lowest (43%). Then, the 20 were subgrouped into a group of 10 highest listeners (60%-77%) and also a subgroup of 16 highest listeners (57%-77%), and the original 20 listeners (43%-77%) (See Table 4-9).

The percent of all listeners whose infant was older than 6 months of age was 75%, which decreased to 69% with the 16-listener subgroup and then increased to 80% with the 10-listener subgroup. Eighty percent of the listeners worked less than half-time in the 10-listener subgroup, 75%

Table 4-8. Percent of listeners whose response was the same as the targeted emotion for each of the 30 samples (Key: 0=0/20, 5=1/20, 10=2/20, 15=3/20, 20=4/20, 25=5/20, 30=6/20, 35=7/20, 40=8/20, 45=9/20, 50=10/20, 55=11/20, 60=12/20, 65=13/20, 70=14/20, 75=15/20, 80=16/20, 85=17/20, 90=18/20, 95=19/20, and 100=20/20) (* at or below chance)

Targeted Emotion for Each Infant	N/P (%)	Perceived Emotion Anger (%)	Fear (%)	Separation (%)	Joy (%)	Elation (%)
Infant # 1	89					
Anger		**0***	30	70	0	0
Fear		0	**70**	25	5	0
Separation		25	45	**30**	0	0
Joy		0	0	0	**55**	45
Elation		5	45	0	15	**35**
Infant # 2	100					
Anger		**60**	20	20	0	0
Fear		35	**45**	20	0	0
Separation		60	20	**20***	0	0
Joy		0	0	0	**70**	30
Elation		0	0	0	0	**100**
Infant # 3	100					
Anger		**75**	0	25	0	0
Fear		0	**75**	25	0	0
Separation		5	10	**85**	0	0
Joy		0	5	0	**90**	5
Elation		5	0	0	10	**85**
Infant # 4	92					
Anger		**25**	10	65	0	0
Fear		20	**65**	15	0	0
Separation		10	0	**90**	0	0
Joy		0	40	0	**60**	0
Elation		0	0	0	0	**100**
Infant # 5	91					
Anger		**75**	5	15	0	5
Fear		65	**15***	20	0	0
Separation		40	10	**50**	0	0
Joy		0	0	0	**75**	25
Elation		25	10	10	0	**55**
Infant # 6	92					
Anger		**50**	40	0	0	10
Fear		15	**45**	0	15	25
Separation		15	30	**55**	0	0
Joy		0	0	0	**55**	45
Elation		0	0	0	0	**100**

Table 4-9. Demographic data and percent agreement with targeted emotion for 20 listeners (mothers)

Rank	Same as Target (%)	Listener #	Infant Age > 6 mos.	Birth # > One	Mother Works < 1/2 Time
1	77	2	+	+	+
2	73	3	+	+	+
3	70	5	+	+	+
4	70	18	-	+	+
5	70	19	+	+	+
6	67	10	+	-	-
7	67	16	+	+	+
8	60	8	+	+	+
9	60	14	-	-	+
10	60	17	+	+	-
Total for 10 Listeners			8/10 (80%)	8/10 (80%)	8/10 (80%)
11	57	1	+	-	-
12	57	4	-	+	+
13	57	6	-	+	+
14	57	7	-	-	+
15	57	13	+	-	+
16	57	15	+	-	-
Total for 16 Listeners			11/16 (69%)	10/16 (63%)	12/16 (75%)
17	53	11	+	-	+
18	50	12	+	-	-
19	47	20	+	-	-
20	43	9	+	-	+
Total for 20 Listeners			15/20 (75%)	10/20 (50%)	14/20 (70%)

in the 16-listener subgroup, and 70% in the 20-listener subgroup.

Fifty percent (10/20) of the mothers (listeners) had more than one infant. Forty percent (8/20) were in the top 10 listeners, and 10% were in the next 6 listeners. The mothers with more children had higher percent scores.

When the data from the 10 best listeners were used, the overall mean percent increased from 61% to 67% (See Table 4-10). If Infant 1 was removed from the analysis, the overall mean increased from 65% to 72%. In other words, with the best listeners and the best infants, the overall mean at 72% was noticeably higher. This showed that the judgments were affected by the type of infant and the type of listener.

Hypothesis A.2:

Statistical and Descriptive Analysis. Hypothesis A.2, which states that there is no significant difference among six infants with respect to the identification of emotions by listening, was analyzed by a Kruskal-Wallis test (Chi-Square approximation; Hays, 1981) (See Table 4-11). The perceived positive emotions for the positive targets were 93% for joy and 83% for elation.

An analysis of the response patterns among the listeners was conducted to determine which emotions within results yielded a chi-square value of 46.44 ($p < 0.0001$) indicating that there is a significant difference among the six infants. The mean percent of responses which were the

Table 4-10. Listeners' percent of responses that were the same as the targeted emotions

Targeted Emotion	# of Mothers		
	20	16	10
Anger	48	46	50
Fear	53	57	65
Separation	55	58	62
Joy	68	74	80
Elation	79	80	78
Mean	61	63	67

Table 4-11. Kruskal-Wallis test (Chi-Square approximation) for agreement with 6 infants' expression of emotions by 20 listeners

Infant #	Sum of Scores	df	Mean Score	CHISQ	p <
1	23100.0		231.0		
2	29700.0		297.0		
3	36600.0		366.0		
4	32400.0		324.0		
5	28200.0		282.0		
6	30300.0		303.0		
		5		46.44	0.0001

same as the targeted emotion for Infant 1 was 38%, for Infant 2 it was 59%, for Infant 3 it was 82%, for Infant 4 it was 68%, for Infant 5 it was 54%, and for Infant 6 it was 61% (See Table 4-10). Overall percent of responses which were the same as the targeted emotion was 61%.

Infant 3 received judgments from the listeners well above chance level (range of 75%-90%) on all emotions. Infant 1 received judgments from the listeners near or below the level of chance for elation (35%), separation (30%), and anger (0%).

Post-hoc Analysis. Since identification of Infant 1's targeted emotions was near chance level on three of the targeted emotions, percent of responses which were the same as the target ($\bar{X}$=38%) was refigured to eliminate Infant 1 and use only Infants 2-6. In Table 4-12 results of each emotion were listed for Infants 1-6 and Infants 2-6. With Infant 1 eliminated, percent of the judgments increased for anger by 9% (48% to 57%), elation by 8% (79% to 87%), separation by 5% (55% to 60%), and joy by 2% (68% to 70%); whereas it decreased by 4% (53% to 49%) for fear. Overall percent increased 4% (61% to 65%).

Differences among the six infants were observed with the subgroup of 10 best listeners (60%-77%). Percent of judgments (responses) which was the same as the targeted emotion increased by 8% for Infants 4 (68% to 76%) and 5

Table 4-12. For 20 listeners, percent of same responses with the targeted emotions of each infant

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All (Mean) (Median)	# 2-6 (Mean) (Median)
Anger	0	60	75	25	75	50	48 55	57 60
Fear	70	45	75	65	15	45	53 55	49 45
Separation	30	20	85	90	50	55	55 52.5	60 55
Joy	55	70	90	60	75	55	68 65	70 70
Elation	35	100	85	100	55	100	79 92.5	87 100
Mean	38	59	82	68	54	61	61	65
Median	35	60	85	65	55	55		
Range	0 to 70	20 to 100	75 to 90	25 to 100	15 to 75	5 to 100		

(54% to 62%). An 11% increase occurred for Infant 6 (61% to 72%).

When comparing the 10 best listeners' responses between 6 infants and 5 infants, a 10% increase occurred for anger (from 50% for 6 infants to 60% for 5 infants) and for elation (from 78% for 6 infants to 88% for 5 infants). Infant 3 continued to receive a high percent of identification of all emotions by the listeners.

Acoustical Analysis

A total of 43% (13 out of 30) of the samples satisfied the 70% criterion for acoustical analysis. These were two samples of anger, two of fear, two of separation, three of joy, and four of elation. The acoustical data for each sample are presented in tables and figures found in Appendix D.

Mean Fundamental Frequency: Mean fundamental frequency was similar for four emotions (range of 413 to 449 Hz), but was noticeably higher for anger ($\bar{X}$ = 523 Hz) (See Figure 4-3). The mean fundamental frequency of the negative emotions (anger, fear, and separation) was 467 Hz (range of 429-523 Hz) which was higher than 423 Hz for the positive emotions (elation and joy).

All five targeted emotions of Infant 3 were analyzed acoustically because they satisfied the 70% listener criterion (See Tables 4-13 and 4-14) (See Figure 4-4).

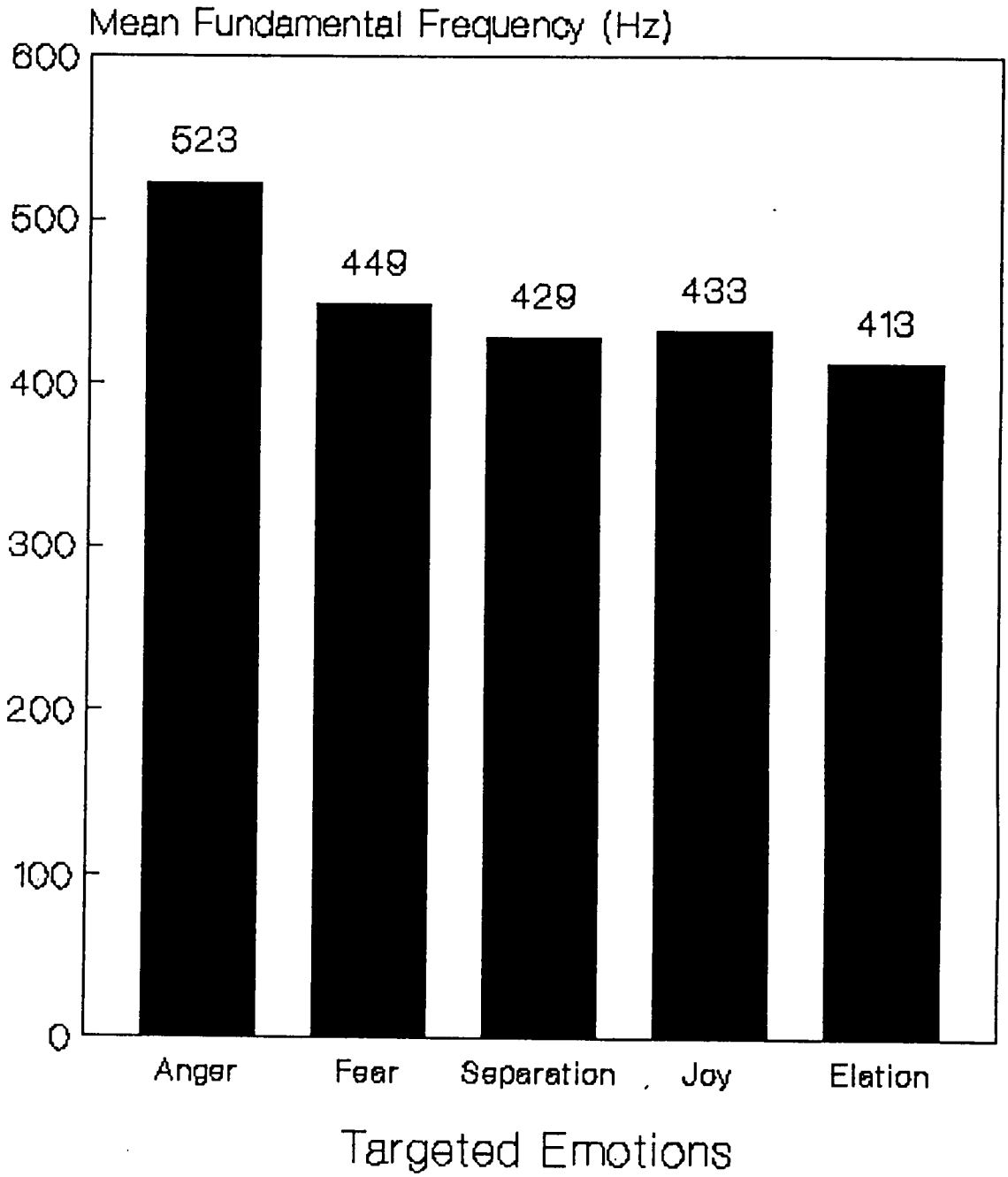

Figure 4-3. Mean fundamental frequency (Fo) for five targeted emotions of infants meeting the 70% criterion

Table 4-13. Fundamental frequency (Fo) data in Hz for Infant 3

Targeted Emotion	$\bar{X}$ Fo (Hz)	Fo Range (Hz)	$\bar{X}$ Fo Inflection (Hz)	$\bar{X}$ Fo Rate (Hz/sec)
Negative				
Anger	514	287	46	452
Fear	479	185	27	126
Separation	460	383	52	407
Positive				
Joy	387	145	51	1030
Elation	449	770	77	1336
Negative Mean	484	285	42	328
Median	460	274	46	407
Positive Mean	418	458	64	1183

Table 4-14. Relative amplitude data in dB for Infant 3

Targeted Emotion	$\bar{X}$ Amplitude (dB)	Amplitude Range (dB)	Amplitude Rate (dB/sec)
Negative			
Anger	21	32	144
Fear	15	36	84
Separation	18	38	176
Positive			
Joy	23	36	498
Elation	15	36	84
Negative Mean	19	35	135
Median	18	36	144
Positive Mean	19	36	291

