BODY, FACE, AND VOICE:
NONVERBAL EXPRESSION OF EMOTION IN INFANCY

A Dissertation
Presented to the
Faculty of the Graduate School
Hahnemann University

In Partial Fulfillment
of the Requirements for the Degrees
Doctor of Philosophy
and
Master of Creative Arts Therapy

by
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August, 1994

Abstract

Ever since the work of Charles Darwin, there has been scientific inquiry into the nonverbal expression of emotion. Especially in the past 25 years, evidence for specific constellations of emotional signals has been accumulating. Whereas patterns of facial expression of many basic emotions have been well established, there is insufficient objective research into the vocal and body movement signals of the fundamental affect states. The study hypothesized that there are specific combinations of vocal and body movement signals that co-exist with facial expression constellations. Eighty segments of 13-month old infants displaying facial expressions of joy, interest, sadness, or anger were coded for the simultaneously occurring vocal and body movement signals of emotion. Vocalization parameters including phrase length, volume, pitch range, and harmonic tone were found to distinguish the emotions. Body movement indicators of emotion included the changing of the body shape in space, and the quantity and quality of shifts in muscular tension. Conclusions support the differential emotions theory (Izard, 1972).

Dedication

To my grandfather, Con Amore,
for his professional legacy.

To my father, Warren,
for nurturing my intellect
and caring for my physical needs.

To my mother, Cynthia,
for giving me emotional
and spiritual direction.

Acknowledgments

I wish to thank my committee members
Louisa Seraydarian Ph.D., Sherry Goodill MCAT, ADTR,
Mike Williams Ph.D., Myrna Shure Ph.D., Harvey Kushner Ph.D.,
Gayle Gates ADTR, and Paul Nolan RMT-BC
for their interest, help and guidance,
with a special thank-you to Dr. Carroll Izard,
for use of his laboratory, archives, students, and funding
as well as for his vision.

Specific thanks go to
Hillary Merman and Amy Williams for body movement coding;
Jennifer Phillips, Monica Brown, Kristen Black and Mindy Kane
for vocal coding;
Kathy Foster, Glen Johnson, and Helen Crosby for pilot vocal coding;
Lisa Goldstein, Ruth Gaudreau, Rita Jacoby, Shawna Gray and Anne Brownell
for pilot body movement coding;
Dr. Bill McCown for early guidance;
Lisa Currie for emotional support during graduate school;
Drs. Judith Kestenberg, Janet Kestenberg-Amighi, Martha Davis,
and Mark Sossin for their previous work and personalized guidance;
Nick McGeorge, James Cuddy, Jeffrey Durham, and Andreas Nicolau for
computer support;
Dr. Leonard Derogatis, Dr. Arthur Nezu and Dianne Dulicai
for their acceptance and support at Hahnemann;
Dr. Maurice Haynes, Chris Hyde, Kathy Spiker, Kristen Black
and many others at the University of Delaware
Human Emotions Laboratory for their help;
and finally Christine Stevens for inspiring me to finish the darn thing.

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There're no words to say
No words to convey
This feeling inside...

Deep in my heart
Safe from my guards
Of intellect and reason
Leaving me at a loss
For words to express my feelings...

- Tracy Chapman (1988).

Introduction

Research Problem and Questions

When a baby shows a particular expression on its face, what is it showing in its body and voice?

What particular body movements and vocal expressions best distinguish between the different expressions?

Rationale

Facial, vocal, and body movement signaling of emotion have been studied in the past, but mostly independent of one another (Scherer, 1979, 1982, 1986, 1988, 1989; Izard, 1972, 1979, 1982, 1984; Ekman, 1972; Kestenberg, 1975). Research of the different expression systems, up to this point in time, have taken place in relative isolation.

Various researchers have called for more research simultaneously measuring the different channels of emotional expression. In 1989, Scherer stated "In the future, it will be very important to combine studies of vocal and facial affect expression, because there are important interdependencies on the muscular level" (Scherer, 1989, p.255). In 1990, Sossin called for validation studies of the Kestenberg Movement Profile by "using known scales and encoding methods for affect and temperament" (Lewis & Loman, 1990, p.167) and recommended doing so through infant research on early affect development. Ekman (1993) and Zajonc (1992) call for more research in identifying the unique constellations of physiological and bodily patterns for each basic emotion. Ekman also suggests studying infants in order to examine ontogeny, and encourages more study of the voice and body. Izard also has been encouraging more cross modality study of the body, voice and face as indicated by his support of the current project.

Thus, it would follow that there is a strong need for a study that examines vocal, facial, and body movements; three systems that involve the muscular tension-flow. To better understand the entire nonverbal system of emotional expression, studies that simultaneously measure expression in the various expression systems need to be done.

Purpose

The purpose of this study will be to measure facial, vocal, and body movement expression of emotion simultaneously in the same infant subjects so as to establish the relationships that are expected to exist between these three emotion signaling systems.

Emotion and Expression

In order to discuss emotional expression, it is first necessary to distinguish between emotion and expression. Izard (1972, p.2) says that emotion can be thought of as having three components, the subjective phenomenological quality, the neurological expressive pattern, and the neural substrate. The internal subjective experience or feeling therefore is thought of as a related function to the outward objective behavior of expression that accompanies and may indicate the emotion. The study of emotion has grown through exploration from each of these perspectives, but since the onset of behavioral observation and psychological science, researchers have been mostly attempting to study emotion by studying expression.

There are many questions to be answered regarding the relationship of emotion and expression. First, how do they interact with one another and with other psychological processes? Which comes first, the emotion or the expression? Or does something else come first, such as a thought or a reflex reaction to a emotion eliciting event? In short, what causes emotional expression to occur? Second, what is the purpose of expression? What functions does the expression serve? Why do we express ourselves and what effect do our expressions have? Thirdly, do different and discrete emotions exist and can we identify them by their expression? And finally, in what ways and through what channels do we express our emotions and how? I will discuss each of these questions in turn.

The cause of expression

The 19th Century Zeitgeist: Emotion causes Expression. In the 19th century, previous to Charles Darwin and William James, the prevailing common sense belief about emotional expression was that it was the result of an inner feeling. One experienced an emotion internally, then had an emotional reaction, then expressed feelings. The emotion and the resulting expression were thought to be triggered by either an external emotion-eliciting event such as a snarling dog or loving wife or an internal event such as suddenly remembering a debt. The paradigmatic order was: *Event -> Emotion -> Expression.*

William James: Action causes Emotion. In 1894, William James (1894/1994) wrote an article entitled "The Physical Basis of Emotion". James put forward a theory that he shared with Professor Lange of Copenhagen, that the expression of emotion was the effect of "organic changes, muscular and visceral". Emotion was seen as a secondary feeling aroused out of the primary organic changes caused by reflexes following an exciting object or thought. Subsequent writers (Izard, 1990b; Lang, 1994; Ellsworth, 1994) have discussed the importance of James' impact on the study of emotion. The theory, dubbed the James-Lange theory of emotion, was simplified to be understood as stimulus precedes action which precedes emotion. In other words, the experience of emotion is caused by the physical reaction and behavioral action that reflexively follows from an eliciting event. The order was rearranged to: *Event-> Expression-> Emotion.*

Sensory Feedback Hypothesis: Expression can cause Emotion. Darwin and James both believed that emotion could be activated by expressive behavior and that expression is used in the regulation of emotion. Many current theorists are re-examining this idea and have dubbed it the sensory feedback hypothesis. It has found substantial empirical support (Izard, 1990a) and it is currently believed that facial expression itself can trigger emotion-specific behavior and plays an all-important role in regulating the emotions system. James' emphasis on the bodily sensations points to the need for measurement of emotion-specific bodily movement and vocalization. He said "we feel sorry because we cry, angry because we strike, afraid because we tremble" (cited in Izard, 1990b). If we could establish that these vocal and body movement behaviors co-occur with the discrete facial expressions, there is support for James' argument. Riskind (1984) and Duclos et al. (1989) found that physical posture has an effect on subsequent emotion experience. Induced facial expressions and postures produced emotion-specific reports of internal emotional experience. Expressive body movement, therefore, plays a regulatory function in emotion and motivation as well as facial expression thus supporting the sensory feedback hypothesis.

Cognitive Psychology: Cognition causes Emotion. With the onset of cognitive psychology, a new debate emerged. Cognition entered the equation. Cognitive theorists such as Richard Lazarus (Lazarus, Averill & Opton, 1970) believe that the cognitive processes of appraisal and attribution lead to the emotional experience and that cognitive "appraisal is a necessary as well as sufficient cause of emotion" (Lazarus, 1991, p. 352). Lazarus believes that even the relationship between emotion and expression is cognitively mediated. Simplified: *event -> cognition -> emotion -> cognition -> expression.*

The Primacy of Affect: Affect precedes Cognition. Zajonc (1980) challenging Lazarus, proposed the affective primacy hypothesis and has shown support for his theory in a series of experiments. One study (Murphy & Zajonc, 1993) showed that subjects had preferences (a gross affective discrimination) for affectively neutral stimuli that were preceded by a suboptimal (4 millisecond) presentation of a smiling face versus those preceded by a an angry face. No such difference was found when the happy and angry faces could be fully recognized (over 1000 milliseconds). Zajonc argues that there is sufficient evidence for the primacy of affect. Another possibility of the order of emotion could be: *Event -> emotion -> cognition -> action.*

Multidetermined emotion: Action, cognition and emotion cause emotion. For Izard (1972; 1992; Izard, Libero, Putnam & Haynes, 1993), also in contrast to Lazarus, emotion is not necessarily preceded by cognition. Emotion, instead, is mediated, elicited, and influenced by "innate releasers, homeostatic processes, drives, and other emotions or emotion components" (p. 80) as well as by cognitions. Emotion changes cognition with its motivational effect and affective-cognitive structures are built. The emotion system is at once independent from and interactive with the cognitive and behavioral systems. Izard (1977, 1992) states that emotion as an internal feeling state is the result of neural processes associated with the emotion being experienced. Basic emotions described as being unique feeling-motivational states with innate and universal expressions and innate neural substrates can have noncognitive activators.

The primacy of emotion or cognition is an ongoing debate but the most likely explanation is that simplistic views do not adequately describe the complex system. The most probable scheme is a system such as:
Event -> cognition and emotion -> expressive and adaptive action.

The purpose of expression

Emotion is what makes us human. Although the historical emphasis on William James' theory has been on the structure and mechanics of emotion, James' real emphasis was on the subjective feeling of emotion and the psychology of emotion. He believed that without feelings, thought and action are "void of human significance" (James, 1890/1950). It is emotion that makes us human and is at the core of individual differences in personality and the primary motivator for behavior.

Emotion is evolutionarily adaptive. Carroll Izard (1972), following Darwin's lead, developed the Differential Emotions Theory (DET). DET stresses the important role of innate factors. Izard believes that the various emotions are inborn and universal, that this is so because they have served an adaptive function in the evolution of the species and that different and discrete emotions emerge through development. Ekman (1972, 1993) also has shown that discrete emotion expressions are cross-cultural and can be distinguished from one another adding support for the universally adaptive function of emotion and expression.

Emotion serves a motivating function. Izard says that emotions serve as "the most important motivating and meaningful experiences of human life and [have] inherently adaptive functions" (Izard, 1972, p.82). Emotion experiences give rise to behavior through action tendencies that become associated to the emotional state. Some psychoanalytic theorists (Schwartz, 1987) also believe that the affects are the prime motivators of behavior, originating in the limbic system and activating motor behaviors including facial expression, and expressive posture and tone of voice.

Emotion is the basis of personality. Emotion is seen as fundamental in personality development. The individual differences seen in emotion activation thresholds lead to different rates of experiencing each of the emotions and the rates of experiencing the various emotions lead to personality traits. For instance, experiencing the positive emotions is related to extroversion while experiencing the negative emotions is more related with neuroticism . An interaction is also found between a mothers' and infants' personality or temperament and their expressive behaviors (Izard, Libero, Putnam & Haynes, 1993).

The specificity of expression

There has been a debate throughout the history of the study of emotion about the specificity of emotions. Some theorists insist that there exist discrete and qualitatively different emotional states. Others believe that emotions can best be understood in dimensional paradigms suggesting that there are varying levels of arousal or intensity and varying levels of pleasantness and unpleasantness or positivity and negativity. Still others such as Izard (1993) see the categorical and dimensional approaches as complementary, not contradictory. Ekman (1993) agrees that it is useful to think of emotions in terms of different intensities and levels of arousal as well as considering them to be discrete states.

The argument for discrete emotions. Darwin (1872) was probably the first to scientifically examine emotional expression. He did so when writing "Means of Expression in Animals" in 1872. He was the first to raise the question as to whether there are only different intensities of emotion as opposed to different qualities of emotion. He found that the "emission of sounds", vocal and otherwise, as well as various muscular movements were indicative of the particular emotional "state of mind" of the animal thus supporting the view that there are clearly distinguishable emotional states even in animals. Taking a more dimensional view, he stated that the only difference between emotional and non-emotional sounds was the volume which indicates . Darwin believed that clear distinctions between emotional states could be signaled by children under the age of two.

William James also spoke of discrete emotions. In James' theory, the discrete emotions are said to be brought on by the associated action. We are frightened because we run, feel angry because we strike and perhaps feel joy because we smile. This notion is being actively explored by the sensory feedback hypothesis of emotion activation and more specifically by testing the facial feedback hypothesis by contemporary biosocial emotion theorists (Izard, 1990a). A couple of the associated actions James spoke are approach and withdrawal behaviors which may be understood as a dimensional view of emotion. Since evidence is lacking supporting the hypothesis that all positive emotions involve approach while all negative behaviors involve withdrawal, an argument is made opposing the dimensional view and supporting the notion of discrete emotions.