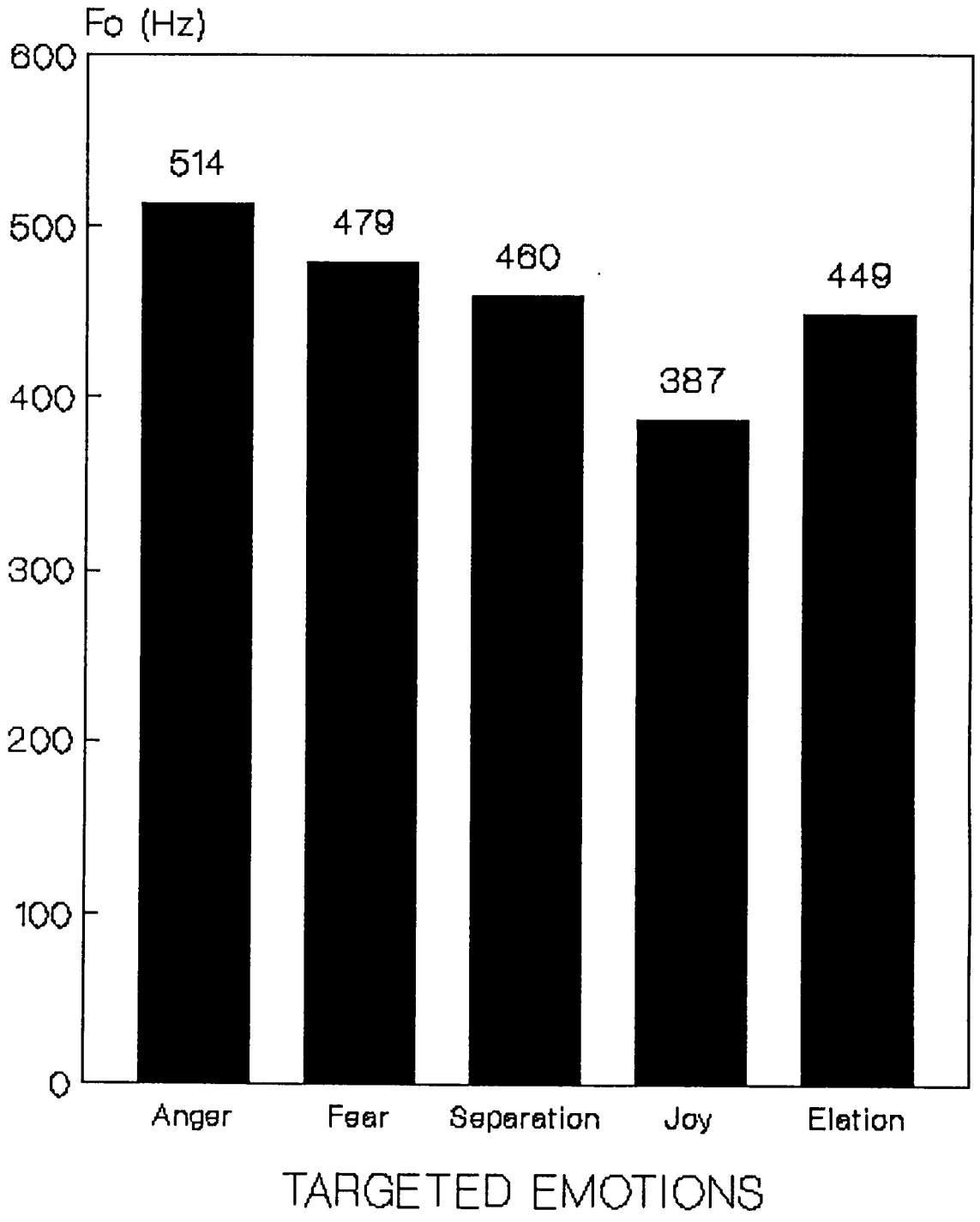

Figure 4-4. Mean fundamental frequency (Fo) of five targeted emotions for Infant 3

For Infant 3, the negative emotions ($\bar{X}$ = 484 Hz) were higher than the positive emotions (418 Hz). It was highest for anger (514 Hz) and lowest for joy (387 Hz).

Mean Fundamental Frequency Range: Fundamental frequency (Fo) range varied among the emotions for Infant 3 (See Figure 4-5). Elation had the highest mean Fo range (770 Hz), then separation with 383 Hz, followed by anger with 287 Hz, then joy with 185 Hz, and finally fear with 145 Hz. For elation, fundamental frequency range of Infant 3 (770 Hz) was much higher than the mean Fo range of all infants (568 Hz). In all the other emotions, the fundamental frequency range for Infant 3 was lower than the mean (Compare Figure 4-5 with Figure D-1).

Mean Fundamental Frequency Inflection: Mean fundamental frequency (Fo) inflection revealed some differences among the five emotions for all the included samples (See Figure D-2) and for Fo inflection of Infant 3 (See Figure 4-6). The mean Fo inflection for 5 emotions of the infants was 61 Hz with a standard deviation of 68 Hz. Upward pitch inflection was computed separately from downward pitch inflection. Mean upward pitch inflection for all emotions was 59 Hz with a standard deviation of 70 Hz. Mean downward pitch inflection for all emotions was 63 Hz with a standard deviation of 65 Hz. When means were determined for each emotion of Infant 3 (See Table 4-13), the mean fundamental frequency inflection for the positive

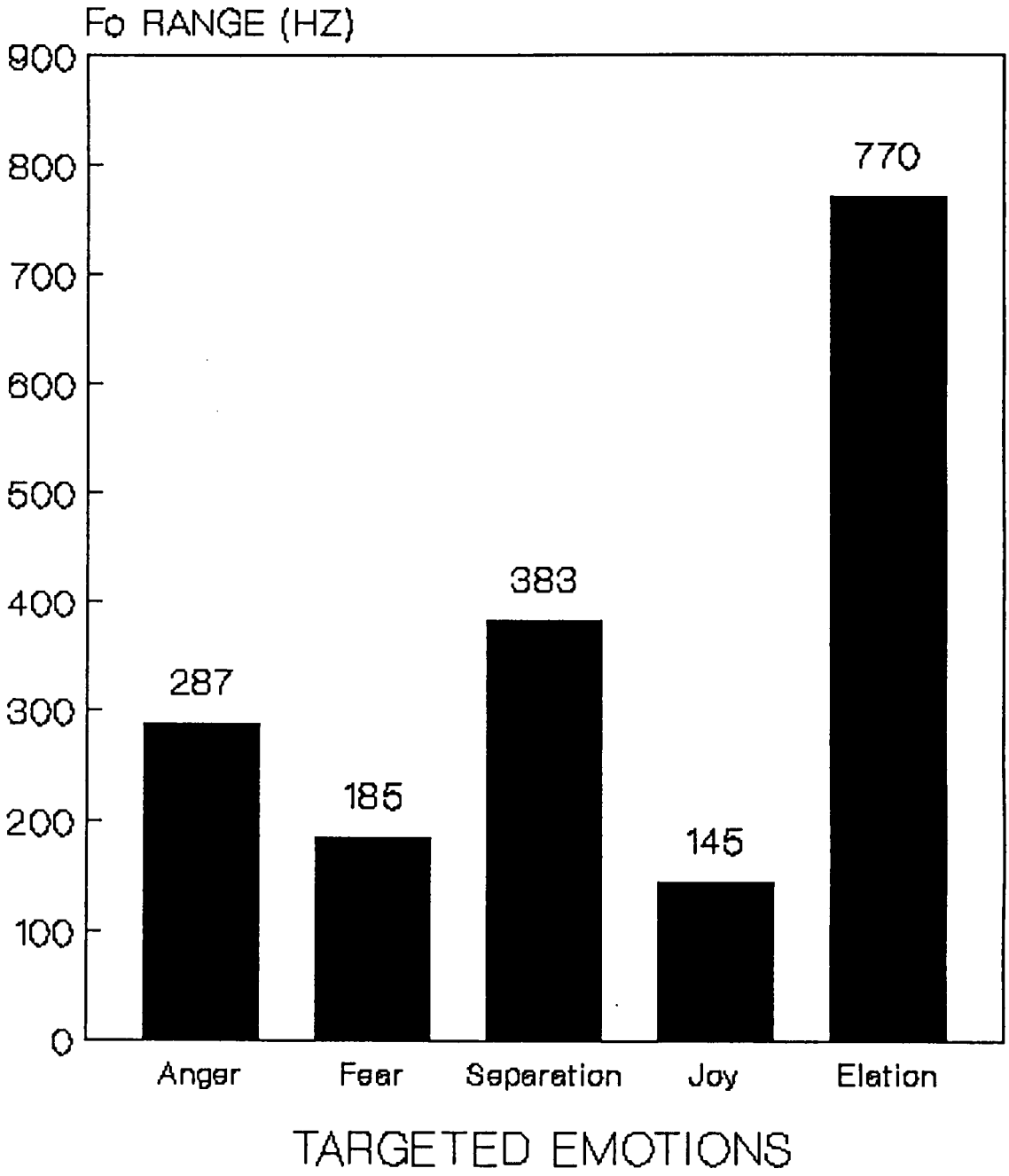

Figure 4-5. Fundamental frequency (Fo) range of five targeted emotions for Infant 3

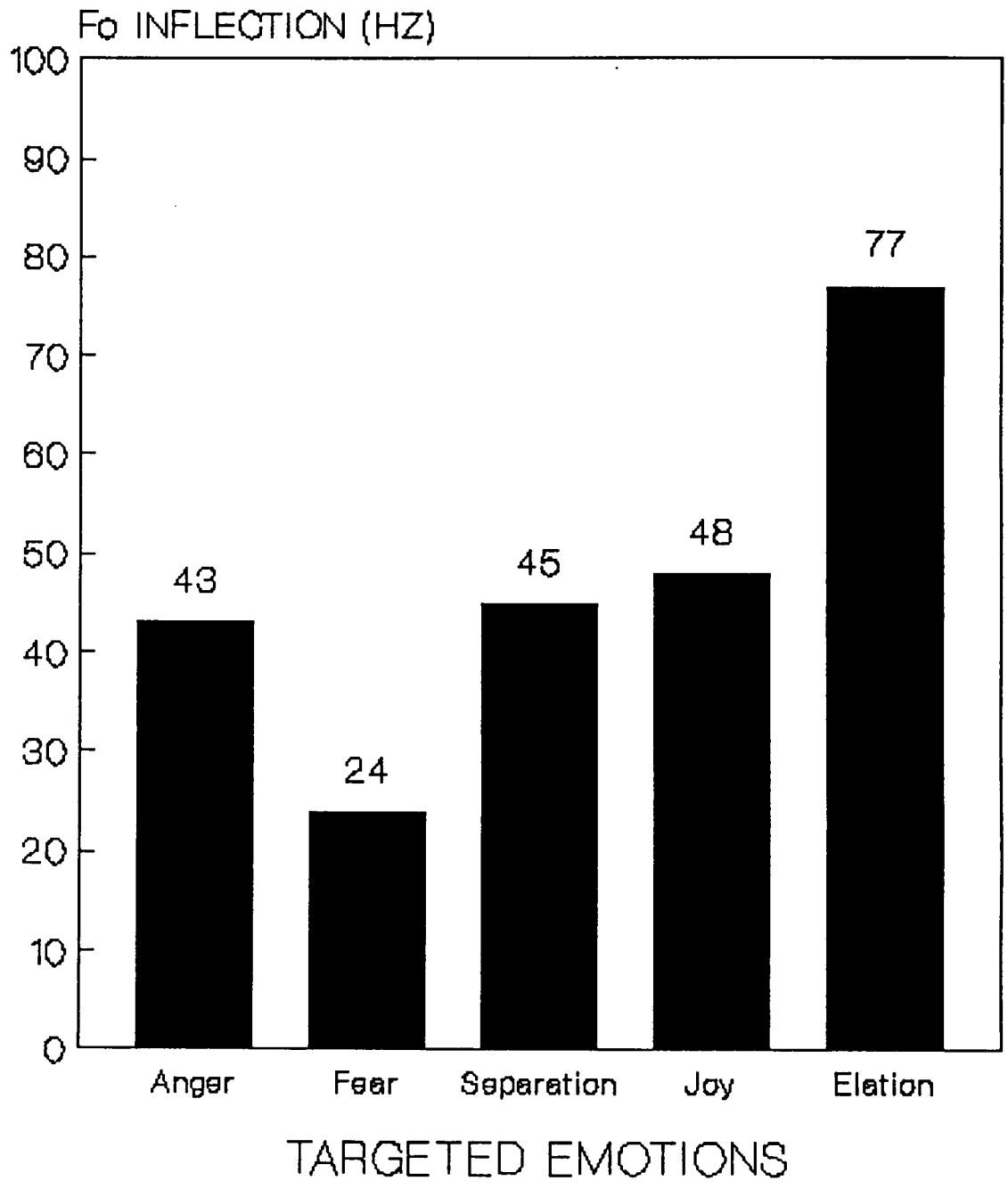

Figure 4-6. Fundamental frequency (Fo) inflection of five targeted emotions for Infant 3

emotions (62.5 Hz) was higher than for the negative emotions (37.3 Hz). Elation had the highest mean fundamental frequency inflection of 77 Hz, as compared to the lowest mean Fo of 24 Hz for fear.

Mean Fundamental Frequency Rate: The mean fundamental frequency rate was determined for the five emotions of Infant 3 (See Figure 4-7). The mean Fo rate for all emotions meeting the criterion was 941 Hz/sec with a standard deviation of 895 Hz/sec. The mean upward pitch inflection rate for all emotions was 937 Hz/sec with a standard deviation of 897 Hz/sec, while the downward pitch inflection rate was 952 Hz/sec with a standard deviation of 894 Hz/sec.

Both upward and downward pitch inflection rates were computed for each emotion and each sample meeting the 70% criterion. The mean upward Fo rate was higher for the positive emotions (1129 Hz/sec) than the negative emotions (582 Hz/sec). Infant 3 also had a higher mean Fo rate for the positive emotions (1088 Hz/sec) than for the negative emotions (306 Hz/sec). Elation had the rate (124 Hz/sec).