In making an argument for the concept of basic emotions, Ekman (1992) calls for more research in distinguishing the universal signals and physiology of the distinct emotions. Evidence for the presence of universal and discrete emotions supports the bioevolutionary view that emotional signaling is an adaptation of the species and a motivational aspect of human behavior. The opposing view, that of the social constructivists who maintain that emotional behavior is learned through schedules of reinforcement and punishment, would be supported by the lack of discrete and universal emotional signals, because learning is more affected by cultural context and thus emotional signals would not be universal. Distinctive universal signals and distinctive physiology are two of the characteristics which Ekman uses to distinguish basic emotions from one another and from other affective phenomena. Ekman and Izard have both found cross-cultural signals of the discrete emotions.

Specific empirical support for the existence of discrete emotions exists in the research of Izard (1993) who found that the discrete emotions accounted for more of the variance than did the positive-negative dimension in studying the relationship between emotion and personality.

The argument against discrete emotions. Zajonc (1992) in his review of physiological studies of emotion found an overall lack of support of evidence for the discrete emotions, finding instead that there are many physiologic correlates along the positive-negative emotionality dimension. Among these are evidence for brain lateralization with positive emotion being found in the left hemisphere while negative emotion was found in the right hemisphere. Changes in breathing patterns and temperature also varied along positive-negative emotion lines.

<u>Channels of expression</u>

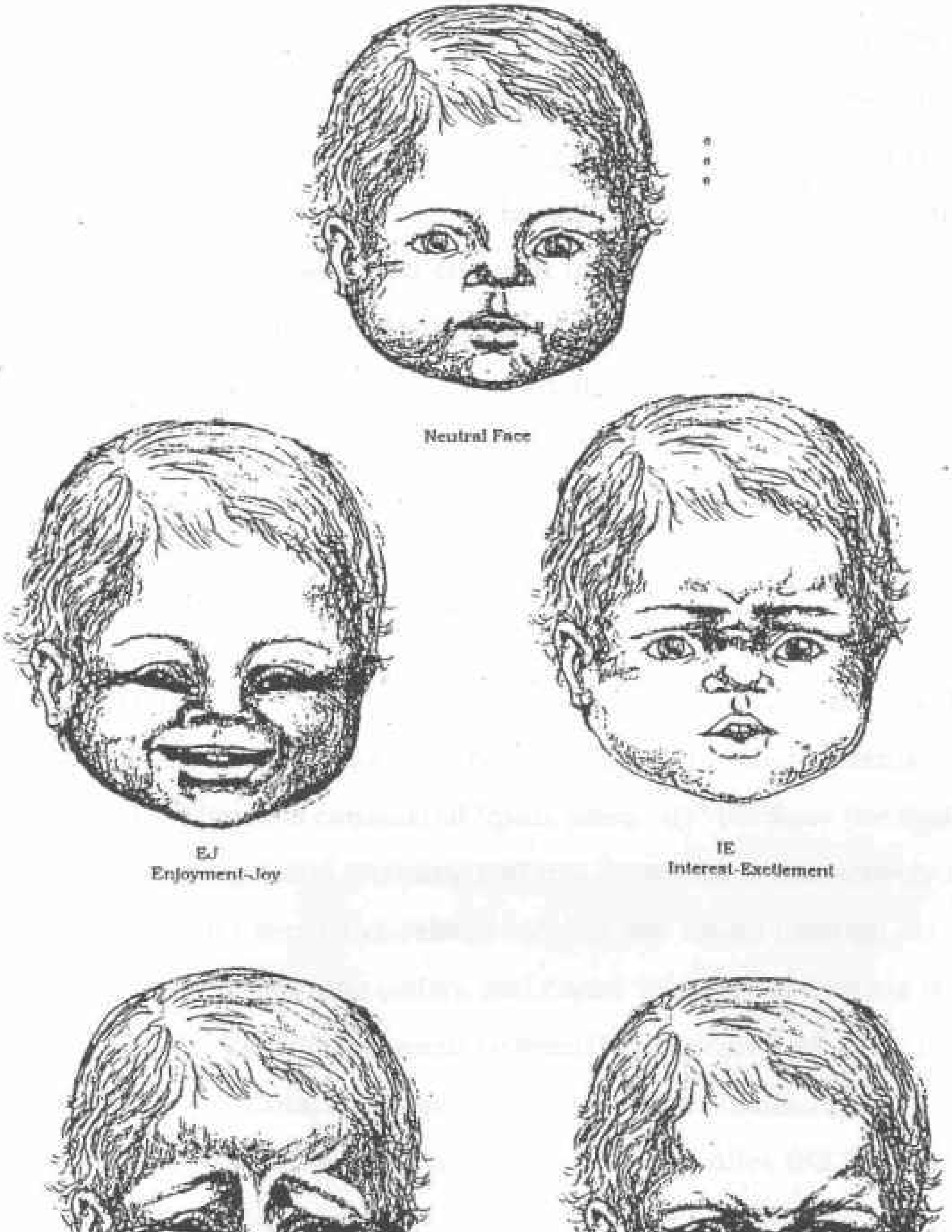
Are the vocal, facial and bodily channels of expression one system or separate systems? It is likely that they share the same substrates in the autonomic nervous system but it is also likely that they develop at different rates and that individuals have preferred channels of expression and differ in their abilities to inhibit their emotional responses in particular channels. Culture and learning may play a part in this but individual differences exist within cultures as well. For instance, some people from some cultures are particularly expressive with their hand gestures and some people from other cultures may do well in inhibiting their facial expressions but not their vocal expression.

Ekman (1992) and Izard (presently) have been busy finding the physiological substrates of emotion expression by identifying distinctive patterns of autonomic nervous system (ANS) activity in the various emotions. ANS patterns serve to prepare a person for the adaptive action and motor behavior that accompany an emotion. The mechanism by which physiological reaction is converted to behavior, either expressive or adaptive, has been called an action readiness by Frijda (1986) and an action plan by Johnson-Laird and Oatley (1989) and Stein and Levine (1989). An action readiness or plan is said to exist for each discrete emotion. Plans and readiness are difficult to observe and it may be easier to measure the action itself.

Ekman and his colleagues have studied the different channels of emotional expression including facial expression, vocal expression and body movement expression. Facial expression has been well established as

Carroll Izard found support for these facial configurations using his two complementary systems for measuring facial expression. The intricacies of this method warrant description. The Maximally Discriminative Facial Movement Coding System (Max) (Izard, 1979) is a method that assigns numerical codes to 29 particular muscular movements of the face. Three regions of the face; namely the brow, eyes, and mouth regions, are coded. Max coding requires three viewings of a video segment in order to separately assign the unique codes to the three facial regions. Real-time and slow-motion viewings are used. Inter-rater reliability has been established at 83%. Figure 1 (reprinted with permission from Izard & Dougherty, 1982, pp. 68-73) illustrates Max appearance changes.

Figure 1
Max Appearance Changes



Izard's second system entitled The System for Identifying Affect Expressions by Holistic Judgments (Affex) (Izard & Dougherty, 1980), makes use of and elaborates on the Max system. Coders identify and label affect by analyzing and integrating all of the movements of the face. Only one run of each video segment is needed for Affex coding and thus leads to greater efficiency. The affect codes are assigned, basically, through the knowledge of the combinations of Max codes that co-occur to signal a particular and distinct emotional state. Affex codes can signify either full-face combinations of a single affect (such as when brows, eyes, and mouth signal a single affect, such as anger) or can signify a blend of signals (such as when the brow signals interest and the mouth signals joy). Figure 2 (reprinted with permission from Figures 5.1 - 5.4, Izard & Dougherty, 1982) shows photographs of full-face expressions of four discrete emotions.

Intra-system reliability of Affex has been found to average 86.5%. There is also sufficient evidence for the validity of the Max and Affex systems. Content-related evidence is considered "quite adequate" because the system involves all parts of the facial anatomy and has drawn on a wide variety of literature. Evidence for construct-related validity was found through an agreement of 88% between Max coders and Facial Expression Scoring Manual (FESM) coders and a 78.2% agreement between Max coders and Affex (the revised FESM) coders. Criterion-related, or predictive evidence of validity was established through the agreement of Max (59.1%) and Affex (62.7%) coders with judgments of untrained raters of emotional state.

Figure 2
Full face expressions of Four Discrete Emotions

5.1. Four-and-one-half-month old male expressing interest

Figure 5.3. One-month-old female expressing sadness

5.2. Seven-month-old male expressing joy

Figure 5.4. Six-month-old female expressing anger

Vocal Expression

Specific and discrete signals of emotional states through vocal expression was again begun with the observations of Darwin and his discussion of the previous work of Herbert Spencer. Great strides in understanding this channel of expression have been made in recent years by the work of Klaus Scherer. A discussion of the particular descriptions of emotional vocalization follows.

Darwin said, "With many kinds of animals, man included, the vocal organs are efficient in the highest degree as a means of expression" (1872, p. 83). According to Darwin, loud sounds are uttered when an animal is strongly excited, terrified, or in the extremity of suffering or distress such as with the cry of a puppy. He attributes this to involuntary contractions of the chest and glottis when the animal becomes emotionally excited. Social animals use their "vocal organs as a means of intercommunication" and signal emotions such as the anticipation of pleasure and loneliness by incessantly calling to one another such as with the neighing of horses or the bleating of sheep. Joy, pleasure, and satisfaction are also said to be vocally expressed as in the deep grunt of a satisfied pig. Astonishment is expressed in monkeys by a "half-piping, half-snarling noise". Impatience is expressed through the use of high piping notes by dogs. Pain and distress are expressed using outcries and shrill screaming which are loud, harsh, prolonged, and high. Anger, in the case of the monkey, is signaled by a deep grunting. Rage is expressed through the use of power and harshness in the voice such as with the roar of a lion or the growl of a dog. He points out that vocal signaling is not exact and he uses the barks of anger and of joy in a dog as an example of similar sounds that signal different emotions.

Vocal emotional expression in humans was addressed by Herbert Spencer in 1858 (Spencer, 1858; as cited by Darwin, 1872). He said that the human voice alters under various emotional states and that this alteration can be heard in the acoustic parameters of loudness, resonance, timbre, pitch, and intervals. Darwin elaborates saying that pitch and interval, such as used in singing, are stressed when humans express emotions that have evolved from courtship behavior, namely love, rivalry, and triumph. Complaining and slight suffering are heard through the use of high pitch. Contempt and disgust are shown by blowing out often producing the sound *pooh* (or *peyoo*). Startle and astonishment are signaled by a rapid inhalation followed by the sound *Oh*. Surprise when paired with pain is expressed through a high pitched inhale with the sound of *Ah* (or *Ow*). Fear is heard through the trembling and husky quality of the voice. Agony and pain are signaled through the use of either deep groans or high piercing screams. Enjoyment and amusement as expressed through laughter or tittering are expressed either through the use of rapidly reiterated interruption, high or low pitch, and distinctive vowel sounds, such as *O* and *A* with men and *E* and *I* with women and children. Passion is signaled through the use of forcible utterances using "great exertion of vocal force". Expression, in general, according to Darwin, relies mostly on the speed, loudness, and "smoothness of flow" of the utterance. Table 1 summarizes Darwin's observations of vocal emotional expression.

Table 1

Summary of Darwin's observations of vocal expression of emotion

Emotion	Loudness	Time	Pitch	Timbre	Example
Excitement	loud				
Passion	forceful				
Love			variable		
Triumph			variable		
Joy					dog bark
Enjoyment		rapid	high or low	"o/a"	human laughter
Amusement		rapid	high or low	"e/i"	human tittering
Pleasure		incessant			sheep bleat
Satisfaction			deep		pig grunt
Surprise			high	"ah"	human inhale
Astonishment		rapid			monkeypiping
Startle		rapid		"oh"	human inhale
Fear			trembling	husky	
Terror	loud				
Distress	loud			shrill	puppy outcry
Loneliness		incessant			horse neigh
Suffering	loud		high		
Agony			deep		human groan
Pain	loud	prolonged	high	harsh	human scream
Anger			deep		dog growl
Rage	powerful			harsh	lion roar
Rivalry			variable		
Complaining			high		
Impatience			high		dog piping
Contempt				"pish"	human exhale
Disgust				"pooh"	human exhale

Note. compiled from Darwin, C. (1872). Means of Expression in Animals.

Klaus Scherer has recently led the empirical research into the vocal expression of emotion. Scherer (1982, 1988) has extensively reviewed the research into the emotional expression of the voice. He has identified specific patterns and combinations of acoustic parameters of the voice which signal discrete emotional states. Table 2 presents a compilation of results from research projects which he has reviewed.

Table 2

Summary of results on vocal indicators of emotional states

Emotion	Joy	Anger	Fear	Sadness	Surprise
Pitch Level	high	high	high	low	high
Pitch Range	-	wide	wide	narrow	-
Pitch Variation	large	-	-	small	large
Pitch Contour	up	up	up	down	up
Loudness	loud	loud	-	soft	-
Amplitude Variation	moderate	-	-	-	-
Tempo	fast	fast	fast	slow	fast
Harmonics	few	many	many	few	many
Envelope	sharp	-	round	round	sharp
Sequence	-	-	fast	-	-

Note. compiled from tables presented by Scherer & Oshinsky, 1977, p.340 and Scherer, 1979, p.513.

These results were obtained mostly from spectrographic analysis of role-played emotional states of adults to uncover the underlying acoustic parameters of emotional vocalization. A typical study asked adults to speak an emotionally neutral sentence such as "I can't believe it" in different emotional tones, such as in surprised, angry, sad, and fearful tones of voice. The results were then obtained through the process of mechanical voice analysis.