Mean Relative Amplitude Range: The mean relative amplitude range was 8 dB for all emotions. The mean upward and downward dB ranges were also computed for all emotions highest Fo rate (1270 Hz/sec), while fear had the lowest Fo and each sample meeting the 70% criterion. The positive emotions had a mean amplitude range larger than the negative

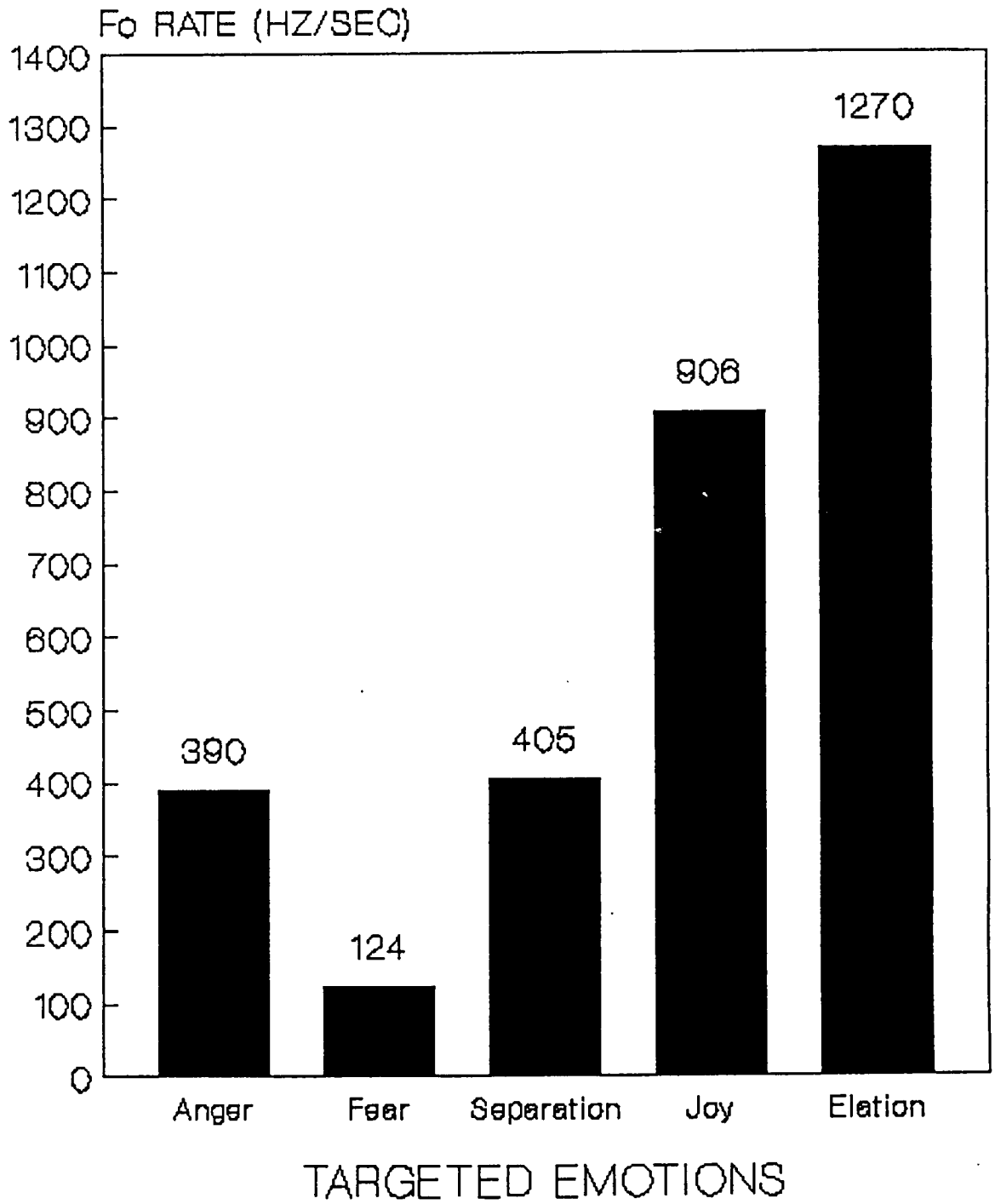

Figure 4-7. Mean fundamental frequency rate for Infant 3

emotions. Joy had the greatest amplitude range of 10.2 dB, while separation had the smallest of 6.3 dB. Infant 3 also had a greater amplitude range for the positive emotions (12 dB) than for the negative emotions (6 dB).

Mean Relative Amplitude Rate: The mean relative amplitude rate (mean dB rate) for all emotions was 287 dB/sec with a standard deviation of 277 dB/sec. The mean downward dB rate for all emotions was 261 dB/sec with a standard deviation of 219 dB/sec. The mean upward dB rate for all emotions was 313 dB/sec with a standard deviation of 322 dB/sec. The mean relative amplitude rate in one direction was also computed for each emotion and each sample which met the 70% criterion. For all of the emotions the upward mean dB rate was greater than the downward mean dB rate.

The mean relative amplitude rate for Infant 3 was greater for the positive emotions (378 dB/sec) than the negative emotions (128.7 dB/sec) (See Figure 4-8). Both elation and joy had the same amplitude rate (378 dB/sec). Fear had the lowest dB rate of 76 dB/sec, while separation (168 dB/sec) had the highest dB rate of the negative emotions.

Of the eight acoustic parameters analyzed, the positive emotions ranked the highest (88% or 7 out of 8 times). For the negative emotions, only anger ranked 1 or 2 (in mean Fo) of the negative emotions. A positive emotion was ranked as

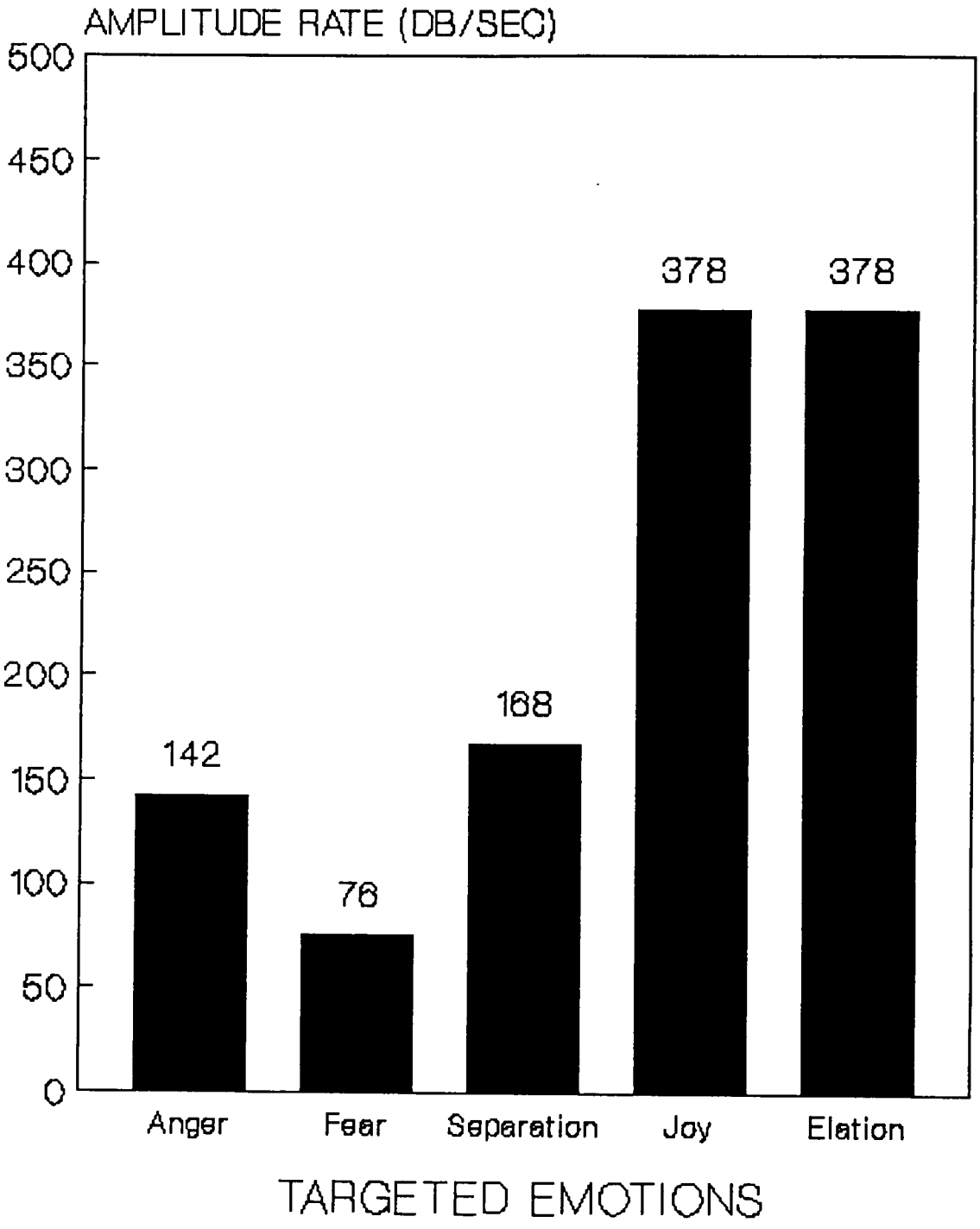

Figure 4-8. Mean amplitude rate of 5 targeted emotions for Infant 3

the lowest only once (mean Fo of elation). Of the negative emotions, anger was frequently ranked higher than either fear or separation (See Table 4-15).

Descriptive Analysis

The acoustic results for three negative emotions (anger, fear, and separation) of the current infant study were compared with the results for the same emotions elicited from adults (Fairbanks, 1940). In Fairbanks study, 79% of the judges (subjects) had the same judgments as the targeted emotion of anger, as compared with 48% of the listeners in the infant study (See Table 4-16). For the targeted emotion of fear, 66% of the subjects agreed in the Fairbanks study as compared with 53% in the current study. Agreement with the targeted emotion of separation/grief was 78% for the Fairbanks' subjects and 55% in the infant study (See Figure 4-9).

The median fundamental frequency for anger expressed by the adults was 229 Hz and for the Infant 3 was 514 Hz (See Table 4-17). The median fundamental frequency for adults expressing fear was 254 Hz and for infants was 479 Hz. The median fundamental frequency was 136 Hz for adults expressing grief and 460 Hz for the infants expressing separation (See Figure 4-10). Both the adults and the infant vocalized separation/grief at a lower Fo than either anger or fear.

Table 4-15. Rank order of 5 emotions for each acoustic parameter measured from infants meeting 70% criterion (Key: A = anger; F = fear; S = separation; J = joy; E = elation)

Rank Order (high to low)	$\bar{X}$ Fo	$\bar{X}$ Fo Range	$\bar{X}$ Fo Inflection Down	$\bar{X}$ Fo Inflection Up	$\bar{X}$ Fo Rate Down	$\bar{X}$ Fo Rate Up	$\bar{X}$ Fo Amplitude Down	$\bar{X}$ Fo Amplitude Up
1	A	E	J	J	E	J	E	E
2	F	S	E	A	J	E	A	A
3	J	A	S	E	A	A	J	J
4	S	J	A	F	F	F	S	S
5	E	F	F	S	S	S	F	F

Table 4-16. Percent agreement for the emotions studied by Hubbard (1991) and Fairbanks (1940) (Key: Cont.= Contempt, Sep.=Separation, Indif.=Indifference; * = no data for this emotion)

Researcher	Emotions						
	Anger	Fear	Sep.	Cont.	Indif.	Joy	Elation
Hubbard	48	53	55	*	*	68	79
Fairbanks	78	66	78	84	88	*	*

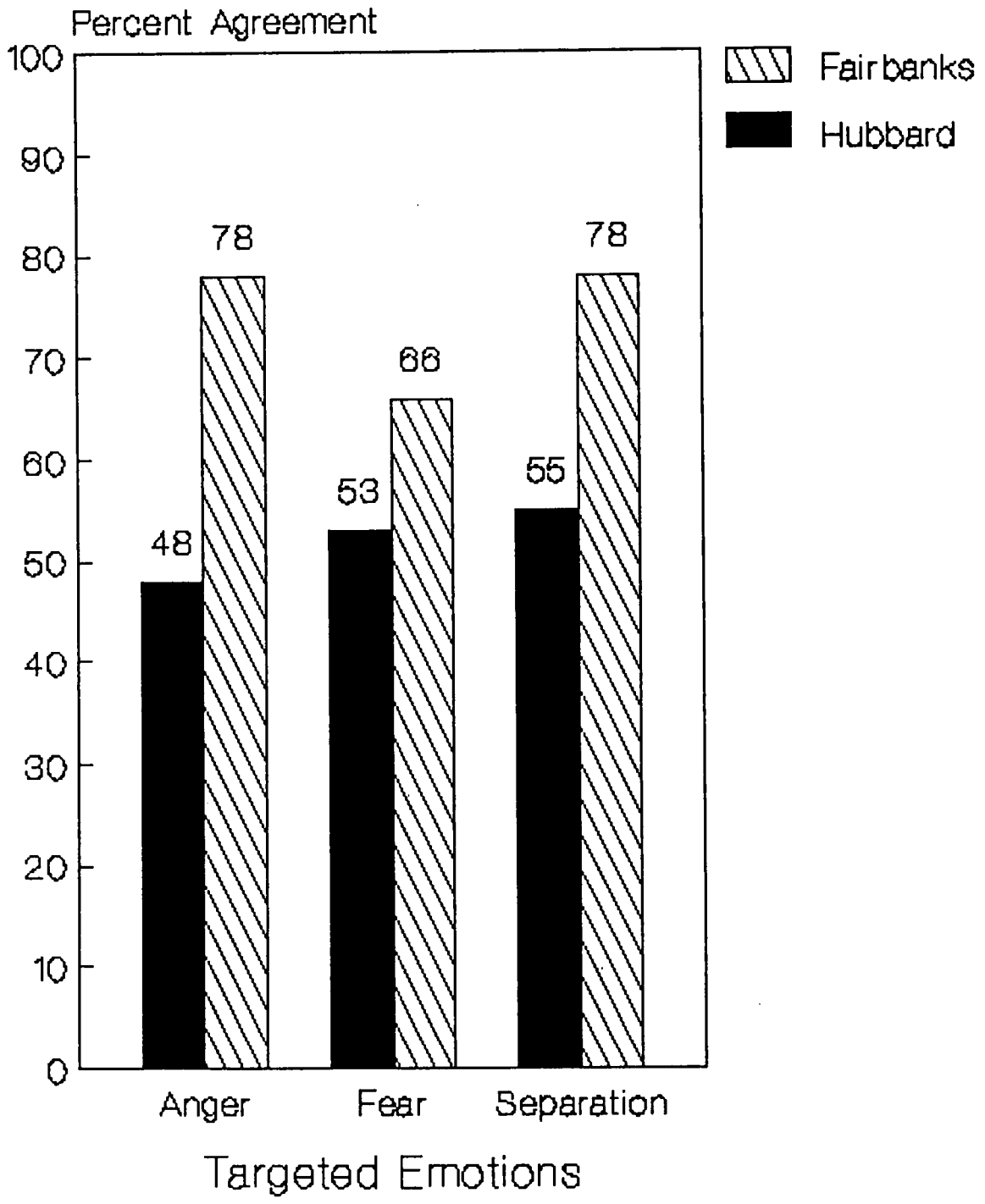

Figure 4-9. Percent Agreement for three emotions of infants meeting 70% criterion (Hubbard, 1991) and six adults (Fairbanks, 1940)

Table 4-17. Fundamental frequency data for three emotions studied by Hubbard (1991) and Fairbanks (1940) reported in Hertz and tones

Emotions	Researcher	Median Fo (Hz)	$\bar{X}$ Fo Range (tones)	$\bar{X}$ Fo Inflection (tones)	$\bar{X}$ Fo Rate (tones/sec)
Anger	Hubbard				
	Inf. $\bar{3}$	514	5.3	0.8	4.6
	$\bar{X}$	509	7.6	1.7	17.6
	Fairbanks	229	10.3	2.6	25.6
Fear	Hubbard				
	Inf. $\bar{3}$	479	3.2	0.6	2.3
	$\bar{X}$	445	4.0	0.9	7.6
	Fairbanks	254	11.2	2.3	19.0
Separation	Hubbard				
	Inf. $\bar{3}$	460	8.0	0.9	0.3
	$\bar{X}$	440	10.9	1.3	4.2
	Fairbanks	136	9.0	1.7	15.6

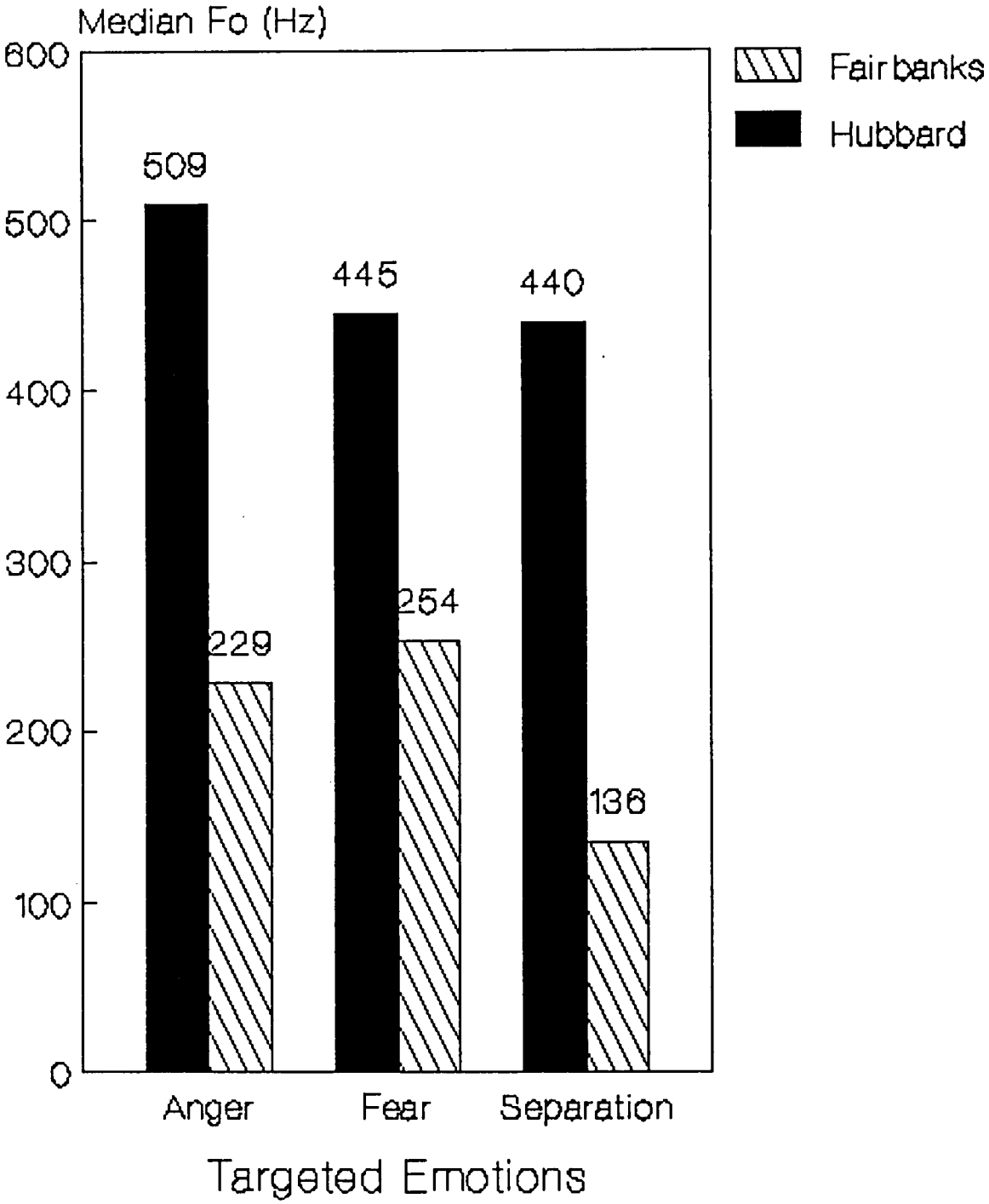

Figure 4-10. Median fundamental frequency for three emotions of infants meeting 70% criterion (Hubbard, 1991) and six adults (Fairbanks, 1940)

The remaining fundamental frequency measures were converted into tones (T = 19.92 x [log10 x (F1/F0)]) for comparison with Fairbanks' data. The mean fundamental frequency range for the adults was 11.2 tones for fear, 10.3 tones for anger, and 9.0 tones for grief. For Infant 3 the mean fundamental frequency range was 8.0 tones for separation, 5.3 tones for anger, and 3.2 tones for fear (See Table 4-17). The Fo range of separation/grief for the adults (9.0 tones) was more similar to that for Infant 3 (8.0 tones) than the other two emotions.

The mean fundamental frequency inflection in the upward direction was similar for fear (1.8 tones) and grief (1.5 tones) in the adults and slightly greater for anger (2.4 tones) (See Table 4-18). The same pattern was observed with the infants, where fear (0.8 tones) and separation (0.9 tones) were similar with anger (1.7 tones) being greater (See Table 4-19). The mean fundamental frequency inflection in the downward direction for the adults was similar between anger (2.8 tones) and fear (2.6 tones) with grief (1.9 tones) being slightly less. With the infants there were similar values for all three emotions with fear (0.9 tones) and separation (1.3 tones) being more different than when compared with anger (1.1 tones).

The mean fundamental frequency rate for upward inflection was different among the emotions for both the adults and the infants (See Tables 4-18 and 4-19). Anger

Table 4-18. Fundamental frequency data for three emotions expressed by actors (in tones)

Emotions	$\bar{X}$ Fo Range (tones)	$\bar{X}$ Fo Inflection (tones)		$\bar{X}$ Fo Rate (tones/sec)	
		Up	Down	Up	Down
Anger	10.3	2.4	2.8	25.6	25.5
Fear	11.2	1.8	2.6	18.4	19.5
Separation	9.0	1.5	1.9	16.6	14.8

Table 4-19. Fundamental frequency data for three emotions expressed by infants (in tones)

Emotions	Infant #	$\bar{X}$ Fo Range (tones)	$\bar{X}$ Fo Inflection (tones)		$\bar{X}$ Fo Rate (tones/sec)	
			Up	Down	Up	Down
Anger	3	5.3	0.8	0.7	5.0	4.2
Anger	5	9.9	2.6	1.4	24.4	30.1
Fear	1	4.8	1.1	1.0	12.8	12.1
Fear	3	3.2	0.5	0.7	2.2	2.4
Separation	3	8.0	0.8	1.0	0.3	0.3
Separation	4	13.8	0.9	1.5	8.0	6.9

presented the greatest rate with 25.6 tones for the adults and 14.7 tones for the infants. Fear resulted in the second largest rate with 18.4 tones for the adults and 7.5 tones for the infants. Separation showed the smallest rate with 16.6 tones for the adults and 4.2 tones with the infants.

The mean fundamental frequency rate for downward inflection had the same pattern as the upward inflection for both the adults and the infants (See Tables 4-18 and 4-19). Anger was 25.5 tones for the adults and 17.2 tones for the infants. Fear was the next largest rate with 19.5 tones for the adults and 7.3 tones for the infants. Separation had the smallest rate with 14.8 tones for the adults and 3.6 tones for the infants.

CHAPTER V

DISCUSSION

Perceptual Analysis

When selecting one of the five emotions, the listeners' percent was higher with each of the targeted positive emotions, e.g. 79% for elation, than with each of the targeted negative emotions, e.g. 55% for separation (See Table 4-3). This occurrence could reflect the two choices for the positive emotions versus the three choices for the negative emotions. However, Tomkins and McCarter (1964), who studied the visual identification of adults' similation of nine emotions, reported higher scores with positive emotions (85%-92%) than negative emotions (60%-77%). Both the Tomkins/McCarter study and the present study had an approximate 25% higher score for the identification of positive emotions. Therefore, the number of choices may not be a major factor. The positive emotion enjoyment yielded the highest percent identified (92%) in the Tomkins and McCarter study with adults, as compared with 68% of the responses for joy in the present study with infants (the second highest percent). Percentages for fear were very similar between the two studies. Tomkins and McCarter reported 60% identification of fear for adults; whereas the

current study reported 53% of infants' fear responses by all listeners and 65% by the 10 best listeners.

Cotterell (1981) also reported 60% identification of fear by normal hearing children on the Test of Emotion Discrimination. This test utilized adult vocalizations of anger, sorrow, joy, and anger. Cotterell reported higher percent identification of anger than joy by both normal hearing and hearing impaired children. However, hearing impaired children ($\bar{X}$ = 32%) performed significantly poorer on joy than did normal hearing children ($\bar{X}$ = 76%). This suggests that anger vocalized by an adult is easier for children to identify auditorily than joy. In the current study, it was easier for adults to identify joy vocalized by an infant than anger. This could suggest a developmental difference in the expression of those two emotions.

Another possible factor facilitating higher identification of positive over negative emotions is the amount of exposure to a negative and positive emotions by the listener (caretaker) and the speaker (infant). In a discussion on infants' emotional communication, Tronick (1989) stated that in a normal communicative interaction an infant is exposed to either 1) an interval of negative affect, 2) an interval of positive affect, or 3) a conversion from negative to positive affect. Thus, he concluded that exposure to negative affect is brief.

Another similarity between the visual results from Tomkins and McCarter (1964) and the auditory results from the current study, was the confusion among the emotions. Anger was never confused with joy in either the visual or auditory study; whereas, anger was confused with fear in both studies, suggesting that anger is easily identified as a negative emotion, but fear is not.

In the visual studies, emotions had a ranking similar to the ranking of the emotions in the present study with infants. Judges identified joy with higher percentage of accuracy (85%) than either fear (50%) or anger (47%) (Izard, Huebner, Risser, McGinnes, and Dougherty; 1980). In comparison with the current infant study, joy was also identified with higher percent of responses (68%) than either fear (53%) or anger (48%). This data suggested that visual cues did not provide significantly more information than auditory cues in the identification of emotions. Ekman and Oster (1979) discussed the perceptual importance of the face, voice, speech, and body movements in the identification of emotions. They concluded that the visual and/or auditory channel selected during emotional communication was dependent upon the speaker, the listener, the message conveyed in each channel, and prior experience.

In the present study, the listeners typically perceived an emotion at the same end of the emotional continuum (negative or positive) (See Figure 5-1). For example, the

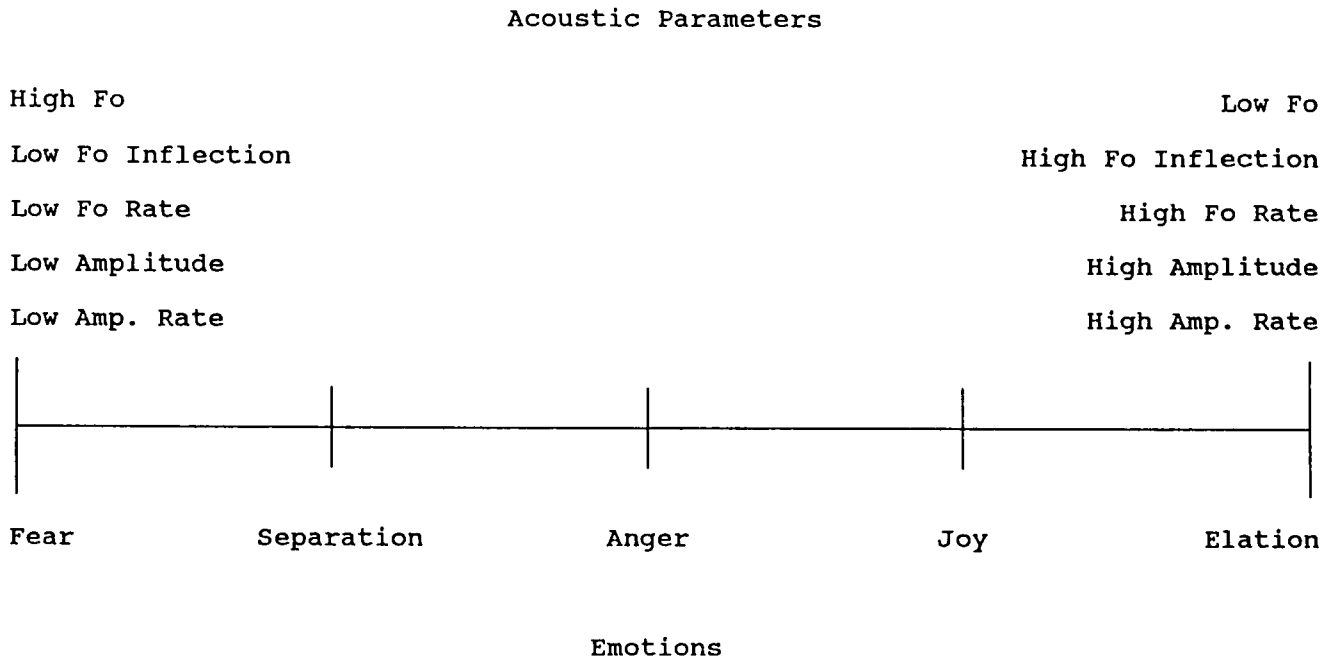

Figure 5-1. Acoustic-emotional continuum for 5 emotions and 5 acoustic parameters

listeners selected 55% of the separation samples as separation, and the remainder as other negative emotions. No positive emotions were chosen (See Table 4-7). This would suggest that separation is a strong negative emotion characterized by discriminating acoustic properties, which are addressed in the section titled Acoustical Analysis.