There have been three basic approaches to the quantification of vocal behavior used in past research (Scherer, 1982). On the most objective end, computerized spectrograhic analysis has been used. This method is costly in terms of equipment, time, and the expertise needed to analyze the results. On the most subjective end, rater's judgments of the underlying emotional state of the subject have been used. In this method, raters simply ascribe an emotion such as angry, sad, fearful, joyful, or interested to a vocalization. Although this method is economical, it lacks the descriptive capacity to better analyze the particular characteristics of the vocalization that may signal the emotional state of the subject. In between these two methods on the objective-subjective continuum, a middle range method exists in which raters auditorily assess the different acoustic parameters of a vocalization. This method is more efficient than spectrographic analysis and more descriptive than the simple attribution of emotional states. It would, however, be dependent on the expertise of the raters and their ability to accurately judge the acoustic parameters present in the vocalizations.

Although considerable research has been done on the vocal expression of emotion (Scherer, 1979, 1982, 1986, 1988, 1989), no formalized and up-to-date system of assessing the acoustic parameters in vocalization has been developed. A System for the Auditory Assessment of Acoustic Parameters in Vocalization (SAAAPIV; Burt, 1991) has been proposed to fill that gap in behavioral research. The primary purpose of SAAAPIV would be to measure the acoustic properties of human vocalizations by using the auditory assessments of trained raters. Raters would use the system to describe 10 specific acoustic characteristics of 4 general parameters of vocalizations; pitch, volume, time, and tone. Within the pitch domain, the mean pitch level, the pitch range, and the pitch variability would be assessed. For the volume domain, the mean loudness, and the loudness variability would be rated. Within the time domain, the duration, tempo, and rhythmicity of the vocalization would be assessed. And for the tone domain, the harmonics present and the quality of the timbre would be rated. For the operational definitions of terms and constructs, please refer to the glossary.

The only other known instruments used for this purpose were developed in 1957 and 1964, long before Scherer's work to summarize the research findings in this field. The first, developed by Trager and Smith (1957) was designed to examine the paralinguistic aspects of English speech. The second, developed by Markel, Meisels, and Houck (1964) was used to judge personality from voice quality. These schemes focused mostly on pitch and loudness and did not have the benefit of previous objective research in the guidance of their construction. The SAAAPIV, on the other hand, draws on the most recent research. Another problem with these schemes, as described by Scherer (1982) was "the assumption of a standard or modal level for different parameters that can be used to determine deviations". The SAAAPIV shares this potential drawback but, as evidenced by preliminary studies of its validity and reliability, the assumption of modal values for a homogenous group of vocalizers has verification and stability.

The relationship between emotion in music and vocal expression

It has been hypothesized that the emotion that we experience when we listen to music has its roots in the expression of emotion through the voice. Herbert Spencer (as quoted from his 1858 essay "The Origin and Function of Music by Darwin, 1872), stated that "emotional speech...is intimately related to vocal music, and consequently to instrumental music". This is said to be the case because "a feeling is a stimulus to muscular action" and the voice, thusly, is affected. Darwin, however, sees this as too general and vague, and can only see loudness as the difference between ordinary and emotional speech. Many researchers have investigated the link between emotion and music (Meyer, 1956; Merriam, 1964; Radocy & Boyle, 1979; Sundberg, 1982a, 1982b; Konecni, 1982; Stratton and Zalanowski, 1989) and have generally found support for Spencer's point of view.

Body Movement Expression

Two aspects of body movement have been examined in regards to their emotional expressiveness, the use of spatial configurations of the body through posture and gesture, and the modulation of the tension in the muscles of the body.

From the world of dance and dance therapy, much has been written on the expressiveness of movement. Marion North (1972), one of the founders of dance/movement therapy, believed that one can learn about a person's state of mind and personality through analyzing their movement patterns. Expanding on the work of Rudolph Laban, she postulated that an individual's variable use of each of the four identified movement factors, the use of weight, the use of space, the use of time and the use of tension flow, could predict the person's personality type. They employed Carl Jung's personality types and related the use of weight with the characteristic of sensing, the use of space with thinking, the use of time with intuiting and the use of tension flow with emotional feeling. Someone observed to be using a great deal of modulation in their use of tension was said to be emotional although the identification of the discrete emotions being experienced is not explicit in the Laban/North conceptualization.

Posture and Gesture as expressive movement

Riskind (1984) did a series of experiments about the causes and effects of postures. Operating with the well-documented assumption that a slumped posture signaled failure while an erect posture signaled success, he found that when subjects mismatched their posture with their experience of success and failure, subsequent changes in mental and emotional states would occur. He concluded that slumping during success was likely to result in less subsequent motivation and less sense of control while slumping during failure actually minimized the experience of depression and helplessness as well as encouraging future motivation. These findings support the theories that see expressive behavior as adaptive and the findings that assume that expressive behaviors can effect subsequent emotion experience. Duclos et al. (1989) also found that adopting expressive postures affects internal emotional experience.

Sogon and Izard (1987) showed that subjects from one culture could identify discrete emotions bodily expressed by dancers of another culture. Although the elements of the expressive movements were not described, this study shows some preliminary evidence that body movement expression of emotion, just as facial expression has been shown to be, is cross cultural and perhaps innate.

In a review of the relationship between affect and body movement, Rossberg-Gempton and Poole (1992) outlined the history of the subject and its debates. They point out that William James' subjects used their own posturing in the interpretation of another's posture leading James to delineate "postures as seen" from "postures as felt". James also described postures using the terms approach, withdrawal, expansion, and contraction. Approach is said to signal attention while withdrawal signals repulsion. Expansion of the body signals varied emotions including pride, conceit, arrogance, and disdain while contraction or the shrinking of the body is said to express feelings of depression and dejection.

Muscle Tension as expressive movement

Darwin (1872) noticed that muscle tension in the body plays a part in the signaling of emotion. For instance, according to him, pain is expressed through the body by a rapid contraction of all the muscles of the body, including those of the face, resulting in trembling.

Modern day researchers have also observed and measured muscle tension in an attempt to identify unique constellations of body expressions for the basic emotions. Manfred Clynes (1989) measured different muscle pressure patterns in various emotion states using pressure gauges called sentographs. Zajonc and McIntosh (1992) reporting on experiments by Levenson, Ekman, and Friesen (Ekman, Levenson, and Friesen, 1983; Levenson, Ekman, and Friesen, 1990; Levenson, Carstensen, Friesen, and Ekman, 1991), state that muscle activity in terms of muscle tension and somatic activity is the worst discriminator between the discrete emotions. Ekman and his colleagues used the task of instructing subjects to move facial muscles into facial prototypes of emotional expressions and measured the accompanying physiological changes. Of the four measures, they found that heart rate distinguished between the emotions the best, finger temperature and skin conductance discriminated moderately and muscle activity the worst. Only when the experimenter manipulated facial expression was accompanied by imagery of past emotional experiences did subjects show any discriminating differences between emotions in their somatic activity. Fear and sadness had less accompanying movement than happiness, anger, disgust and surprise.

Other researchers associate a high level of tension with feeling anxious (Jacobsen, Barlow), fearful (Mehrabian), resistive (Braatoy, Reich), and excited (Duffy). Relaxation of the muscles has been associated with disrespect (Mehrabian) and total immobility of the muscles is said to be related to feeling inhibited (Deutsch) (Rossberg-Gempton and Poole, 1992).

The most comprehensive method of observing movement patterns has emerged in the fields of dance and dance therapy. Judith Kestenberg, a psychiatrist and pioneer in movement analysis expanded on the work of Rudolph Laban (Laban & Lawrence, 1947). Kestenberg points to the modulation of the muscle tension in the body as the prime signal of emotional state. The movement or *flow* of muscle tension in the muscles of the body is called *tension-flow*. By examining tension-flow in detail, Kestenberg (1975; Berlowe & Kestenberg, 1990a; Lewis & Loman, 1990) has noticed that there are particular patterns of tension-flow that she calls *rhythms*. The rhythms are particular combinations of the *attributes* of the tension-flow. The attributes include the *intensity* of the tension (either high or low), the *consistency* of the change in the tension-flow (either even or adjusting), and the speed or the *slope* of the *change* in the tension-flow (either gradual or abrupt). In addition to the attributes described by Kestenberg, the nature of the *reversal* of the tension-flow (either round or sharp) has been found to be useful.

The rhythms of tension-flow develop in the infant and child in a predictable developmental sequence and originate in necessary bodily functions. *Oral* rhythms are established through the functions of sucking and biting used in early infant feeding. *Anal* rhythms are learned through the development of control over the retention and elimination of feces by the anus. *Urethral* rhythms develop through the use of the muscles involved with the urethra to allow for either the interruption or fluid release of urine. *Inner genital* rhythms have their prototype in the slow undulations of the birth canal in women that is evident during sex and childbirth. *Outer genital* rhythms have their origins in the thrusting of the male during sex. Each of these rhythms can have either a *libidinal* or *aggressive/sadistic* quality. Aggressive/sadistic rhythms are usually of either higher intensity or incorporate more abrupt changes in the tension-flow. Thus, 10 different tension-flow rhythms exist, each being made up of unique combinations of the tension-flow attributes. Table 3 presents these combinations as they are conceived by the author based on Kestenberg (Berlowe & Kestenberg, 1990).

Table 3

Tension-flow rhythms as unique combinations of attributes

	Tension-Flow Attribute			
Rhythm	Consistency	Intensity	Change/Slope	Reversal
Oral				
sucking[a]	even	low	abrupt	round
snapping	even	low	abrupt	sharp
Anal				
twisting	adjusting	low	abrupt	round
defecating	even	high	gradual	sharp
Urethral				
running	adjusting	low	gradual	round
run-stop-go	adjusting	low	gradual	sharp
Inner-Genital				
undulating	even	low	gradual	round
large wave	even	high	gradual	round
Outer-Genital				
jumping	even	high	abrupt	round
leaping	even	high	abrupt	sharp

Note. Table conceived by Burt based on Kestenberg (Berlowe & Kestenberg, 1990)
[a] in each set of rhythms, the libidinal rhythm is listed above the aggressive/sadistic rhythm

Kestenberg (1975) implicates both tension-flow and what is called *shape-flow* in the bodily expression of emotion. Shape-flow, similar to the posture patterns identified by William James, is made up of the elements of growing and shrinking that occur in each of the three dimensions in which the body exists (vertical, horizontal, and sagittal). There is said to be a natural coordination of tension-flow and shape-flow resulting in paired combinations called *affinities*. Kestenberg (1975, p.198) has paired some emotional states to these affinities as can be seen in Table 4.

Table 4

Affinities and emotional states as described by Kestenberg

Emotion	Shape-flow		Tension-flow attribute
Poise	narrowing	with	even flow
Pleasure	widening	with	flow adjustment
Strain	shortening	with	high intensity
Pleasure	lengthening	with	low intensity
Impatience	hollowing	with	abrupt change
Content	bulging	with	gradual change

From Kestenberg's work, the Kestenberg Movement Profile (KMP) (Sossin, 1987; Lewis & Loman, 1990; Berlowe & Kestenberg, 1990), a behavioral rating scale, has been developed. The parts of the KMP that are designed for the observation of tension-flow attributes and shape-flow were employed for this dissertation.

Multi-system Expression

As is the case, Darwin (1872) was the first to relate the auditory reception of emotion with both the vocal and body movement expression systems by saying "it is obvious that whenever we feel the 'expression' of a song to be due to its quickness or slowness of movement - to smoothness of flow, loudness of utterance, and so on - we are, in fact, interpreting the muscular actions which produce sound, in the same way in which we interpret muscular action generally" (p. 89).

Ekman advocates the use of increasing the number of behavioral modalities in the study of emotion. By looking at different channels of nonverbal behavior more can be learned about the concealment of emotion "because of differences among individuals in their ability to monitor and disguise their facial expressions, vocal characteristics or body movements" (Ekman, O'Sullivan, Friesen & Scherer, 1991, p. 126) Indicators of deceit were examined from observing the face, voice and the body. They found that deceit could be indicated facially by what they call a masking smile which involves a blend of the full face joy expression with other expressions. Vocally, deceit can be indicated by a higher pitch and in body movement, deceit may be indicated by fewer rhythmic marking or illustrative hand gestures.

Brownell and Lewis (1990) have constructed a theoretical connection between body movement and vocalization by adapting the Kestenberg Movement Profile into the KMP Vocalization Profile for the observation of vocalization.

Burt (1990a) has done preliminary work with exploring infant emotional expression by using systems that address both facial and vocal signaling. He found that untrained listeners of tape recordings made of infants expressing full-face expressions accurately agreed with previous facial coding. Raters listened to tape recordings and judged whether they thought that the baby felt angry, sad, joyful, or interested. In all but the joy-face condition, the raters judged the vocalizations as matching the facial signal significantly more than they judged the vocalization as expressing any of the other possible emotions. With the joy-face condition, there was no difference in the number of raters that judged the vocalization as joyful from those that judged it as being interest, however, significantly more of the raters judged it to be either joy or interest (positive hedonic tone) rather than anger or sadness (negative hedonic tone).

Another preliminary study done by Burt (1990b) can be used to guide and generate hypotheses for the current research project. Using trained raters' subjective ratings of acoustic parameters of 42 vocalizations, he found that the emotions of interest and joy could be distinguished from the emotions of anger and sadness on the basis of vocalization but that there were very few distinguishing characteristics found between joy and interest (affects of positive hedonic tone) and between sadness and anger (affects of negative hedonic tone). The results are presented in Table 5.

Table 5

Mean rankings and modal descriptors of auditory assessments of acoustic parameters of infant vocalizations during four facial expressions.