Fear is a weaker negative emotion than anger or separation with 8% of the targeted samples of fear perceived as a positive emotion and 16% of the positive emotions perceived as fear. This agrees with Ekman and Oster's (1979) conclusion from a review of the literature on children's recognition and production of emotions that happiness is the easiest and fear is among the most difficult emotions for children to recognize. Possibly there are acoustic properties of fear, e.g. fundamental frequency rate, which influence the listener to cross the negative boundary into the positive realm. A larger percentage of the targeted samples of elation (17%), as compared to joy (7%), were perceived as negative (See Table 4-7). Elation is considered more intense than other positive emotions (Cicchetti & Hesse, 1983) and exhibits acoustic characteristics similar to negative emotions (Scherer, 1986). In summarizing the acoustical data from several studies of emotional expression, Scherer (1986) reported that both elation and anger contained the following acoustic characteristics: increased mean Fo, increased Fo

range, increased Fo variability, and increased mean intensity.

Among the negative emotions, a response analysis was completed to determine patterns of confusion. There appeared to be more confusion between anger and separation than between fear and anger or fear and separation (See Table 4-7). Anger was selected for 26% of the separation samples and separation was chosen for 32% of the anger samples; whereas, fear was chosen for 17% of the anger samples and 19% of the separation samples. Anger must share similar acoustic characteristics with separation for one emotion to be perceived as the other.

When the demographic data was compared according to subgroupings of the listeners, some factors emerged. In Table 4-7, the listeners were ranked according to their percent agreement with all targeted emotions from the highest to the lowest percentages. As the listeners' judgments were analyzed in subgroups of 20, 16, or 10, the percentages of listeners increased for those who worked less than half-time and whose infant's birth order was not the first. The greater increase was observed with the infant's birth order occurring after the first birth (80% of the best 10 listeners and 50% of all 20 listeners). Therefore, experience in raising at least one infant appeared to facilitate a higher percent agreement with the targeted emotion.

A 40% difference was observed between Infant 1 (38%) and Infant 3 (82%). This difference may have been related to Infant 1 being 9 months of age; whereas, the other infants were 11-13 months of age. This lower identification of the targeted emotions for Infant 1 could suggest less developed cognitive skills for this infant. Cognition influences the development and expression of emotions (Sroufe, 1979). It is "... only with some development of [the cognitive skills:] causality, object permanence, intentionality, and meaning are there joy, anger, and fear..." (Sroufe, 1979, p. 491).

Acoustical Analysis

Out of the 13 samples that satisfied the 70% criterion, only Infant 3 had all five emotions meet the criterion. The five ranged from 75% to 90%. The emotions of Infant 3 had distinct acoustic patterns, which could be used as a reference for comparison with the other infants.

When the fundamental frequency data were ranked, the positive emotions exhibited the highest ranking for 5 of the 6 fundamental frequency measurements, i.e. anger had the highest Fo (514 Hz) (See Table 4-15). This data agreed with Scherer's (1982) report of higher rankings in fundamental frequency for positive emotions as reported in the literature.

A difference between elation and joy in all of the fundamental frequency measures may have been a factor in the discrimination between elation and joy. Elation had a higher Fo ranking than joy on the four Fo measures, e.g. Fo rate was 1270 Hz/sec for elation and 906 Hz/sec for joy.

Positive emotions had higher rankings for 7 of the 8 acoustic parameters studied. Mean fundamental frequency was lowest for the positive emotions. The negative emotions received the lowest rankings for 7 of the acoustic parameters. This suggested an acoustic-emotional continuum with the positive emotions on the end with the higher values for amplitude rate, fundamental frequency rate, fundamental frequency inflection, and fundamental frequency range.

Descriptive Analysis

The percent of same responses for the 5 assimilated negative emotions of 6 actors in Fairbanks study (1940) was 27% higher ($\bar{X}$ = 78.8%) than the percent of responses of 3 negative emotions of 6 infants in the present study (52%). The largest difference (30%) was observed in anger, suggesting that anger in adults is easier to identify than in infants. When comparing the same 3 negative emotions (anger, fear, and separation) utilized in both studies, the results from Fairbanks study was 22% higher ($\bar{X}$ = 74%) than the current study (52%), suggesting that negative emotions are easier to identify in adults than in infants. Also, the

experimental design and procedures may have affected the difference in results. Fairbanks used actors to assimilate the emotions which is not feasible with infants.

Since all 5 emotions of Infant 3 met the 70% criterion, only the acoustical data from Infant 3 were utilized for discussion. Results indicated that the adults had a greater extent of fundamental frequency rate (e.g., 25.6 tones/sec for anger) than did Infant 3 (5.0 tones/sec for anger). When the three emotions (anger, fear, and separation) were ranked from high to low for mean Fo rate, the ordering was the same for both the adults and Infant 3, suggesting that the adults and Infant 3 have similar acoustical characteristics for these three emotions. Possibly, mean fundamental frequency rate is the acoustic parameter which facilitates the listener in identifying anger, fear, or separation.

Of the mean fundamental frequency inflection for the 3 emotions, separation was ranked highest for Infant 3 and lowest for the adults. Of the mean Fo range for the 3 emotions, separation was ranked highest with Infant 3 and lowest for the adults. However, mean Fo range for fear was lowest for Infant 3 and highest for the adults.

In summary, the perceptual and acoustical data for 6 infants were discussed. The perceptual results indicated that infants' emotions were identified as negative or positive with high reliability, suggesting that the acoustic

parameters facilitated the identification of the emotions. Positive emotions had a higher ranking than negative emotions in 7 of the 8 acoustic parameters measured, indicating a possible acoustic-emotional continuum. Fear and separation received the lowest ranking for 7 of the 8 acoustic parameters. Comparison of the present study with Fairbanks (1940) revealed some similarities between infants and adults, i.e. rank order of the three emotions for Fo rate.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

Five emotions (anger, fear, separation, joy, and elation) of 6 infants were video recorded during specified conditions. Twenty listeners identified auditorily which one of the 5 emotions they perceived. Their responses were recorded as percent of responses that were the same as the targeted emotion. The results indicated the following percent of responses which were the same as the targeted emotion: elation with 79%, joy with 68%, separation with 55%, fear with 53%, and anger with 48%. A Kruskal-Wallis Test (Chi-Square) indicated a significant difference among the emotions. A significant difference among the 6 infants was revealed in a Kruskall-Wallis Test. Intrajudge reliability was extremely high for agreement in identifying emotions as negative or positive (98%) and lower for agreement on specified emotions (67%).

An acoustical analysis was conducted on those samples for which 70% of the responses were the same as the targeted emotions. Six acoustical parameters were measured: mean fundamental frequency, mean fundamental frequency range, mean fundamental frequency inflection, mean fundamental frequency rate, mean relative amplitude range, and mean

relative amplitude rate. Results revealed differences among the 5 emotions, relative to negative emotions versus positive emotions, but were not as strong with individual emotions. Relative amplitude rate and fundamental frequency rate were higher with positive emotions than with negative emotions.

In a comparison of the current results with a study conducted by Fairbanks (1940), indicated that perception of adults' vocal expressions of negative emotions (anger at 78%, fear at 66%, and separation at 78%) are easier than those of infants (anger at 48%, fear at 53%, and separation at 55%). There were larger values in the acoustical properties of the adults' emotions (25.6 tones/sec for anger) than the infants' (5 tones/sec for anger). Mean fundamental frequency rate was similar in the ranking of the three emotions for both the adults and the infants. It appears that emotions have discriminating acoustical characteristics.

Conclusions

The results of this study suggest the following conclusions:

1. Infants' vocalized emotions are significantly different as judged by trained and experienced listeners (mothers).

2. Infants' vocalized emotions are acoustically different in the rate of the mean fundamental frequency and the mean relative amplitude.

3. A negative/positive analysis produced higher percents of judgments that were the same as the targeted emotions.

4. Infants, who are 9 through 12 months old, are significantly different in their vocalized emotions.

Implications for Future Studies

1. Studying a larger number of various age groups of infants would provide developmental information on the acquisition of vocalized emotions.

2. Different listener groups, e.g. teenage mothers or fathers, could provide information on emotional perception.

3. The effects of acoustic filters on vocalized emotions would add to the understanding of the acoustic parameters involved in the perception of emotions.

4. Spectral parameters should be analyzed to determine acoustic patterns for particular emotions.

5. Different vocalized emotions should be studied to determine perceptual and acoustic characteristics.

6. A comparison of auditory, visual, and auditory with visual cues would suggest the channel utilized in the perception of emotions.

7. The conditions utilized to elicit a particular emotion should be compared to determine any effect on the perception or acoustic parameters of the targeted emotion.

Limitations of the Study

1. Due to difficulties in obtaining appropriate video recordings, this study was limited to only six infants.

2. The effect of training on the listeners was not determined.

3. Presenting the emotions auditorily without the visual cue, reduced the number of samples which met the 70% criterion for acoustical analysis.

4. The listening cues provided for each emotion could have shaped the listeners' responses.

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APPENDICES

APPENDIX A

APPENDIX A

INSTRUCTIONS FOR LISTENING TO/JUDGING EMOTIONS

Thank you for volunteering to be involved in this important study of the vocal patterns of young infants. The study consists of the following 3 parts: 1) listening to recordings of 5 different emotions, 2) discussing the vocal characteristics of these emotions, and 3) identifying the emotion heard. You will be listening to short recorded samples of different infants vocalizing five different emotions (separation, anger, fear, joy, and elation). These emotions were evoked in the conditions described on the attached sheet. A description of the listening cues for each emotion is provided to help you in differentiating between the emotions.

The recorded samples will be played in random order, which means that there is no predictable order to the presentation of the 5 emotions.

Each recorded sample will be played twice. Do not circle an emotion until after you have heard both presentations of one sample. You will be given time to make your decision. You must circle only one of the five emotions for each sample.

The description of the listening cues is only a guideline for making a choice; however, listen to the emotion you "feel", then circle your choice. There is no right or wrong

answer. What is important is the emotion that you perceive or feel while listening.

DESCRIPTION OF THE SITUATION AND AUDITORY CUES
FOR EACH EMOTION

ANGER
Situation: The vocal response to a toy, an object, or food being withheld.

Listening Cues: Sometimes starts with short, intense repeated sounds indicating frustration or "Give it to me." Sometimes immediately goes to intense, loud cry with longer repeated sounds indicating a state of being mad.

FEAR
Situation: The vocal response to a stranger or feared object approaching the infant.

Listening Cues: Sometimes starts with short or somewhat longer, repeated sounds and sometimes immediately starts with short repeated cries. Sometimes sounds uncertain or sometimes frantic about the situation. Sometimes hear comforting sounds or a whimper. Usually not very loud, but could become intense at times.

SEPARATION
Situation: The vocal response to mother leaving her infant alone in the room.

Listening Cues: Typically sounds desperate, forlorn, or pitiful. Quickly goes to a cry, if not immediately with long, very intense, repeated wails. Usually becomes mad with time.

JOY
Situation: The vocal response to playing with a toy.

Listening Cues: Usually short, repeated light, happy (sometimes breathy) sounds which are usually not loud nor intense overall.

ELATION
Situation: The vocal response to tickling or playing "peek-a-boo".

Listening Cues: Repeated, short, intense sounds which are deeper and stronger than joy. May hear a giggle, a squeal, and usually quick upward pitch jumps.

ANY QUESTIONS?

REMEMBER: * Select only one (1) emotion.

* Select the emotion that best represents the emotion you hear or feel.

* Do not leave any unanswered.

* Circle your choice for each sample after hearing it played two (2) times.

****

RESPONSE SHEET 1

1.	Separation	Fear	Anger	Joy	Elation
2.	Separation	Fear	Anger	Joy	Elation
3.	Separation	Fear	Anger	Joy	Elation
4.	Separation	Fear	Anger	Joy	Elation
5.	Separation	Fear	Anger	Joy	Elation
6.	Separation	Fear	Anger	Joy	Elation
7.	Separation	Fear	Anger	Joy	Elation
8.	Separation	Fear	Anger	Joy	Elation
9.	Separation	Fear	Anger	Joy	Elation
10.	Separation	Fear	Anger	Joy	Elation
11.	Separation	Fear	Anger	Joy	Elation
12.	Separation	Fear	Anger	Joy	Elation
13.	Separation	Fear	Anger	Joy	Elation
14.	Separation	Fear	Anger	Joy	Elation
15.	Separation	Fear	Anger	Joy	Elation

RESPONSE SHEET 2

1.	Separation	Fear	Anger	Joy	Elation
2.	Separation	Fear	Anger	Joy	Elation
3.	Separation	Fear	Anger	Joy	Elation
4.	Separation	Fear	Anger	Joy	Elation
5.	Separation	Fear	Anger	Joy	Elation
6.	Separation	Fear	Anger	Joy	Elation
7.	Separation	Fear	Anger	Joy	Elation
8.	Separation	Fear	Anger	Joy	Elation
9.	Separation	Fear	Anger	Joy	Elation
10.	Separation	Fear	Anger	Joy	Elation
11.	Separation	Fear	Anger	Joy	Elation
12.	Separation	Fear	Anger	Joy	Elation
13.	Separation	Fear	Anger	Joy	Elation
14.	Separation	Fear	Anger	Joy	Elation
15.	Separation	Fear	Anger	Joy	Elation
16.	Separation	Fear	Anger	Joy	Elation
17.	Separation	Fear	Anger	Joy	Elation
18.	Separation	Fear	Anger	Joy	Elation
19.	Separation	Fear	Anger	Joy	Elation
20.	Separation	Fear	Anger	Joy	Elation
21.	Separation	Fear	Anger	Joy	Elation
22.	Separation	Fear	Anger	Joy	Elation
23.	Separation	Fear	Anger	Joy	Elation
24.	Separation	Fear	Anger	Joy	Elation

25.	Separation	Fear	Anger	Joy	Elation
26.	Separation	Fear	Anger	Joy	Elation
27.	Separation	Fear	Anger	Joy	Elation
28.	Separation	Fear	Anger	Joy	Elation
29.	Separation	Fear	Anger	Joy	Elation
30.	Separation	Fear	Anger	Joy	Elation
31.	Separation	Fear	Anger	Joy	Elation
32.	Separation	Fear	Anger	Joy	Elation
33.	Separation	Fear	Anger	Joy	Elation

APPENDIX B

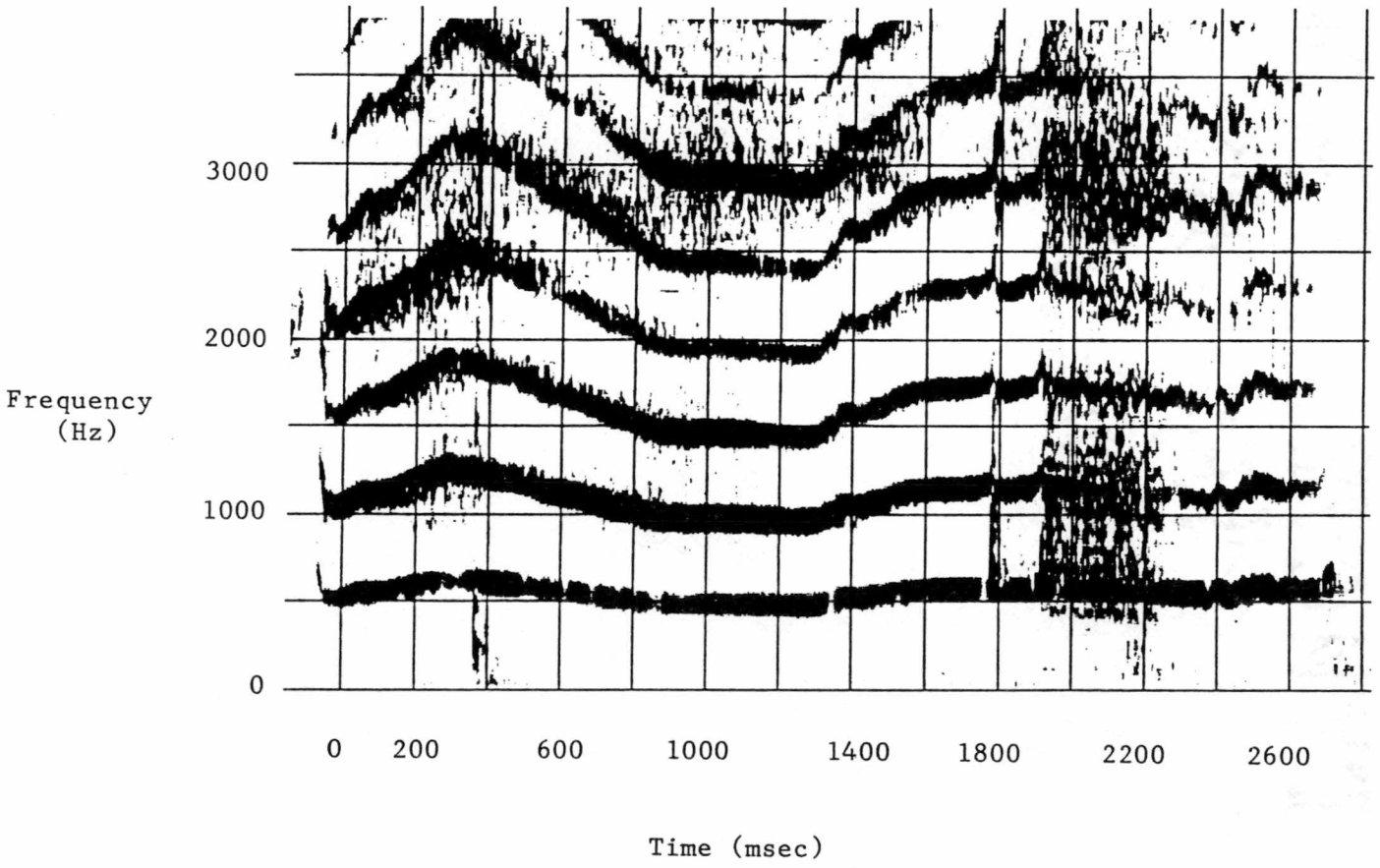

Figure B-1. Narrow-band spectrogram of targeted emotion anger for Infant 3.

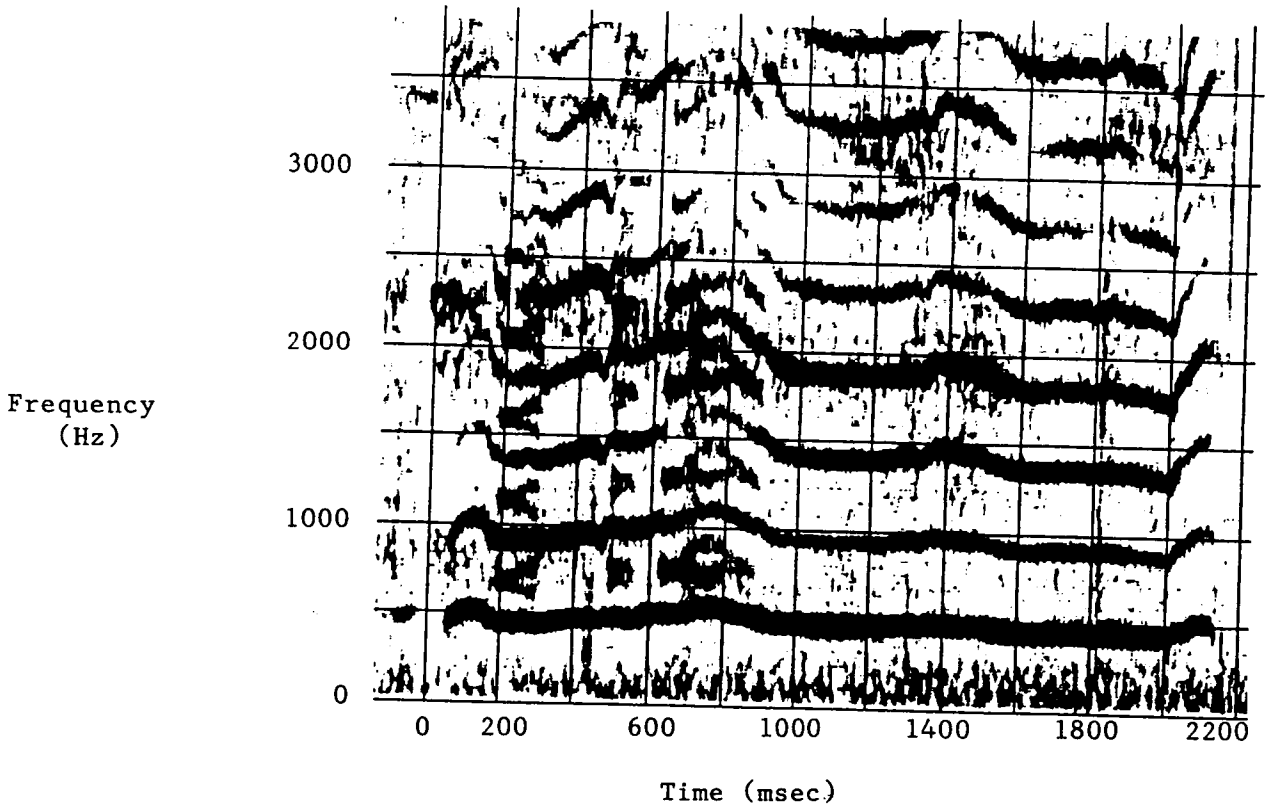

Figure B-2. Narrow-band spectrogram of targeted emotion fear for Infant 3.

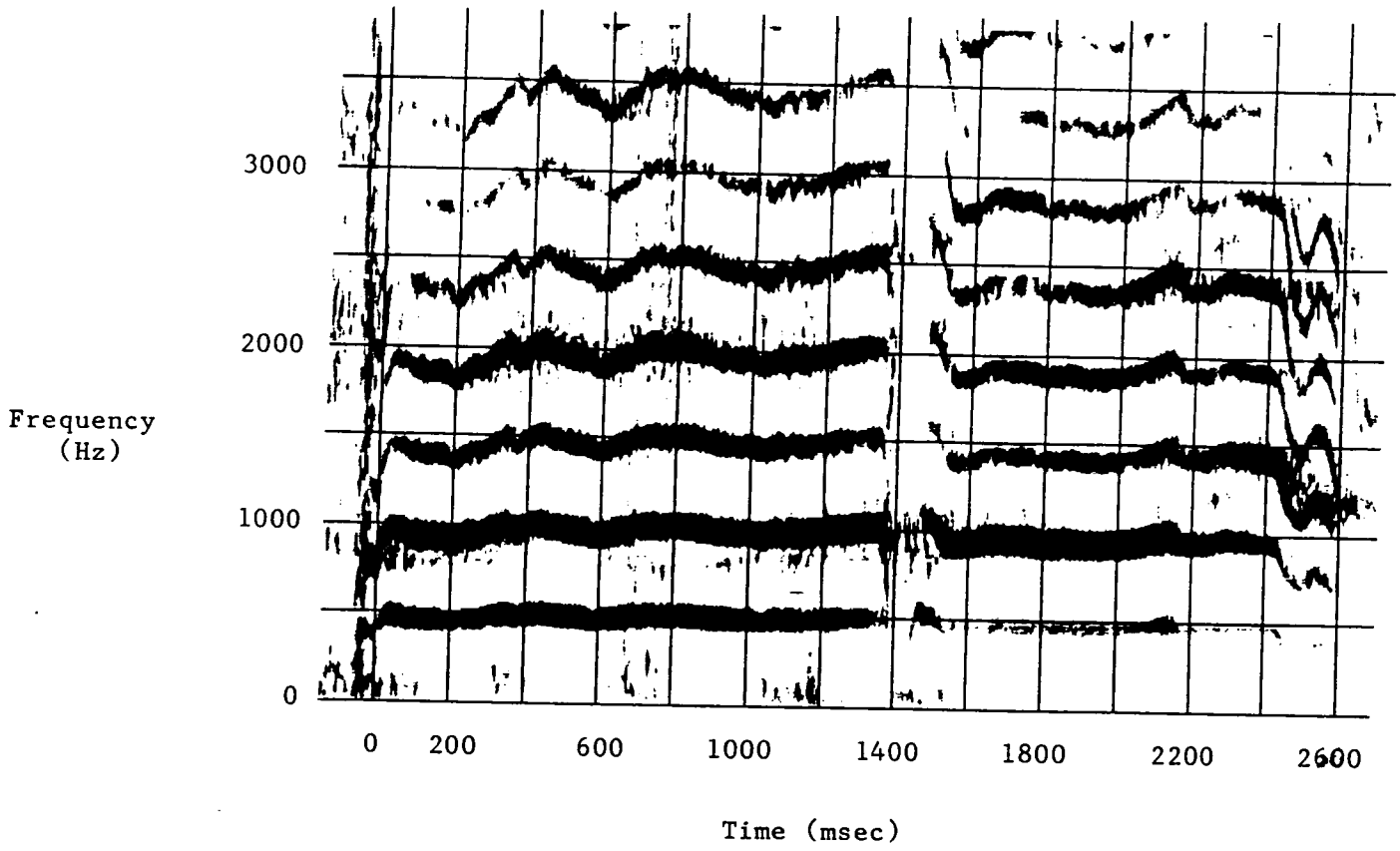

Figure B-3. Narrow-band spectrogram of targeted emotion separation for Infant 3.

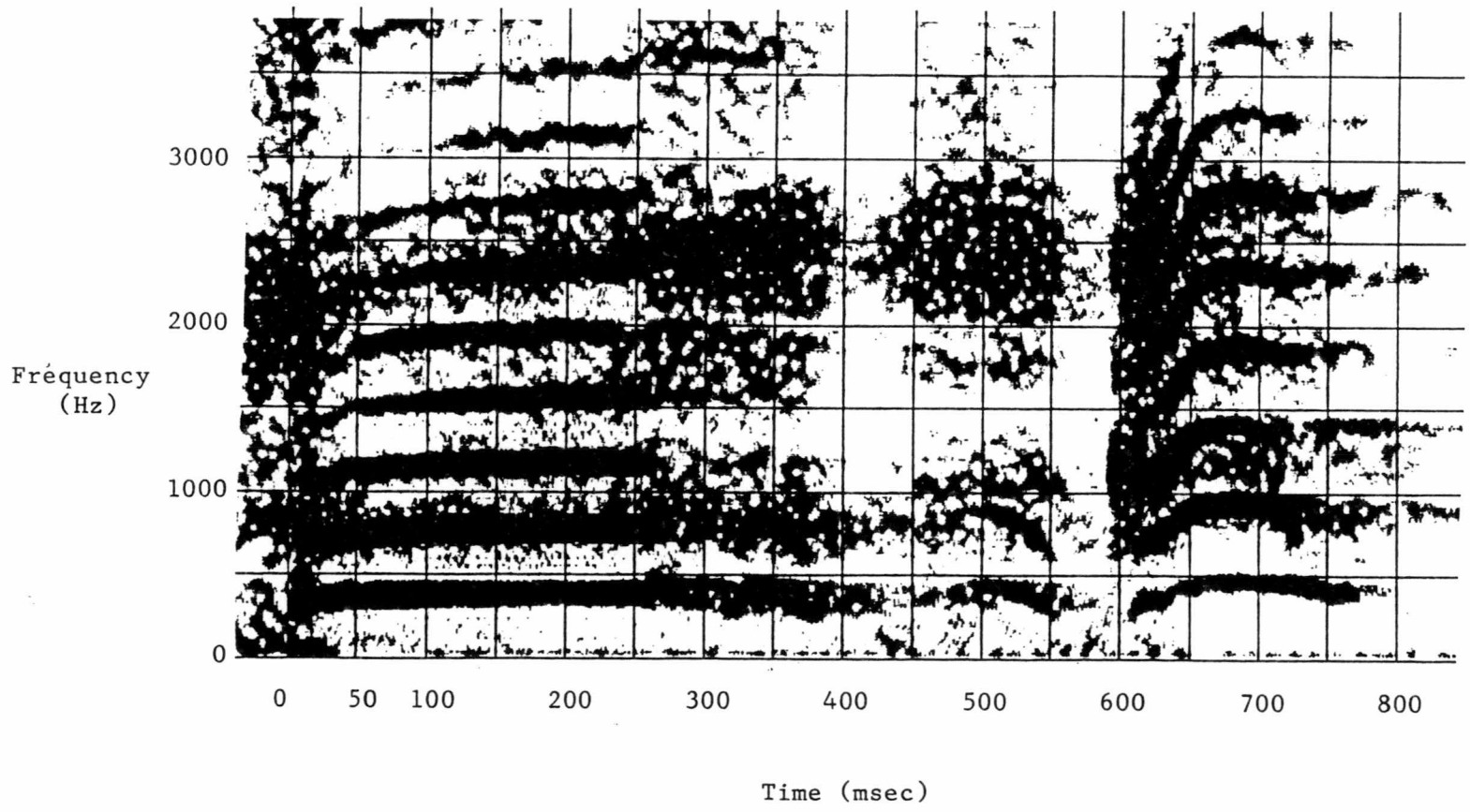

Figure B-4. Narrow-band spectrogram of targeted emotion joy for Infant 3.