	Facial Expression			
Acoustic parameter	Anger	Sadness	Interest	Joy
Pitch Level.......	Moderate	Moderate	Moderate	Moderate
Pitch Range.......	Wide	Wide	Narrow	Narrow
Pitch Variability.	Large	Large	Small	Small
Pitch Direction...	Ascending	Ascending	Ascending	Ascending
Pitch Contour.....	Peak	Peak	-	Peak
Loudness..........	Loud	Moderate	Soft	Soft
Loudness Variance.	Moderate	Moderate	Small	Small
Volume Direction..	Crescendo	Crescendo	Crescendo	Crescendo
Volume Contour....	-	-	Peak	Peak
Duration..........	Normal	Normal	Short	Short
Tempo.............	Fast	Slow	Fast	Slow
Rhythm............	Rhythmic	Rhythmic	Arrhythmic	Arrhythmic
Harmonics.........	Many	Many	Few	Few
Timbre............	Nasal	Nasal	Clear	Clear
Pleasantness......	Unpleasant	Unpleasant	Pleasant	Pleasant
Characterization..	Wail	Cry	Inhale	Inhale

In Rossberg-Gempton and Poole's (1992) review, they discuss multi-system studies including research that concluded that bodily expressions do communicate affective information but facial expression is relied on more heavily by people interpreting emotional state (Dittman, Parloff & Ross, 1965). They also mention a paper that states that specific affect is communicated through movement in the body and face whereas gross affect, such as positive or negative emotion, is communicated through static postures and facial configurations (Ekman & Friesen, 1967). Ekman had also found that the head signaled more about the type of emotion while the body signaled more about the intensity of the emotion. The body was also implicated more in coping with the emotion while the face was more involved in expressing the emotion.

Hypotheses

General Hypothesis

The expectation of this research project is that there will be distinct and discernible combinations of vocal and body movement descriptors for each of the facial expression conditions.

Specific Hypotheses

More specific hypotheses were formulated based on the previous vocal research of Scherer (1979; 1982; 1988; Scherer & Oshinsky, 1977) and Burt (1990a; 1990b) and the theoretical assumptions regarding body movement expression of Kestenberg (1975; Berlowe & Kestenberg, 1990).

Vocal Co-Occurences with Facial Expressions

During full face expressions of joy, babies will vocalize with narrow pitch range, ascending pitch direction, small loudness variability, short duration, arhythmicity, few harmonics, and clear timbre.

During full face expressions of interest, babies will vocalize with moderate pitch level, narrow pitch range, small pitch variability, soft volume, small loudness variability, short duration, arhythmicity, and few harmonics.

During full face expressions of sadness, babies will vocalize with low-moderate pitch level, ascending pitch direction, soft-moderate loudness, moderate loudness variability, moderate duration, slow tempo, rhythmicity, and nasal timbre.

During full face expressions of anger, babies will vocalize with wide pitch range, large pitch variability, ascending pitch direction, loud volume, fast tempo, and many harmonics.

These hypotheses are also shown in Table 6 below:

Table 6

Hypothesized vocal co-occurences with facial expressions

	Facial Expression			
Acoustic Parameter	Joy	Interest	Sadness	Anger
Pitch Level	-	Moderate	Low-Moderate	-
Pitch Range	Narrow	Narrow	-	Wide
Pitch Variability	-	Small	-	Large
Pitch Direction	Ascending	-	Ascending	Ascending
Pitch Contour	-	-	-	-
Loudness	-	Soft	Soft-Moderate	Loud
Loudness Variability	Small	Small	Moderate	-
Volume Direction	-	-	-	-
Volume Contour	-	-	-	-
Duration	Short	Short	Moderate	-
Tempo	-	-	Slow	Fast
Rhythm	Arrhythmic	Arrhythmic	Rhythmic	-
Harmonics	Few	Few	-	Many
Characterization	-	-	-	-
Timbre	-	-	Nasal	-

Vocal Predictors of Facial Expression

The following variables will discriminate positive hedonic vocalizations (joy and interest) from negative hedonic vocalizations (sadness and anger):

Table 7

Hypothesized vocal predictors of hedonic tone

	Hedonic Tone	
Acoustic Parameter	Positive	Negative
Pitch Range	narrower	wider
Loudness	softer	louder
Loudness Variability	smaller	greater
Duration	shorter	longer
Rhythmicity	arrhythmic	rhythmic
Harmonics	fewer	more
Timbre	clearer	more nasal

The following variables will discriminate certain facial expressions from all others:

Table 8

Hypothesized vocal predictors of discrete emotions

	Facial Expression			
Acoustic Parameter	Joy	Interest	Sadness	Anger
Pitch Level	-	-	lowest	-
Pitch Range	-	-	-	widest
Pitch Variability	-	smallest	-	largest
Loudness	-	softest	-	loudest
Duration	-	-	-	longest
Tempo	-	-	slowest	fastest
Harmonics	-	-	-	most

The following variables will discriminate joy from interest:

Table 9

Variables hypothesized to distinguish emotion pairs of the same hedonic tone

Acoustic Parameter	Emotion	
	Positive	
	Joy	Interest
Vowel	a as in pat	a as in mate
Pitch Variability	greater	smaller
Loudness	louder	softer
Characterization	inhale	babble
	Negative	
	Sadness	Anger
Vowel	e as in pet	a as in pat
Pitch Level	lower	higher
Pitch Range	narrower	wider
Pitch Variability	smaller	larger
Loudness	softer	louder
Tempo	slower	faster
Harmonics	fewer	more
Characterization	cry	wail

Hypothesized Body Movement Co-Occurrences with Facial Expression

Tables 10, 11 and 12 contain the expected outcome of the co-existing body movement descriptors of the four emotional states under study.

Table 10

Hypothesized Affinities of emotional states

Emotion	Shape-flow		Tension-flow attribute
Interest	narrowing	with	even flow
Joy	widening	with	flow adjustment
	lengthening	with	low intensity
	bulging	with	gradual change
Sadness	shortening	with	high intensity
Anger	hollowing	with	abrupt change

Note. adapted from Kestenberg's terms as translated Poise -> Interest; Pleasure + Content -> Joy; Strain -> Sadness; Impatience -> Anger)

Table 11

Hypothesized Tension-Flow Attributes of emotional states

Anger - Even flow Consistency, High Intensity, Abrupt Change[a]
Sharp reversals (Outer genital sadistic - Leaping)
Sadness - Even Consistency, High Intensity, Abrupt Change
(Outer genital libidinal - jumping or leaping)
Interest - Even Consistency, Low Intensity, Gradual Change
Rounded Reversals (Inner genital libidinal - undulating)
Joy - Adjusting Consistency, Low Intensity, Abrupt Change
Rounded reversals (Anal libidinal - twisting)

Note. hypotheses formed based on combined ideas of Kestenberg, Goodill, and Burt.
[a] Underlined attributes are from full agreement.

Table 12

Hypothesized Shape-Flow Elements of emotional states

Anger -	horizontal growing	(widening)
	saggital shrinking	(hollowing)
Sadness -	vertical shrinking	(shortening)
Interest -	saggital growing	(bulging)
	horizontal shrinking	(narrowing)
Joy -	vertical growing	(lengthening)
	horizontal growing	(widening)
	saggital growing	(bulging)

Definition of Terms

Due to the amount and the highly technical nature of many of the terms used in this study, the definition of terms are included in the Glossary.

Method

The Study of Emotion

Izard (1982, 1984) proposed three basic approaches to the study of emotion; psychobiological study, behavioral-expressive study, and subjective-experiential study. Psychobiological inquiry uses neurophysiological and biochemical measures. Behavioral-expressive inquiry makes use of behavioral rating systems and subjective-experiential inquiry makes use of self-report scales. It is on the behavioral-expressive level that this dissertation was based.

Subjects

Following an involved selection process described later in this section, 80 segments of videotape of 13 month old infants experiencing the Strange Situation procedure (Ainsworth et al, 1978) were chosen by randomly selecting 20 segments for each of the pure facial expressions of joy, interest, sadness, and anger as coded using the Max and Affex systems described later. Forty-nine separate infants were observed; 25 appeared in just one facial expression condition, 18 appeared with 2 facial expressions, 5 appeared in 3 facial expression conditions, and 1 appeared with all 4 facial expressions. The subjects were successfully and adequately videotaped and audiotaped for the purposes of the present study. The subjects and their mothers were voluntarily participating in longitudinal research conducted at the University of Delaware Human Emotions Lab under the direction of Dr. Carroll Izard. The subjects were all of European-American descent and were generally of middle to upper-middle socio-economic status. They were approximately 50% male and 50%

female. The subjects were treated in accordance with the APA ethical standards for research with human participants.

Design

The research design is a non-experimental correlational approach that attempted to discover the relationships between 12 descriptors of vocal expression, 7 descriptors of body movement expression and 4 facial expression conditions. The variables are as follows in Table 13.

Table 13

Variables under study

Independent Variable	Dependent Variables	
Facial expression (MAX & AFFEX)	Vocal expression (SAAAPIV)	Bodily Expression (KMP-BA)
Anger	# Phrases	Tension-flow consistency(even/adjusting)
Sadness	Pitch Level	Tension-flow intensity (low/high)
Interest	Pitch Range	Tension-flow change (gradual/abrupt)
Joy	Pitch Variability	Tension-flow reversals (round/sharp)
	Loudness	Horizontal Shape-flow (widen/narrow)
	Loudness Variabil.	Vertical Shape-flow (lenghten/shorten)
	Duration	Saggital Shape-flow (bulge/hollow)
	Tempo	
	Rhythmicity	Derived
	Harmonics	Tension-flow quality(indulging/fighting)
	Timbre	Bipolar Shape-flow (grow/shrink)
	Characterization	

Materials

High quality videotaping and sound equipment was used to collect the records. Video playback equipment with slow motion capabilities was used for the visual observations of facial and body movement. Dubbed versions of the audio records of the segments was made using a high quality cassette tape recorder and playback for the auditory observations employed high quality stereo headphones.

Procedure

Originally, approximately 200 infant and mother pairs were videotaped during the Strange Situation procedure (Ainsworth et al, 1978). This procedure includes eight segments which become increasingly stressful for the infant. It proceeds through various situations where the infant and mother are brought into a room with toys by an observer and then left alone with each other. Then a stranger enters the room, first watches, then engages the mother in conversation, then tries to engage the infant in play. Next, the baby is left alone with the stranger by the mother, followed by a reunion of the mother and infant simultaneous with the stranger leaving the room. The baby, then, is left completely alone for a while until the stranger re-enters the room. Finally, the mother reunites with the infant for the second time while the stranger again leaves. As would be expected, this procedure elicits many different emotional reactions in the infants. Typically, the babies show some fear or caution when the stranger is around, anger and sadness when the mother leaves, joy when she returns and interest with the toys that are in the room.

Each of the segments of this procedure for all of the infant subjects in the studies were coded using the Maximally Discriminative Facial Movement Coding System (Max) (Izard, 1979) and the System for Identifying Affect Expressions by Holistic Judgments (Affex) (Izard & Dougherty, 1980).

The Max system assigns numerical codes to all possible movements observed in the muscles that control the three distinct regions of the face namely the brow, the eyes, and the mouth. Table 14 lists the Max codes and their meanings.

Table 14

Max Codes

Brow Region
- 20 - brows raised in normal or arched shape
- 21 - one brow raised higher than the other
- 22 - brows raised and drawn together in straight or normal shape
- 23 - inner corners of brows raised
- 24 - brows drawn together, may be slightly lowered
- 25 - brows sharply lowered and drawn together

Eye Region
- 30 - eyes enlarged with round appearance, tissue between upper lid and brow stretched, upper lid not raised
- 31 - eye fissure widened with upper lid raised
- 33 - eyes narrowed or squinted by action of eye sphincters or brow depressors
- 34 - eyes squinted without cheek movement
- 35 - visual scanning
- 37 - eye fissure tightly closed
- 38 - cheeks raised
- 42 - nasal bridge furrowed

Mouth Region
- 50 - mouth open and round or oval
- 51 - mouth open and relaxed
- 52 - mouth open or closed with corners pulled back and slightly up
- 53 - mouth open and tense with corners retracted straight back
- 54 - mouth open, angular, and squarish
- 55 - mouth open and tense
- 56 - mouth open or closed with corners drawn downward or outward possibly with chin pushing up the center of the lower lip
- 57 - one mouth corner slightly retracted with lips pressed against teeth
- 58 - both mouth corners slightly retracted with lips pressed against teeth
- 59A - (=51+66) mouth open and relaxed with the tongue forward beyond the gum line possibly with the tongue moving
- 59B - (=54+66) mouth open and angular with upper lip pulled up and tongue forward beyond the gum line possibly with the tongue moving
- 61 - upper lip raised on one side
- 63 - lower lip lowered and possibly slightly forward
- 64 - lower lip or both lips rolled inward
- 65 - lips pursed
- 66 - tongue forward beyond the gum line possibly moving

All regions
- 0 - No observable movement
- NS - nonscorable
- NC - noncodable
- OBS - Area to be coded is obscured or out of view

As an example using the Max system, if the brows are observed to be drawn tightly together and down a code of 25 is assigned to the brow region. If the eyes are tightly shut, a code of 37 is assigned to the eye region. If the mouth is open and squarish, a code of 54 is assigned the mouth region. The Max code for this expression is 25+37+54.

In using the Affex system, a coder, previously trained on the Max system, will see the Max signals, note their combination and translate them into Affex codes which indicate the probable emotional state of the infant. As in the example above, when the Affex coder sees the 25+37+54 Max codes occurring together, he or she will recognize it as an anger signal and code the segment AR. Table 15 lists the Affex codes, the affect signals with Max codes and descriptions by facial region, the combinations of Max codes that are translated into the Affex codes, and the most prototypical and indicative combinations signaling each affect. At the suggestion of Dr. Izard, so as to cut down on error, only these most prototypical combinations were used in the study.

Table 15

Affex Codes

IE - Interest

Interest signals by region

brows	eyes	mouth
20 - raised	33 - narrowed	51 - open,relaxed
24 - together	34 - squinted	59a - open,tongue out
0 - no mvmt	0 - no mvmt	65 - lips pursed

Combinations of Max codes that make for the Affex code of IE

24+0+51	24+0+59a	24+0+65	24+33+51	
24+34+65	24+34+51	24+34+59a	24+33+65	20+34+65
0+34+65	24+OBS+51	20+34+51	20+33+51	20+0+51
20+OBS+51	0+34+51	OBS+34+51	24+33+59a	0+34+59a
20+34+59a	OBS+34+59a	20+0+59a	20+33+59a	

Most prototypical and indicative combinations signaling Interest

24+0+51 = brows pulled together, eyes normal, mouth open and relaxed
24+0+59a = brows pulled together, eyes normal, mouth open and relaxed, tongue forward
24+0+65 = brows pulled together, eyes normal, lips pursed
24+33+51 = brows pulled together, eyes squinted, mouth open and relaxed

EJ - Joy

Joy signals by region

brows	eyes	mouth
0 - resting	33 - narrowed	52 - corners back and up

Combinations of Max codes that translate to the Affex code of EJ

0+33+52	0+33+52+NC	OBS+33+52

Most prototypical and indicative combinations signaling Joy

0+33+52 = brows relaxed, eyes narrowed, mouth corners up and back
0+33+52+NC = brows relaxed, eyes narrowed, mouth corners up and back, and a noncodable movement
OBS+33+52 = brows obscured, eyes narrowed, mouth corners up and back

Table 15 (Continued)

Affex Codes

SD - Sadness

Sadness signals by region

brows	eyes	mouth
23 - inner corners up	33 - narrowed	56 - corners down
	38 - cheeks up	63 - lower lip down

Combinations of Max codes that translate to the Affex code of SD

23+0+56 23+33+56 23+0+56+63 23+OBS+56

Most prototypical and indicative combinations signaling Sadness

23+0+56 = inner brows raised, eyes neutral, mouth corners drawn downward

23+33+56 = inner brows raised, eyes narrowed, mouth corners drawn downward

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AR - Anger

Anger signals by region

brows	eyes	mouth
25 - down and together	33 - narrowed	54 - open and squarish
	38 - cheeks up	55 - open and tense

Combinations of Max codes that translate to the Affex code of AR

25+33+54 25+0+54 25+33+55 25+0+55 25+OBS+54

Most prototypical and indicative combinations signaling Anger

25+33+54 = brows down and together, eyes narrowed, mouth open and squarish

25+0+54 = brows down and together, eyes neutral, mouth open and squarish

25+33+55 = brows down and together, eyes narrowed, mouth open and tense

25+0+55 = brows down and together, eyes neutral, mouth open and tense

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Combinations of Max codes can result in either full face expressions of a single expression (as listed in Table 8) or blends of expressions by having a signal for one expression in one region while having a signal for another expression in another region. Only full face expressions were selected for the present study. Also, only the four most commonly observed expressions out of the 11 expressions identified by Izard were used. They are joy, interest, sadness, and anger. There were not sufficient numbers of full-face expressions of the remaining 7 expressions, namely surprise, disgust, contempt, fear, shame, pain, and fatigue, to yield enough segments for proper study.

The mean duration of the four full face expressions were calculated using all available data from the 13 month-old visit. From 3253 instances of full facial expressions of interest coded using the Affex system, the average duration was 6.4 seconds. Likewise from 846 instances of joy faces, the average duration was 2.9 seconds, the average duration of sad faces from 417 instances was 2.9 seconds and the average duration of angry faces from 818 instances was 4.3 seconds. Twenty-five segments of average or longer duration for each of the four full-face expressions were then randomly selected from a list of all qualifying instances using a random numbers table. The segments were of between 2.9 and 48.0 seconds in length. Use of segments of mean or longer duration helped to ensure that the segments were long enough to code for body movement and maximized the chances for some vocalization to be present.

Some problems were encountered in selecting the segments. An attempt was made at selecting Affex coded segments that had been found to have been in 80% agreement with the Max system. This agreement was calculated by translating Max code combinations into Affex codes and then comparing these translated Affex codes with the Affex coders codes. Seventy-six subjects were found to have had agreement ranging from .74 to .97 which was sufficient to proceed and to have confidence in the reliability of the facial coding. Of the 100 segments selected, 35 (10 interest, 10 sadness, 8 anger, and 7 joy) had troubles with the original videotaping, sound recording or video editing. Twenty-one segments (7 interest, 6 joy, 5 sadness, and 3 anger) had only close up videotaping and no wide angle videotaping which was preferable for body movement coding. Eight video segments (3 sadness, 2 anger, 1 joy and 1 interest) had no audio, disqualifying them from the study. Four segments (2 anger, 1 sadness and 1 interest) did not to have a clock superimposed on the videotape purportedly making the segments impossible to locate. And finally two videotape segments (1 interest and 1 anger) were found to have ended before the facial expression desired. It was decided that 65 segments, 15 of each facial expression, was insufficient for the study, so a decision was made to use some close-up videotapes in the body movement coding. This brought the number of codeable segments back up to 79 with 18 segments of each facial expression. It was also found that a clock was not necessary to locate the segments so the segments with no clock were re-included which brought the number up to 83 with 19 segments of each facial expression. After double checking for missing audio or video, 5 segments were regained making for 80 total segments with 20 in each facial expression, a number deemed sufficient for the study.

On direction from Dr. Izard, criteria was made stricter and only the most prototypical Max combinations (as seen in Table 15) were allowed. Many of the formerly considered segments were then disqualified. Subsequently, it was decided to allow segments of any duration, not just those of average or longer duration. This shortened the average duration of the segments which made both vocal and body movement coding more difficult. In order to lengthen the segments then, rather than requiring one combination of Max codes per segment, a change of Max codes was allowed as long as the combination still qualified as the specific full face expression under the Affex system. Average Max-Affex inter-system reliability was .96. The segments ended up ranging from .4 to 28.2 seconds in duration. The overall average length was 7.2 seconds. The average joy expression lasted 6.2 seconds, the average interest expression 7.0 seconds, the average sadness expression 3.9 seconds, and the average anger expression lasted 11.7 seconds. The number of segments in the study was finalized at 80 with 20 segments of each expression.

Once the segments were selected, they were dubbed onto a videotape in random order. Specific technical instructions for setting up the equipment and the dubbing procedure were written and these were followed by research assistants (see Appendix C). Each segment included 2 seconds of frozen frame video on either end of the segment in order for coders to get a running start on their observations but their coding was limited to the specific time period indicated. Segment identifiers were added to each segment. This edited video received special effects editing that blocked the faces of the subjects so that the body movement coders could not see the facial expressions that the Max and Affex coders saw, in order to ensure the independence of observations. The videotape was also audiotaped for the vocal expression coding and also included segment identifiers.

Following the video editing, 1 segment (interest) was judged to be uncodable by the body movement coders as the baby's body was too obscured.

Vocal expression rating

Three vocal expression raters were selected from among the University of Delaware undergraduate research assistants receiving academic credit by working in the Human Emotions Lab. They were selected on the basis of having had some musical or vocal training and having interest in the project. Their time spent doing the vocal coding counted toward their academic credits. They were trained to use A System for the Auditory Assessment of Acoustic Parameters in Vocalization (SAAAPIV) developed by Burt (1991) based on the work of Scherer (1982, 1988), (previously described in the literature review). The training consisted of fully assessing 15 previously rated segments. The raters were given feedback as to how their judgments differed systematically from the assessments of other raters. If at that point they had 80% or better agreement with previous raters, they were allowed to begin to rate the segments involved in the study. If they had not reached 80% agreement, they were further instructed and rated more previously rated segments until their level of agreement met criteria.

Once the coders were trained and became adequately reliable, two of them listened to all 80 segments, rating each vocalization on 10 acoustic parameters. The raters judged each vocalization on a 6 point scale for each property of pitch, volume, time, and tone. They also were asked to characterize the vocalization by choosing from a set of 17 semantic descriptors of infant vocalizations. The SAAAPIV form employed is included in Appendix A. After the segments were rated, three systems were used to generate the final rating. First, if the ratings by the two judges on a particular parameter fell within two points of each other, they were averaged to obtain the final rating. Sixty-nine percent (1159 of 1684) of the ratings were calculated using this first method. Secondly, if the ratings were more than two points apart, a third trained rater determined the final rating choosing a number between the scores of the original raters. Thirty-one percent (525 of 1684) of the ratings were determined using this second method.

Body movement expression rating

Two body movement raters trained in using the Kestenberg Movement Profile (KMP), described earlier in the literature review (Berlowe & Kestenberg, 1990; Lewis & Loman, 1990; Sossin, 1987) were recruited from amongst attendees at the annual Kestenberg Movement Profile conference. Out of nine attendees interested in rating four were chosen to rate 5 sample segments on shape-flow and tension-flow. Agreement percentages on the tension-flow and shape-flow ratings of the five sample segments were calculated for each possible combination of the four raters. Hillary Merman, a member of the Academy of registered dance therapists (ADTR) and Certified Movement Analyst (CMA) and Amy Williams, a graduate student at Antioch New England Graduate School in the dance/movement therapy program, were selected as the final raters due to their being the pair with the best overall inter-rater agreement. Hillary was trained in the KMP during her CMA training at the Laban/Bartenieff Institute for Movement Studies (LIMS) and Amy was trained during a semester long course in the KMP in her graduate program. They volunteered in order to contribute to the project and practice their skill.

Both raters judged all 80 video segments and rated the body movement of the infants in terms of tension-flow and shape-flow. Tension-flow is the change in the tension of the muscles in the body and shape-flow is the change in the shape and configuration of the torso and limbs of the body.

Tension-flow measures were derived from a drawing of a curve or series of curves that represent the changes in the tension of the muscles from bound tension flow to free tension flow. When the muscles are becoming bound the line goes down and when the tension is freeing up from being bound the line goes up. This drawing is also called a tracing. Figures 3, 4, 5, and 6 are actual examples of tension-flow notation various segments. In figures 3 and 4, Hillary's tracing is found above Amy's. Each rater was instructed to make two such tracings for each segment, and to choose the best based on a third observation.

For each segment, the four attributes of tension flow mentioned earlier were extracted from the tracings by the primary investigator. Potential experimenter bias was controlled both by remaining blind as to the facial expression being displayed in the segment and by using objective criteria for extracting the data from the movement notations. The operational definitions of the attributes are as follows and examples of notations of each of the attributes are labeled in Figure 3.

:

Consistency - the presence or absence of more than one reversal of the line while remaining on one side of the neutral line, even flow having only one reversal, flow adjustment having more than one reversal.

Intensity of tension-flow - determined by the location of the reversal in tension-flow on the tracing, high intensity reversing beyond the high intensity line, low intensity reversing within the high intensity line.

Change in the tension-flow - the *slope* of the tracing from nadir to zenith and vice-versa, gradual change being a line of less than 45 degrees, abrupt change being a line of greater than 45 degrees.

Reversal of the tension-flow - Round reversals are characterized by a curvilinear line at the point of direction change, and sharp reversals are characterized by the presence of an angle at the point of direction change.

Frequencies of each polarity of each attribute was first collected for each segment. The frequencies, then were converted into the percentages that each polarity accounts for within that particular attribute. Table 16 is an example of a results table based on the example in Figure 3.

Figure 3
Two coder's tension-flow notation of segment 26 - Joy facial expression

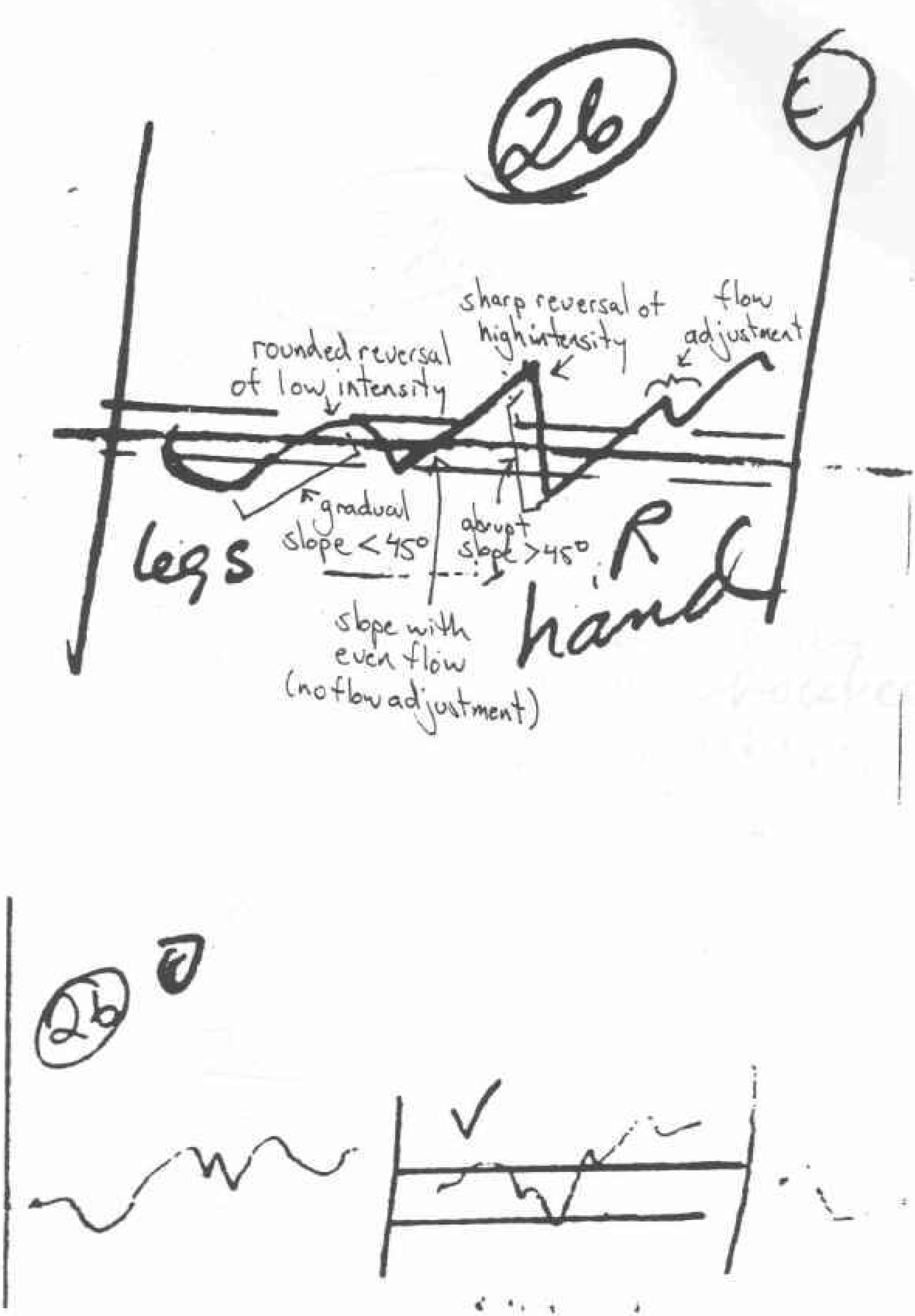

Figure 4
Two coder's tension-flow notation of segment 32 - Anger facial expression