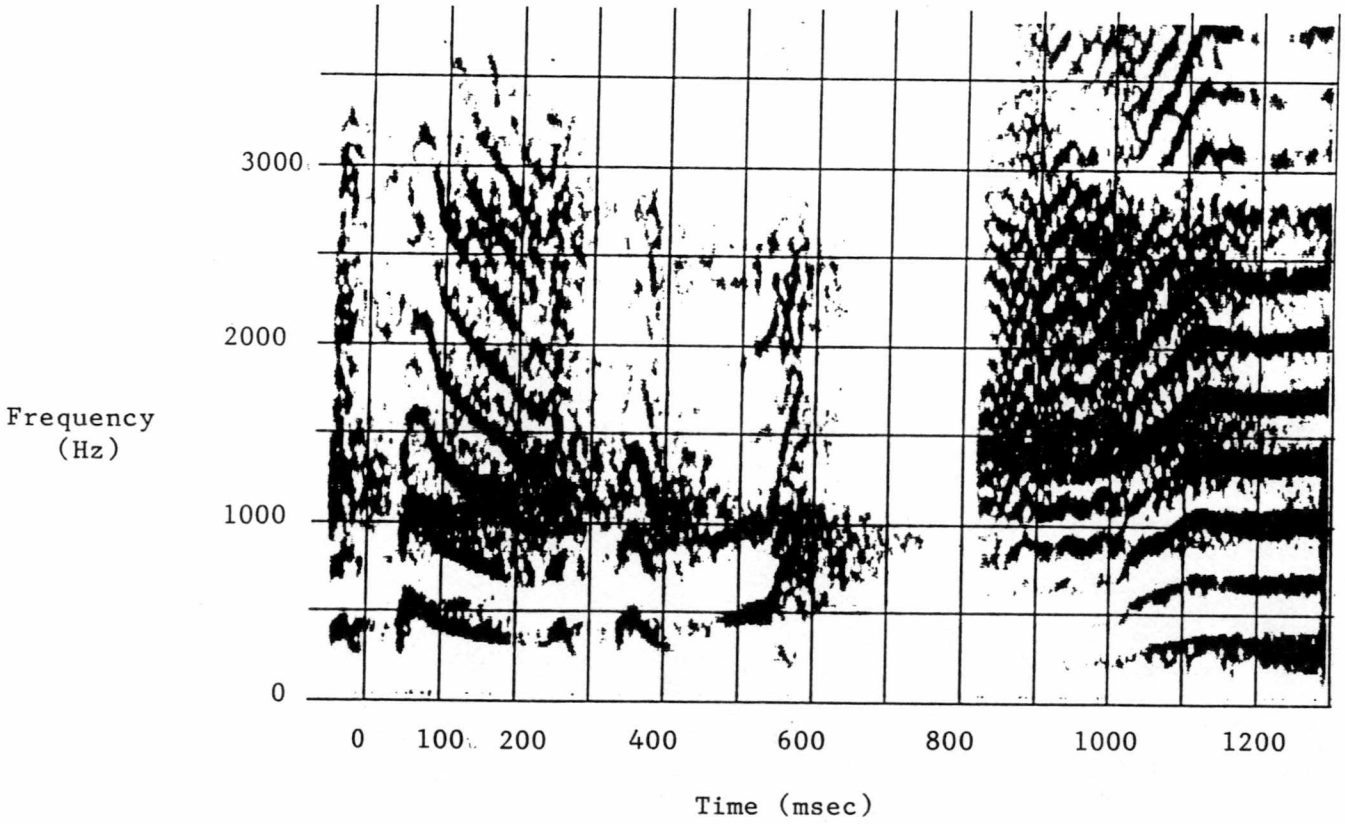

Figure B-5. Narrow-band spectrogram of targeted emotion elation for Infant 3.

APPENDIX C

APPENDIX C

Table C-1. Responses of listener 1 to 5 targeted emotions for 6 infants (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant # 1	2	3	4	5	6	Total % for Infants All	# 2-6
Anger	F	F	A	F	A	A	50	60
Fear	F	S	S	S	A	E	17	0
Separation	S	A	S	S	F	F	50	40
Joy	E	J	J	J	J	J	83	100
Elation	J	E	E	E	E	E	83	100
Mean % Agreement	40	40	80	60	60	60	57	60

Table C-2. Responses of listener 2 to 5 targeted emotions for 6 infants (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant # 1	2	3	4	5	6	Total % for Infants All	# 2-6
Anger	S	A	A	S	A	A	67	80
Fear	F	A	F	F	S	F	67	60
Separation	A	F	S	S	S	S	67	80
Joy	J	J	J	J	J	J	100	100
Elation	F	E	E	E	E	E	83	100
Mean % Agreement	40	60	100	80	80	100	77	84

Table C-3. Responses of listener 3 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	S	A	A	A	S	A	67	80
Fear	S	F	F	F	S	F	67	80
Separation	S	A	S	S	S	S	83	80
Joy	E	J	J	J	J	E	67	80
Elation	A	E	E	E	E	E	83	100
Mean % Agreement	20	80	100	100	60	80	73	84

Table C-4. Responses of listener 4 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	F	F	A	S	A	F	33	40
Fear	F	F	S	F	S	A	50	40
Separation	S	A	S	S	S	S	83	80
Joy	E	E	J	F	J	E	33	40
Elation	E	E	A	E	E	E	83	80
Mean % Agreement	60	40	60	60	80	40	56	56

Table C-5. Responses of listener 5 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	S	A	A	S	A	F	50	60
Fear	F	F	F	F	F	F	100	100
Separation	F	A	S	S	A	A	33	40
Joy	E	J	J	J	J	J	83	100
Elation	F	E	E	E	E	E	83	100
Mean % Agreement	20	80	100	80	80	60	70	80

Table C-6. Responses of listener 6 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	F	S	A	S	A	A	50	60
Fear	S	F	S	F	A	F	50	60
Separation	F	A	S	S	A	S	50	60
Joy	J	J	J	J	E	E	67	60
Elation	S	E	E	E	A	E	67	80
Mean % Agreement	20	60	80	80	20	80	57	64

Table C-7. Responses of listener 7 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	S	A	S	S	E	F	17	20
Fear	J	A	F	F	A	F	50	60
Separation	F	F	S	A	A	F	17	20
Joy	J	J	J	J	J	J	100	100
Elation	E	E	E	E	E	E	100	100
Mean % Agreement	40	60	80	60	40	60	57	60

Table C-8. Responses of listener 8 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	S	S	A	A	S	A	50	60
Fear	F	A	F	F	A	F	67	60
Separation	S	A	F	S	S	F	50	40
Joy	E	J	J	F	J	J	67	80
Elation	F	E	E	E	S	E	67	80
Mean % Agreement	40	40	80	80	40	80	60	64

Table C-9. Responses of listener 9 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant # 1	2	3	4	5	6	Total % for Infants All	# 2-6
Anger	S	A	A	A	A	E	67	80
Fear	S	S	F	S	A	E	17	20
Separation	S	F	A	A	A	A	17	0
Joy	E	E	J	J	E	E	33	40
Elation	E	E	E	E	F	E	83	80
Mean % Agreement	40	40	80	60	20	20	43	44

Table C-10. Responses of listener 10 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant # 1	2	3	4	5	6	Total % for Infants All	# 2-6
Anger	S	A	S	S	A	A	50	60
Fear	F	F	F	F	A	F	83	80
Separation	A	A	S	S	A	S	50	60
Joy	J	J	J	F	J	E	67	60
Elation	E	E	E	E	A	E	83	80
Mean % Agreement	60	80	80	60	40	80	67	68

Table C-11. Responses of listener 11 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	S	A	A	A	F	F	50	60
Fear	F	F	S	S	A	A	33	20
Separation	F	S	S	S	F	S	67	80
Joy	E	E	J	F	J	J	50	60
Elation	F	E	E	E	S	E	67	80
Mean % Agreement	20	80	80	60	20	60	53	60

Table C-12. Responses of listener 12 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	F	F	A	S	A	F	33	40
Fear	S	S	F	F	F	F	67	80
Separation	F	S	F	S	A	F	33	40
Joy	J	E	J	F	J	E	50	40
Elation	F	E	E	E	A	E	67	80
Mean % Agreement	20	40	80	60	60	40	50	56

Table C-13. Responses of listener 13 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	S	A	A	S	A	E	50	60
Fear	F	F	F	F	A	E	67	60
Separation	A	A	S	S	A	S	50	60
Joy	J	E	F	F	J	J	50	40
Elation	F	E	E	E	F	E	67	80
Mean % Agreement	40	60	80	60	40	60	57	60

Table C-14. Responses of listener 14 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	S	A	A	S	A	F	50	60
Fear	F	A	F	A	F	J	50	40
Separation	F	S	S	S	S	S	83	100
Joy	E	J	J	J	E	J	67	80
Elation	F	E	J	E	A	E	50	60
Mean % Agreement	20	80	80	60	60	60	60	68

Table C-15. Responses of listener 15 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	S	A	S	S	A	F	33	40
Fear	F	A	F	A	A	A	33	20
Separation	A	S	S	S	S	F	67	80
Joy	J	E	J	J	E	E	50	40
Elation	E	E	E	E	E	E	100	100
Mean % Agreement	60	60	80	60	60	20	57	56

Table C-16. Responses of listener 16 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	S	A	S	S	A	A	50	60
Fear	F	F	F	F	A	F	83	80
Separation	F	A	S	S	A	S	50	60
Joy	J	J	J	J	J	J	100	100
Elation	F	E	J	E	A	E	50	60
Mean % Agreement	40	80	60	80	40	100	67	72

Table C-17. Responses of listener 17 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	S	S	A	S	A	F	33	40
Fear	F	A	F	A	A	J	33	20
Separation	A	F	S	S	S	S	67	80
Joy	J	J	J	F	J	J	83	80
Elation	F	E	E	E	E	E	83	100
Mean % Agreement	40	40	100	40	80	60	67	64

Table C-18. Responses of listener 18 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	S	S	A	A	S	A	50	60
Fear	F	S	F	F	A	E	50	40
Separation	S	A	S	S	S	A	67	60
Joy	J	J	E	J	J	J	83	80
Elation	E	E	E	E	E	E	100	100
Mean % Agreement	80	40	80	100	60	60	70	68

Table C-19. Responses of listener 19 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	F	F	A	S	A	A	50	60
Fear	F	A	F	F	S	E	50	40
Separation	F	A	S	S	S	S	67	80
Joy	J	J	J	J	J	E	83	80
Elation	E	E	E	E	E	E	100	100
Mean % Agreement	40	40	100	80	80	60	47	56

Table C-20. Responses of listener 20 for the targeted emotions for each infant (A = Anger, F = Fear, S = Separation, J = Joy, E = Elation)

Targeted Emotion	Infant #						Total % for Infants	
	1	2	3	4	5	6	All	# 2-6
Anger	F	A	S	F	A	A	50	60
Fear	S	F	S	A	A	J	17	20
Separation	F	A	S	S	S	F	50	60
Joy	E	J	J	F	E	E	33	40
Elation	J	E	E	E	E	E	83	100
Mean % Agreement	0	80	60	40	60	40		