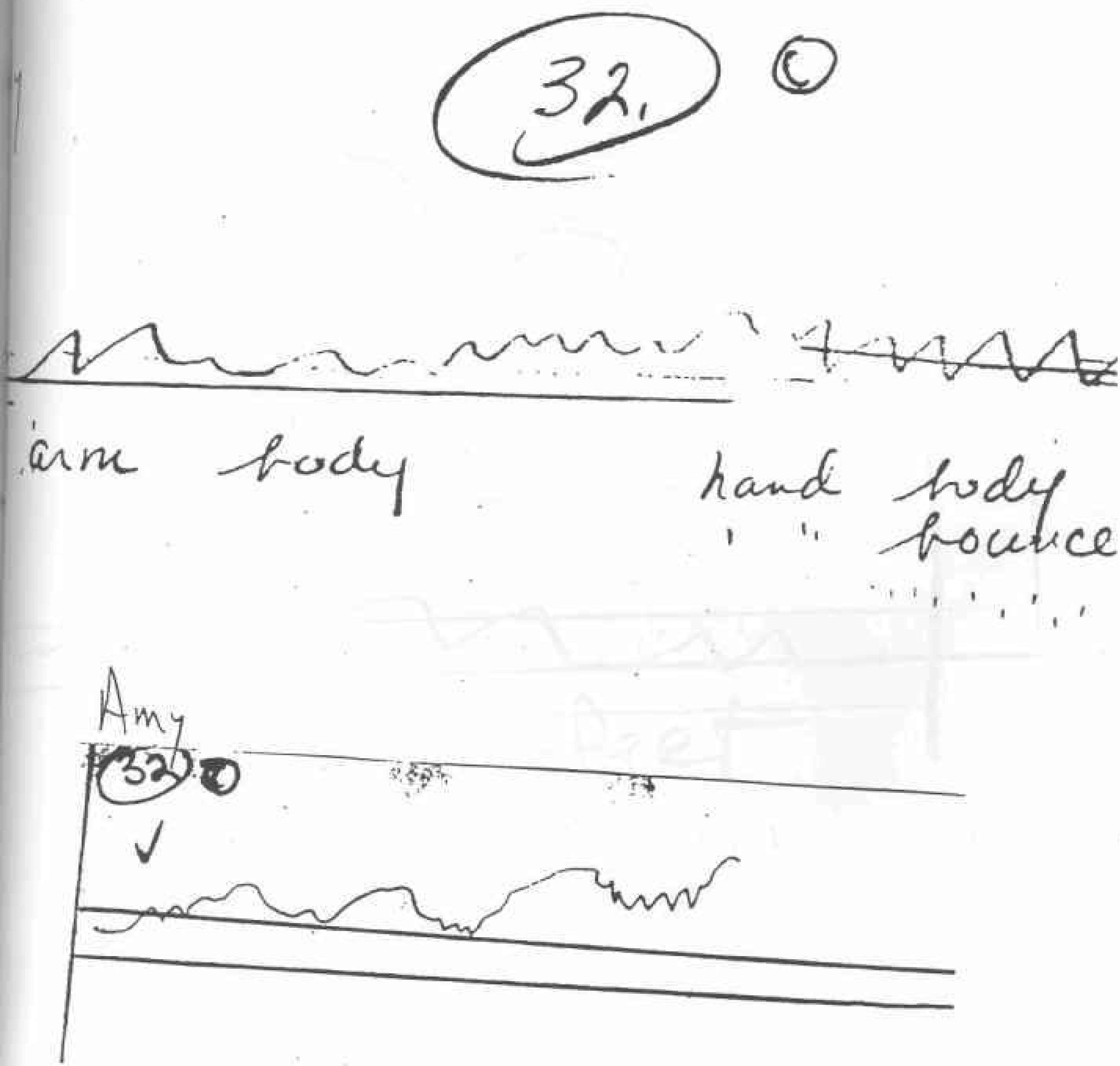

Figure 5
Tension flow notation of segment 27 - Sadness facial expression

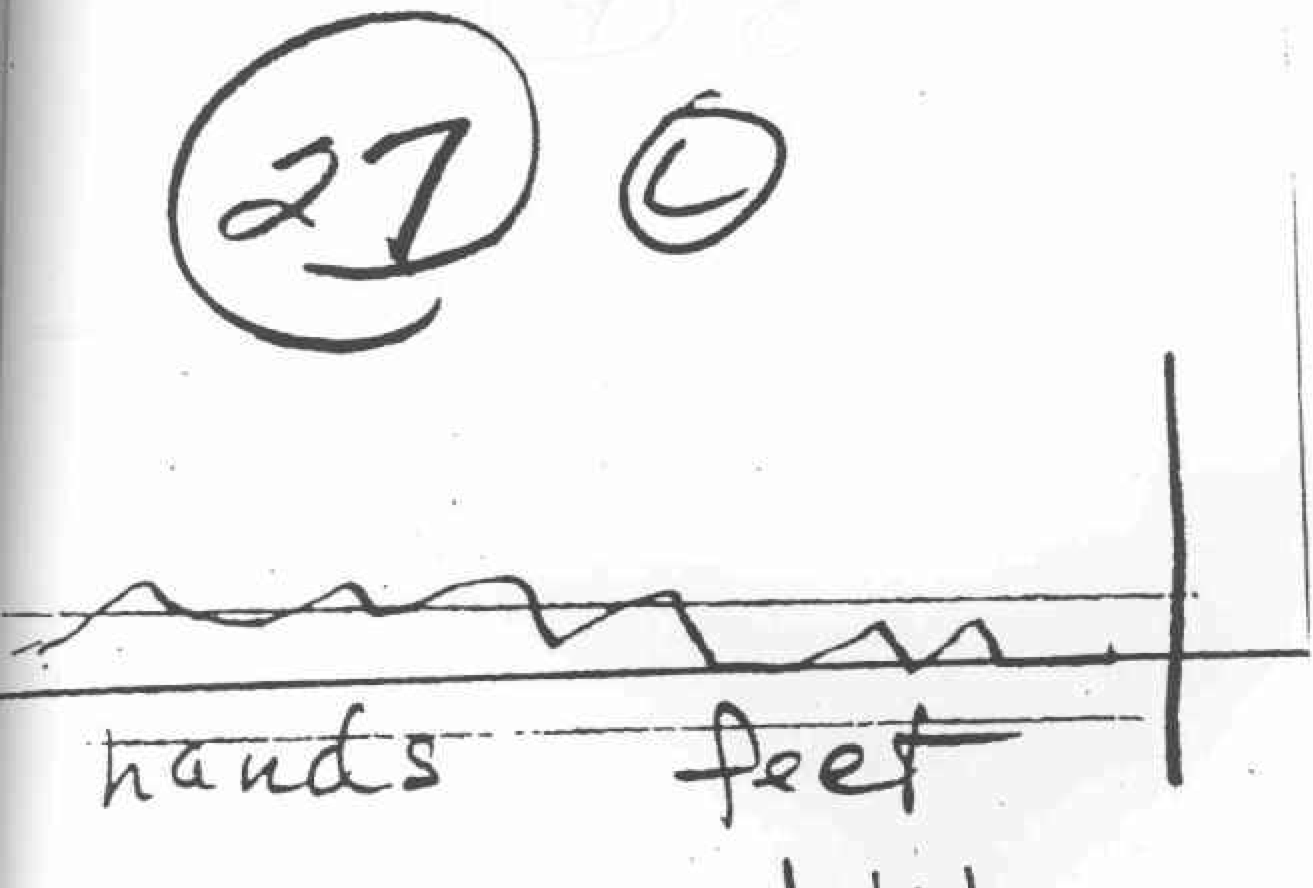

Figure 6
Tension flow notation of segment 9 - Interest facial expression

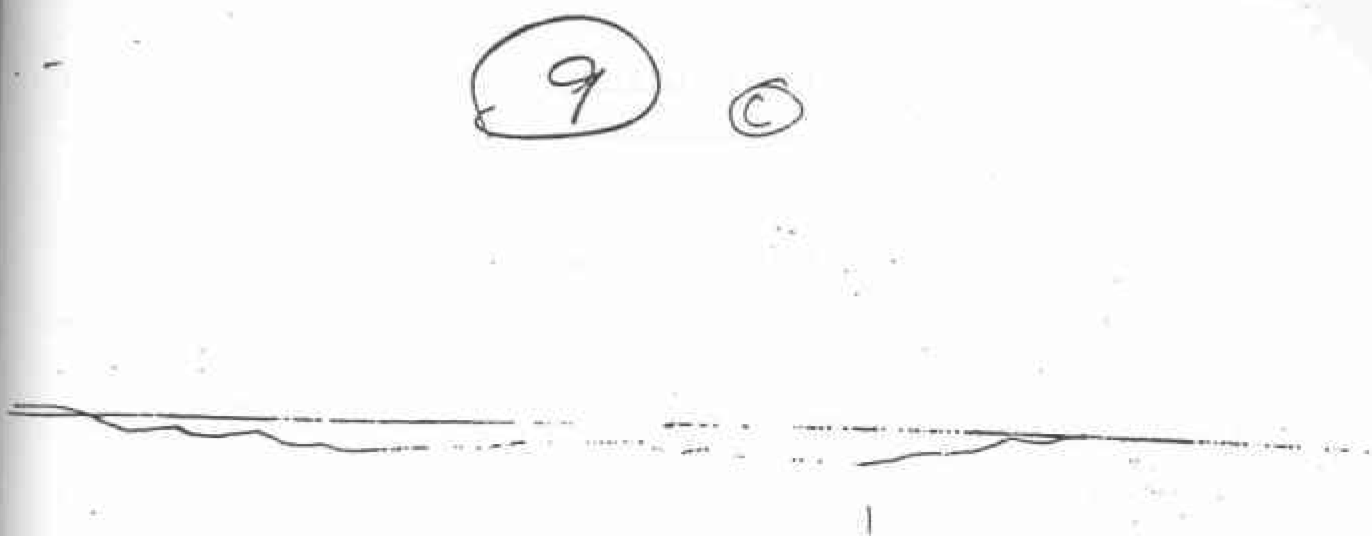

Table 16

Tension-flow attributes results for tracing of segment 26 by Rater 1

Consistency..	Flow Adjustment	1 (14%)	Even Flow	6 (86%)	7 slopes
Intensity....	Low/Neutral....	1 (17%)	High.....	5 (83%)	6 reversals
Slope........	Gradual........	3 (43%)	Abrupt...	4 (57%)	7 slopes
Reversal.....	Round..........	2 (33%)	Sharp...	4 (67%)	6 reversals
Totals.......	Indulging......	7 (27%)	Fighting.	19 (73%)	

The average of the two rater's percentages derived from the tension flow attributes were used for the purposes of the data analysis.

In addition to making a tracing for each segment the raters recorded changes in shape-flow. For this, the raters simply tallied the occurrence of widening, narrowing, lengthening, shortening, bulging, and hollowing movements. Figure 7 shows the completed shape-flow tally sheets by each of the coders for segment 17.

Figure 7

Shape-flow tally sheets for segment 7

egment #	17	Take #	1	Amy	
arrowing		Widening	1	Total Horizontal	1
hortening		Lengthening		Total Vertical	
ollowing		Bulging	1	Total Saggital	1
tal Shrinking	0	Total Growing	2	Grand Total	2

egment #	17	Take #	2	Hillary	
arrowing		Widening	1	Total Horizontal	1
hortening		Lengthening	[illegible]	Total Vertical	0
ollowing		Bulging	1	Total Saggital	1
tal Shrinking	0	Total Growing	2	Grand Total	2

Inter-rater reliability

A potential drawback to this study is the low inter-observer agreement in the coding of body movement and vocal behaviors. For the body movement variables, which use ratio data, a Pearson r correlation was calculated in order to find the degree of association between the two observers' ratings on each of the variables. Significant correlations indicate good inter-observer reliability. Table 17 presents the inter-observer correlations for body movement.

Table 17

Inter-observer correlations of body movement observations

Movement parameter	Pearson r	p
Tension flow [a]		
Number of reversals	.3411	.002
Number of slopes	.3411	.002
Even Consistency	.1705	>.10
Adjustments	.1705	>.10
Neutral Intensity	.0417	>.10
Hi/Low Intensity	.0417	>.10
Gradual Change	.0274	>.10
Abrupt Change	.0274	>.10
Rounded Reversals	-.0098	>.10
Sharp Reversals	-.0098	>.10
Indulging	.2305	.04
Fighting	.2305	.04
Shape flow [b]		
Narrowing	.2690	.02
Widening	.4370	<.001
Shortening	-.0147	>.10
Lengthening	.0660	>.10
Hollowing	-.0461	>.10
Bulging	.2286	.05
Horizontal	.4646	<.001
Vertical	.2068	.07
Saggital	.4998	<.001
Shrinking	.2636	.02
Growing	.5079	<.001
Total Shape Flow Changes	.6841	<.001

[a] (N = 78; 2-tailed significance)
[b] (N = 76; 2-tailed significance)

For the tension-flow measures, there were significant inter-observer correlations 4 of the 12 measures, namely the numbers of slopes and reversals observed and the percentage of indulging and fighting qualities employed by the subjects. In the shape-flow measures, 8 of the 12 measures which include narrowing, widening, and bulging as well as the derived variables of horizontal, saggital, shrinking, and growing movements and total instances of shape flow changes were found to have significant correlations.

The vocalization variables employed ordinal data from a 6-point scale in which rating categories were mutually exclusive and exhaustive. Cohen's Kappa statistic was used to assess the inter-observer agreement and to adjust for chance. Kappa is the proportion of the difference between the observed agreement (OA) and the chance agreement (CA) to 1 minus the chance agreement ($\kappa = OA-CA/1-CA$). Landis and Koch (1977, as cited by Fleiss, 1981; and Haley & Osberg, 1989) identify Kappas below .40 as indicating poor agreement, from .40 to .75 as fair to good agreement, and above .75 as excellent agreement. An overall Kappa statistic is calculated using the formula $\kappa = \Sigma(OA-CA)/\Sigma(1-CA)$. Table 18 presents the inter-observer agreement for the vocalization variables.

Table 18

Inter-observer agreement percentages and correlations of vocalization variables

Vocalization Variables	N	Observed Agreement	Chance Agreement	Statistic
		Nominal variables		
				κ^a
Content	107	.55	.26	.39†
Characterization	107	.34	.15	.21†
		Ordinal variables		
				ICC[c]
Pitch Level	99	.83	.44	.32†
Pitch Range	100	.72	.44	.43††
Pitch Variability	99	.59	.44	.18
Loudness	100	.85	.44	.70†††
Loudness Variability	98	.73	.44	.14
Duration	100	.88	.44	.70†††
Tempo	100	.67	.44	.08
Rhythmicity	100	.64	.44	.32†
Harmonics	99	.72	.44	.23†
Timbre	100	.81	.44	.39†

[a] Kappa = (Observed Agreement - Chance Agreement / 1 - Chance Agreement)
[b] Shrout-Fleiss fixed set intraclass correlation coefficient (Shrout & Fleiss, 1979)
† fair reliability, †† moderate reliability ††† substantial reliability (Landis & Koch, 1977)

With the vocal coding, both of the nominal variables, and 7 of the 10 ordinal measures reached at least fair inter-observer agreement using the Kappa (κ) and Intraclass Correlation Coefficient (ICC) statistics respectively. The overall agreement of .509 is considered in the moderate agreement range. At least fair agreement was found in 2 of the 3 pitch variables (pitch level and pitch range), 1 of the 2 loudness variables (loudness), 2 of the 3 time variables (duration and rhythmicity), and both tone variables.

For the purpose of exploratory research, a decision was made to include all variables in the statistical analysis even if they lacked inter-observer agreement with the knowledge that these variables may not be considered reliable and therefore may not be valid, however with the hope that their inclusion may yield some useful hypotheses.

The final raw data for the body movement variables were calculated by averaging each of the raters findings with the other. By utilizing this method, it was hoped that a more valid measure of the variable was arrived upon.

The establishment of a baseline criteria for inter-observer reliability during the training of the vocal coders apparently had the desired effect. Due to the scarcity of body movement coders, the time and expense involved in dubbing, masking, and labeling many segments of videotape, and the distance between those used (one in Georgia and one in New York City), training up to a reliability criteria was impractical.

The findings lead to many important results and spur on some important thought about the signaling of emotion, however, conclusions about signals that did not meet acceptable reliability criteria should be considered hypothetical and subject to further investigation.

Results

Hypothesis

There will be distinct and discernible combinations of vocal and body movement descriptors for each of the facial expression conditions.

Descriptive Statistics

Two sets of descriptive statistics were run, the first being crosstabulations of the nominal variables with the facial expressions and the second being the means of the ordinal, interval, and ratio variables also across the facial expressions.

Table 19 presents the crosstabulation of the vowel sounds vocalized by the infants during the four facial expressions.

Table 19

Facial expression by vowel content of vocal expression

	Facial Expression				
Vowel	Joy	Interest	Sadness	Anger	Total
No vocalization	7	11	4	3	25
"e" as in pet	7	7	5	3	22
"a" as in pat	4	0	1	12	17
"i" as in pit	1	0	6	1	8
"ee" as in peel	1	1	1	0	3
"oo" as in Pooh	0	0	3	0	3
"u" as in putt	0	1	0	0	1
"o" as in Poe	0	0	0	1	1

As can be seen, a joy facial expression was equally accompanied by either no vocalization or the vocalization of the vowel "e", as in a soft chuckle "heh, heh". Interest was most often accompanied by no vocalization, but when it was it was most often "e" as well. Sadness was most often signaled with the vowels "i" and "e", while anger was most often signaled with the vowel "a" as in "Waaaa".

Table 20 presents the crosstabulation of the vocalization descriptors by the facial expressions.

Table 20

Facial expression by vocal expression descriptor

	Facial expression				
Descriptor	Joy	Interest	Sadness	Anger	Total
silence	7	11	4	3	25
cry	1	0	6	10	17
coo	5	3	1	0	9
exhale	2	4	0	1	7
wail	0	0	1	4	5
fret	0	2	2	0	4
call	1	0	2	0	3
laugh	3	0	0	0	3
inhale	1	0	1	0	2
whine	0	0	1	1	2
gasp	0	0	2	0	2
sob	0	0	0	1	1

Joy was most often expressed with no vocalization but when one was present it was most often characterized as a coo. Interest was also most often expressed in silence but when it was it was most likely characterized as an exhale. Sadness vocalization was most often characterized as a cry, followed in frequency with silence. Anger was also most often characterized as a cry with the characterization of a wail being the second most common.

In combining the findings of Tables 19 and 20, Joy, when audible was most likely a coo of the vowel "e" as would be expected when the mouth corners are drawn up and back. Interest, when audible, was most likely an exhale with the vowel sound "e" as in heavy breathing. Sadness was most often expressed in a cry with the vowel sounds "i" or "e". Anger was most often a cry with the more open "a" sound.

Table 21 presents the means and standard deviations for each of the body movement variables across the four facial expression groups.

Table 21

Means and standard deviations of body movement variables for four facial expressions

	Joy		Interest		Sadness		Anger	
Movement Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Segment length(sec)	6.25 ±	6.19	6.88 ±	7.37	3.88 ±	4.62	11.74 ±	9.22
Tension Flow Variables								
Changes								
# of Slopes	4.38 ±	3.09	4.92 ±	3.82	2.70 ±	1.32	4.78 ±	2.81
# of Reversals	3.38 ±	3.09	3.92 ±	3.82	1.70 ±	1.32	3.78 ±	2.81
Flow fluctuation								
% of Even	65.74 ±	30.66	73.47 ±	21.06	60.88 ±	27.18	51.16 ±	24.60
% of Adjusting	34.30 ±	30.65	26.55 ±	21.07	39.14 ±	27.20	48.88 ±	24.58
Flow intensity								
% of Neutral/Low	31.10 ±	23.96	57.98 ±	28.20	42.62 ±	25.15	42.61 ±	28.32
% of High	68.92 ±	23.97	42.05 ±	28.21	57.40 ±	25.16	57.40 ±	28.32
Flow transition								
% of Gradual	82.77 ±	19.32	83.51 ±	21.30	87.59 ±	15.49	87.98 ±	11.62
% of Abrupt	17.26 ±	19.34	16.52 ±	21.31	12.44 ±	15.51	12.05 ±	11.64
Flow reversals								
% of Rounded	66.42 ±	27.13	68.75 ±	22.11	70.76 ±	27.00	76.28 ±	27.58
% of Sharp	33.60 ±	27.13	31.27 ±	22.12	29.26 ±	26.99	23.74 ±	27.59
Flow effort quality								
% of Indulging	61.52 ±	11.86	70.73 ±	10.81	65.49 ±	14.18	64.52 ±	15.54
% of Fighting	38.52 ±	11.88	29.32 ±	10.80	34.56 ±	14.18	35.52 ±	15.55
Shape Flow Variables								
Horizontal Plane								
# of Narrowings	.45 ±	.63	.43 ±	.63	.50 ±	.43	.78 ±	.75
# of Widenings	.52 ±	.79	.63 ±	.62	.58 ±	.63	1.02 ±	.79
# total horizontal	.98 ±	1.24	1.07 ±	1.09	1.08 ±	.98	1.80 ±	1.30
Vertical Plane								
# of Shortenings	.35 ±	.61	.13 ±	.28	.42 ±	.54	.39 ±	.63
# of Lenghtenings	.61 ±	.53	.28 ±	.46	.32 ±	.52	.52 ±	.55
# total vertical	.96 ±	.94	.41 ±	.60	.75 ±	.80	.91 ±	.92
Saggital Plane								
# of Hollowings	.18 ±	.24	.16 ±	.34	.10 ±	.26	.20 ±	.41
# of Bulgings	.35 ±	.49	.32 ±	.56	.22 ±	.47	.55 ±	.81
# total saggital	.53 ±	.53	.47 ±	.74	.32 ±	.63	.75 ±	1.11
Total Shape Direction								
# Shrinking	.98 ±	1.06	.72 ±	.92	1.02 ±	.82	1.36 ±	1.16
# Growing	1.49 ±	1.10	1.22 ±	1.22	1.12 ±	1.39	2.10 ±	1.64
Total Shape Flow								
# S-F Changes	2.46 ±	1.79	1.95 ±	1.81	2.15 ±	1.96	3.46 ±	2.49

In terms of means alone, joy facial expressions are accompanied by the most high intensity tension-flow, most abrupt transitions in tension-flow, the most sharp tension-flow reversals, and the highest percentage of fighting effort qualities. Joy also has the most lenghtenings and the most vertical movement. The variable means indicate that interest facial expressions are accompanied by the most number of tension-flow slopes and reversals, the most even flow fluctuation, the most neutral flow intensity, and the highest percentage of indulging effort qualities. Interest also has the least number of shape-flow changes in 7 of the 12 categories. Sadness which had the shortest duration segments on average, had none of the tension-flow variables in excess of the other facial expressions. In fact, the only variable in which it had greater values than the other facial expressions was number of instances of shortening movements. Again, based on means, anger facial expressions which lasted the longest on average were accompanied by the most adjusting flow fluctuation, the most gradual flow fluctuations, and the most rounded flow reversals. Anger is also associated with the most narrowing and widening, thus the most horizontal movement, the most hollowingand bulging, thus the most saggital movement, the most shrinking and the most growing, thus the most number of shape-flow changes overall.

Table 22 presents the means and standard deviations of the vocalization variables across the four facial expression groups.

Table 22

Means of vocalization variables for four facial expressions

	Joy		Interest		Sadness		Anger	
Vocal variable	mean	sd	mean	sd	mean	sd	mean	sd
# of vocal Phrases	.95 ±	.89	.85 ±	1.31	1.50 ±	1.70	2.20 ±	1.74
Pitch (6 point scale)								
Level (Low-High)	3.63 ±	.69	3.32 ±	.88	3.47 ±	.81	3.55 ±	.63
Range (Narrow-Wide)	2.50 ±	.87	2.41 ±	.99	2.94 ±	.74	3.58 ±	1.04
Variance (small-large)	2.41 ±	.99	2.19 ±	.93	2.91 ±	.65	3.02 ±	.89
Volume (6 point scale)								
Loudness (soft-loud)	1.52 ±	1.38	.79 ±	1.04	2.82 ±	1.62	3.48 ±	1.69
Variance(small-large)	1.96 ±	1.01	1.78 ±	.67	2.44 ±	.53	2.81 ±	.65
Time (6 point scale)								
Phrase length (short-long)	1.30 ±	1.07	.84 ±	.99	1.98 ±	1.11	2.98 ±	1.46
Tempo (slow-fast)	3.41 ±	.73	4.00 ±	1.12	3.40 ±	.99	3.06 ±	.88
Rhythmicity (uneven-even)	2.12 ±	.62	2.39 ±	1.09	2.68 ±	1.26	3.45 ±	1.22
Tone (6 point scale)								
Harmonics (few-many)	2.38 ±	.65	2.60 ±	1.11	3.03 ±	1.02	3.19 ±	.74
Timbre (gutteral-nasal)	3.38 ±	.65	3.36 ±	.52	3.29 ±	.80	3.88 ±	.92

As illustrated in the previous table, Joy had the highest pitch level, the most uneven rhythm, and the fewest harmonics when examining the means alone. Interest had the fewest vocal phrases, the lowest pitch level, the narrowest pitch range, the smallest pitch variability, the softest volume, the smallest volume variability, the shortest phrase length, and the fastest tempo. The only extreme mean found with the sad facial expression was that it was the most gutteral of the four expressions. Anger, on the other hand, had many extreme means. Angry facial expressions are accompanied by vocalizations with the most vocal phrases, the widest pitch range, the largest pitch variability, the loudest volume, the largest loudness variability, the longest phrases, the slowest tempo, the most even rhythm, the most harmonics, and the most nasal tone.