APPENDIX D

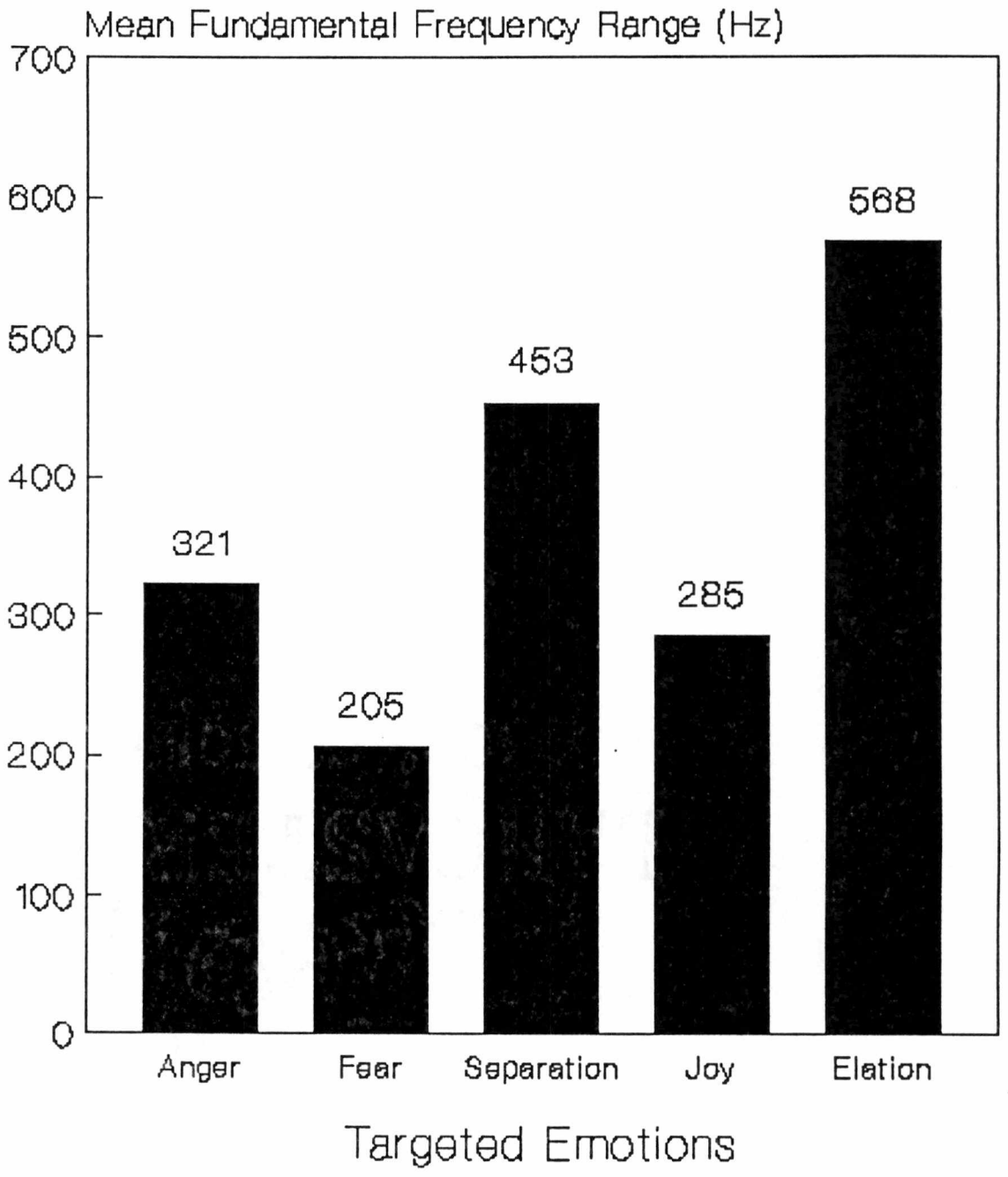

Figure D-1. Fundamental frequency range of 5 targeted emotions for infants

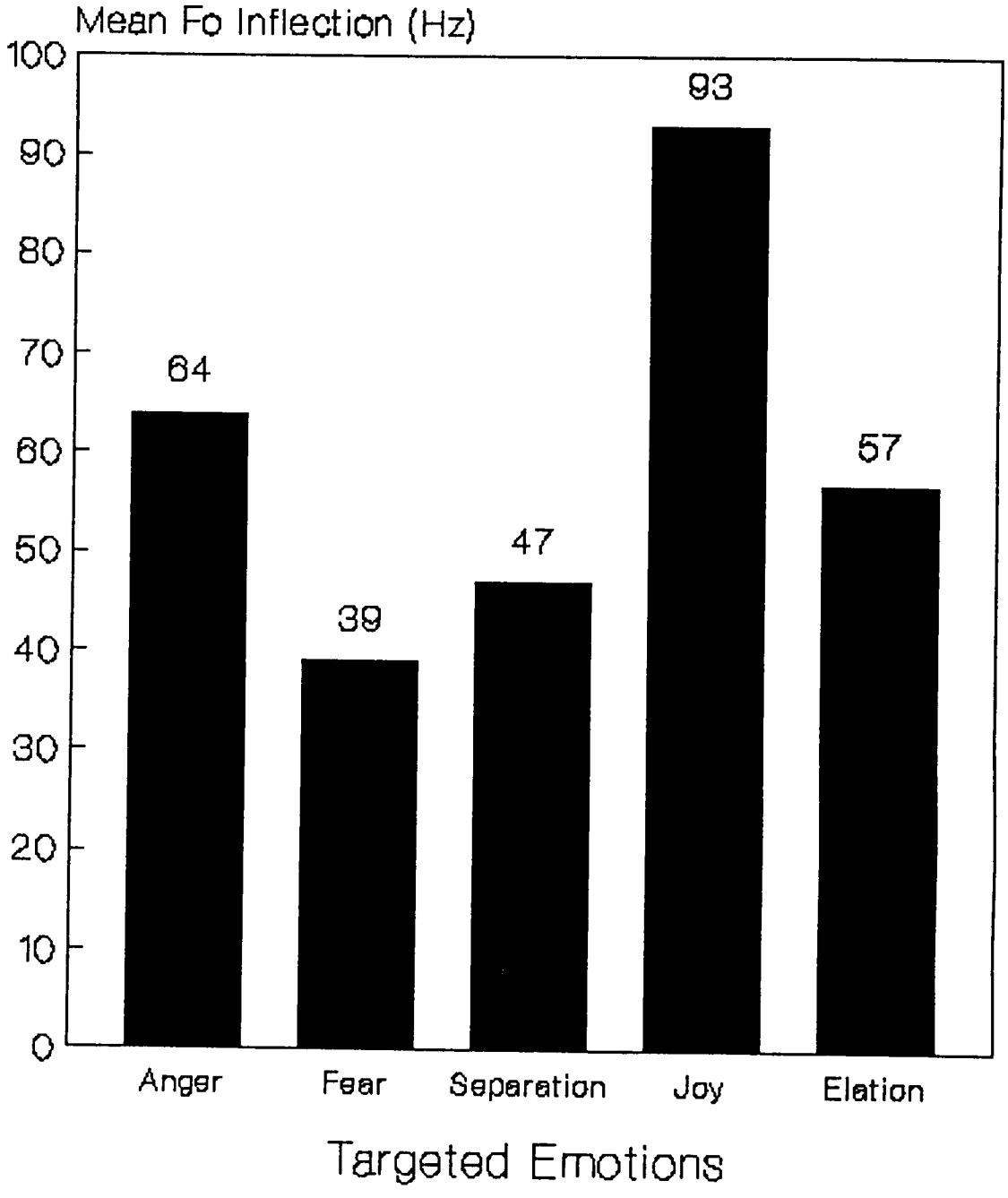

Figure D-2. Fundamental frequency inflection of 5 targeted emotions for infants

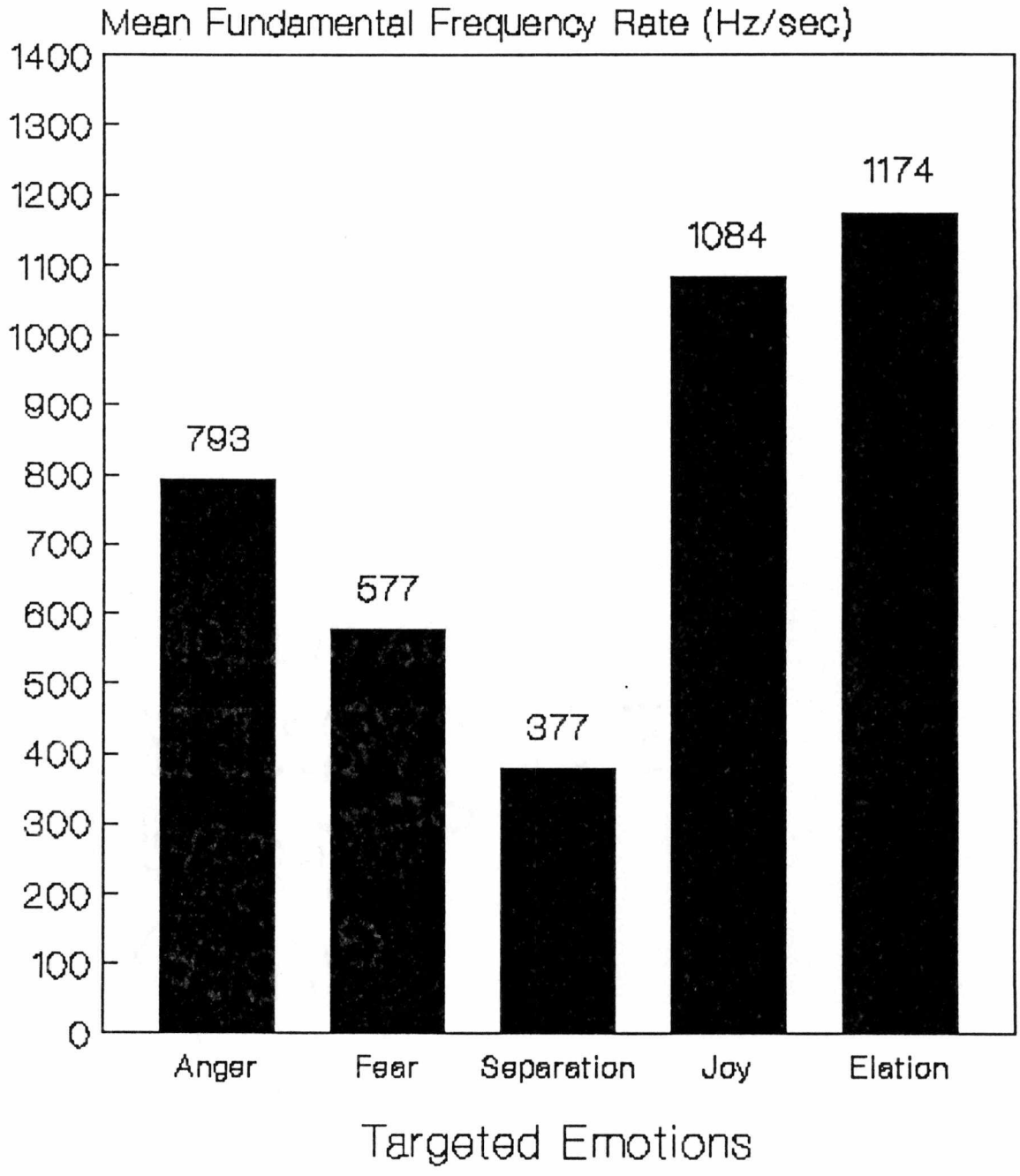

Figure D-3. Fundamental frequency rate of 5 targeted emotions for Infants

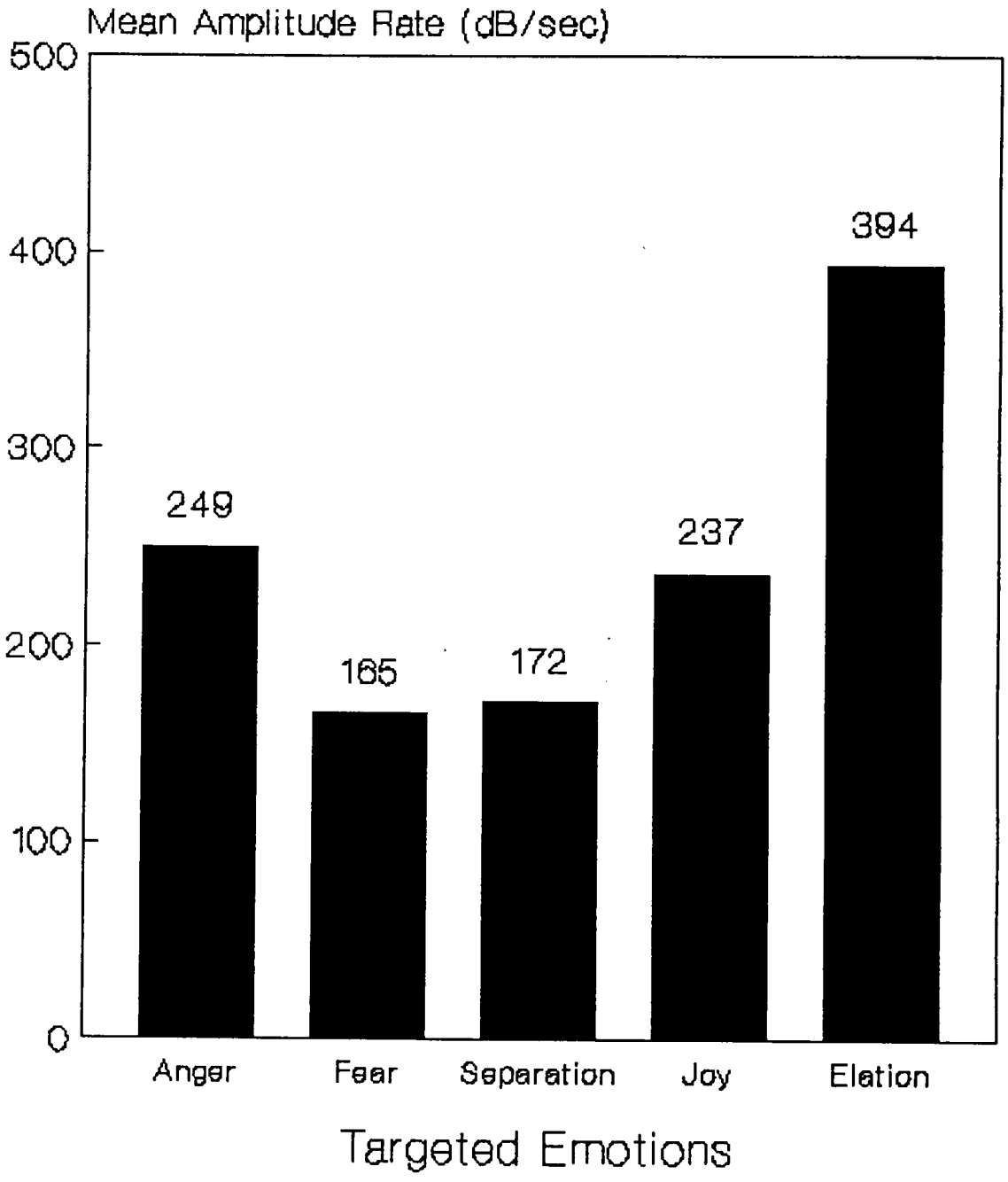

Figure D-4. Relative amplitude rate of 5 targeted emotions for infants

VITA

Charlotte Ann Hubbard was born in Lawrence, Kansas on March 3, 1952. She attended elementary schools in that city, and was graduated from Lawrence High School in May 1970. The following August, she entered the University of Kansas, Lawrence, Kansas, and in March 1975, she received a Bachelor of Science in Education with a major in Speech Pathology. In June 1975, the author entered the Graduate School of Wichita State University, Wichita, Kansas, and completed the Master of Arts degree in Logopedics in August 1976. She fulfilled the position as Speech/Language Pathologist in the Marysville Public School District, Marysville, Kansas from August 1976 until June 1978. In September 1978, the author moved to Berrien Springs, Michigan to begin a position as Instructor in Communicative Disorders at Andrews University. In September 1981, she entered the Graduate School of the University of Tennessee, Knoxville and received a Doctor of Philosophy with a major in Speech and Hearing Science in August 1991. She has accepted a position as Assistant Professor in the Department of Speech Pathology and Audiology at Ball State University, Muncie, Indiana which begins in August 1991.