Correlational Findings

Pearson r correlation coefficients were calculated for all possible variable combinations. Of 648 correlations, 159 were significant at least to the .01 level. Most of these were expected as 9 of the body movement variables were derived from other variables and many were correlated with the length of the segment. 88 of the correlations found to be significant were not associated to the length of the segment and were not derived from other variables. These correlations were thought to have interpretive meaning and are listed in Tables 23-26.

Table 23

Selected Significant Body Movement Correlations[a]

Correlations with segment length

	Segment Length
Even Flow	-.3868*
Adjusting Flow	.3871*
Timbre	.3460*

Tension Flow Inter-Correlations

	% Gradual Transition	% Abrupt Transition
# Slopes	-.2876*	.2880*
Rounded Reversal	.5026**	-.5026**
Sharp Reversals	-.5026**	.5026*

Tension Flow - Shape Flow Correlations (Affinities)

	Fluctuation		Intensity		Effort Quality	
	Even	Adjust	Neutral	High/Low	Indulging	Fighting
Narrowing	-.4352**	.4353**				
Widening	-.3270	.3273			-.3086^	.3088^
Shortening			-.3385	.3385	-.2754	.2753
Horizontal	-.4300**	.4302**			-.2912^	.2915^
Vertical			-.3726*	.3727*	-.2671	.2671
Shrinking	-.3174	.3176				
Growing	-.2900	.2905			-.2758	.2760
Total	-.3460*	.3464*			-.2732	.2734

[a] selected on basis of not being derived from other variables and not directly attributable to segment length

all correlations listed $p \leq .05$, 2 tailed probability

* $p \leq .01$, ** $p \leq .001$; N = 55, w/o nonvocal phrases

^ $p \leq .01$, ^^ $p \leq .001$; N = 79, with nonvocal phrases

Table 24

Body Movement Shape Flow Inter-correlations

	Narrow	Widen	Lengthen	Hollow	Bulge	Horizontal	Vertical	Saggital	Shrinking
Widening	.5378**								
Lengthening	.3638*	.3293							
Hollowing	.3308		.4178*						
Bulging			.5134**	.4185**					
Horizontal			.3935*						
Vertical	.2977	.2796^^		.2960	.3936*	.3282			
Saggital							.4192**		
Shrinking		.4236**	.4379**			.6728**	.7014**	.4222**	
Growing	.4831**			.3883*		.7131**	.5966**	.7330**	.5029**

[a] selected on basis of not being derived from other variables and not directly attributable to segment length

all correlations met $p \le .05$, 2 tailed probability

* = $p \le .01$, ** = $p \le .001$; N = 55, w/o nonvocal phrases

^ = $p \le .01$, ^^ = $p \le .001$; N = 79, with nonvocal phrases

Table 25

Selected Significant Correlations of Body Movement and Vocalization Variables

Tension Flow - Vocalization Correlations

	Pitch Level	Pitch Range	Loudness	Loudness Variance	Duration	Timbre
Seg Length						.3460*
Even		-.3443*	-.3129	-.3863*	-.3298	
Adjusting		.3444*	.3130	.3864*	.3301	
Neutral	.3415					
HighLow	-.3415					
Indulging	-.3366					
Fighting	.3357					

Shape Flow - Vocalization Correlations

	# Vocal Phrases	Pitch Range	Loudness	Phrase Duration	Tempo	Harmonics
Narrowing				.3176		.3758*
Widening					-.3332	
Horizontal		.3237	.2675	.3410		
Vertical	.3188^					
Shrinking	.2824		.2826	.2862		.3909*
Total S-F		.3219	.2827	.3083^		

Note. Correlations selected on basis of not being derived from other variables and not directly attributable to segment length. All correlations met $p \leq .05$, 2 tailed probability

* = $p \leq .01$, ** = $p \leq .001$; N = 55, w/o nonvocal phrases

^ = $p \leq .01$, ^^ = $p \leq .001$; N = 79, with nonvocal phrases

Table 26

Selected Significant Vocalization Inter-Correlations[a]

	Pitch Variance	Loudness	Loudness Variance	Phrase Duration	Tempo	Rhythm	Harmonics	Timbre
# Vocal Phrases		.5878^^		.2776				
Pitch Range	.7216**	.4491**	.7064**	.7207**		.4831**	.3324	
Pitch Variance		.4119*	.7009**	.5699**				
Loudness			.5373**	.6466**			.3773*	
Loudness Variance				.6299**		.4640**		.3227*
Duration					-.3212	.6560**	.3638*	.3970*
Rhythmicity								.3879*

Note. Correlations selected on basis of not being derived from other variables and not directly attributable to segment length. All correlations met $p \leq .05$, 2 tailed probability

* = $p \leq .01$, ** = $p \leq .001$; N = 55, w/o nonvocal phrases

^ = $p \leq .01$, ^^ = $p \leq .001$; N = 79, with nonvocal phrases

The correlations between the variables lead to a number of conclusions best presented in outline form.

1. Correlations with segment length:
 a. Longer segments had higher percentages of adjustment in tension flow.
 b. Segment length is associated with timbre, longer segments being more nasal.

2. Tension-flow inter-correlations show that:
 a. Gradual change in tension flow is related to rounded reversals while the opposite is true that abrupt change in the tension-flow is related to sharp reversals.

3. Affinities, the relationship between tension-flow and shape-flow variables are found between:
 a. tension-flow adjustment and narrowing shape-flow
 b. tension-flow adjustment and widening shape-flow
 c. high intensity tension-flow and shortening shape-flow

4. Affinities between tension-flow and the broader shape-flow descriptors were found between:
 a. tension-flow adjustment and horizontal shape-flow as expected due to the adjustment-narrowing and adjustment-widening correlations
 b. tension-flow adjustment and shrinking shape-flow due to the strength of the adjustment-narrowing correlation
 c. tension-flow adjustment and total shape-flow occurrences due to the strength of the combination of adjustment-narrowing and adjustment-widening correlations
 d. high intensity tension-flow and vertical shape-flow due to the strength of the high intensity-shortening correlation

5. Shape-flow inter-correlations show that:
 a. lengthening is associated with narrowing
 b. lengthening is associated with widening
 c. lengthening is associated with hollowing
 d. lengthening is associated with bulging
 e. hollowing is associated with narrowing
 f. hollowing is associated with bulging

6. Independent correlations between specific shape-flow variables and the broader categories of shape-flow: (Since all of the shape-flow variables are associated with segment length, caution must be taken in interpreting these findings.)
a. horizontal plane shape-flow co-occurs with lengthening
b. vertical plane shape-flow co-occurs with bulging
c. horizontal plane shape-flow co-occurs with vertical plane shape- flow
d. saggital plane shape-flow co-occurs with vertical plane shape-flow
e. shrinking shape-flow is associated with widening
f. shrinking shape-flow is associated with lengthening
g. shrinking shape-flow is associated with horizontal plane shape-flow
h. shrinking shape-flow is associated with vertical plane shape-flow
i. shrinking shape-flow is associated with saggital plane shape-flow
j. growing shape-flow is associated with narrowing
k. growing shape-flow is associated with hollowing
l. growing shape-flow is associated with horizontal plane shape-flow
m. growing shape-flow is associated with vertical plane shape-flow
n. growing shape-flow is associated with saggital plane shape-flow
o. growing shape-flow is associated with shrinking shape-flow

7. Tension-flow variables that correlate with vocal variables indicate that there is a relationship between:
a. pitch and intensity of tension-flow, higher pitch co-occurring with high intensity tension-flow
b. pitch and the fighting efforts in tension-flow, higher pitch being associated with the fighting efforts
c. pitch range and tension-flow adjustment, with wider pitch range being associated with more tension-flow adjustments
d. loudness and tension-flow adjustment, with greater loudness being associated with more tension-flow adjustments
e. loudness variability and tension-flow adjustment, with more variability in the loudness being associated with more tension-flow adjustments
f. vocal phrase duration and tension-flow adjustment, with longer vocal phrase duration being associated with more tension-flow adjustments

8. Shape-flow variables that correlate with vocal variables indicate that there is a relationship between:
a. pitch range and horizontal plane shape-flow
b. pitch range and total shape-flow occurrences
c. vocal phrase duration and narrowing shape-flow, with longer vocal phrases being associated with more narrowing
d. vocal phrase duration and horizontal plane shape-flow, with longer vocal phrases being associated with more horizontal plane shape-flow occurrences
e. tempo and widening shape-flow, with slower tempo vocalizations being associated with more widening
f. harmonics and narrowing, with more harmonics co-occurring with more narrowing
g. harmonics and shrinking, with more harmonics co-occurring with more shrinking

9. Vocal descriptors inter-correlations show that:
 a. pitch variability is associated with pitch range
 b. loudness is associated with pitch range
 c. loudness is associated with pitch variability
 d. loudness variability is associated with pitch range
 e. loudness variability is associated with pitch variability
 f. loudness variability is associated with loudness
 g. vocal phrase duration is associated with pitch range
 h. vocal phrase duration is associated with pitch variability
 i. vocal phrase duration is associated with loudness
 j. vocal phrase duration is associated with loudness variability
 k. vocal phrase duration is associated with tempo
 l. rhythmicity is associated with pitch range
 m. rhythmicity is associated with loudness variability
 n. rhythmicity is associated with vocal phrase duration
 o. harmonics is associated with pitch range
 p. harmonics is associated with loudness
 q. harmonics is associated with vocal phrase duration
 r. timbre is associated with loudness variability
 s. timbre is associated with vocal phrase duration
 t. timbre is associated with rhythmicity

<u>Multivariate Analysis of Variance</u>

Many significant correlations indicate that a multivariate analysis is called for. Therfore, a Multivariate Analysis of Variance (MANOVA) was performed on the data derived from the observations in order to find how the body movement and vocal expressions differed for each of the facial expression conditions. The overall or omnibus test of significance, the Wilk's Lambda (Λ), was found to be significant. This statistic which compares between-group variability to within group variability (Stevens, 1986) showed that the combinations of independent variables within each dependent variable were found to have significant differences. In other words, overall differences were found between the groups enough to warrant further investigation. Follow-up univariate F tests were then run for each of the 29 variables. Fourteen were found to have significance of less than .10, eight were of less than .05, and four of less than .01. Table 27 presents the results.

Table 27

Tests of Significance

Multivariate

	Wilks Λ	Approx F	Sig. of F
55 cases (only vocal episodes)	.03	1.78	.006
79 cases (all episodes)	.27	1.46	.030

Univariate

	(3,51) D.F.		(3,75) D.F.	
	F	Sig of F	F	Sig of F
Vocal Phrase Duration	22.92	<.001	11.89	<.001
Loudness	19.50	<.001	13.32	<.001
Loudness Variability	5.51	.002	-	-
Pitch Range	4.81	.005	-	-
Rhythmicity	4.08	.011	-	-
Segment Length	4.06	.012	4.34	.007
Neutral Intensity Tension-Flow	3.04	.037	3.38	.023
High/Low Intensity Tension-Flow	3.03	.038	3.38	.023
Pitch Variability	2.63	.060	-	-
Harmonics	2.56	.065	-	-
Even Tension-Flow	2.54	.067	2.49	.067
Adjusting Tension-Flow	2.54	.067	2.49	.067
# Tension-Flow Slopes	2.35	.084	2.47	.068
Lengthening Shape-Flow	2.33	.085	1.89	>.10
# Vocal Phrases	1.64	>.10	3.44	.021

Since clear differences were found between the four facial expressions on many body movement and vocal variables, further examination of the differences was called for using post-hoc multiple comparison tests. Those results will be presented in Tables 30 and 31 but first another multivariate procedure was necessary.

Multivariate Analysis of Covariance

A potential artifact in the investigation is the number of variables that correlate with the length of the segment that was tape recorded. Thirteen of the total 36 variables and 8 of the 12 shape-flow variables significantly correlate with segment length. The number of shape-flow changes such as widening or lengthening would naturally be more in longer video segments. And since the length of the video segments selected for the four facial expressions differed, with anger being the longest and sadness being the shortest, it was necessary to determine to what extent this may have impacted on the results. Table 28 presents those variables that significantly correlated with segment length.

Table 28

Variables significantly correlating with segment length

	Pearson r	p
Shape-flow		
Narrowing	.4955	<.001
Widening	.5979	<.001
Bulging	.3355	.012
Horizontal	.6271	<.001
Saggital	.3274	.015
Shrinking	.4116	.002
Growing	.5367	<.001
Total Shape-flow	.5566	<.001
Tension-flow		
Slopes and Reversals	.5913	<.001
Even	-.3868	.004
Adjusting	.3871	.004
Vocal		
# Vocal phrases	.4869	<.001
Timbre	.3460	.010

Therefore, in order to factor out the effect of segment length, a multivariate analysis of covariance (MANCOVA) was run using the segment length variable as a covariate. The hypothesis was supported by the Wilks Λ statistic, the overall test of significance. As seen in Table 29, nine of the 29 variables showed significant differences between the 4 groups of facial expressions when the effect of segment length was factored out.

Table 29

Analyses of Covariance

Multivariate test[a] (MANCOVA)

	Value	Approx F	Sig of F
Wilks Λ	.23	4.10	<.001

Univariate tests[b] (ANCOVA)

Variable	F	Sig of F
Shape-flow		
Narrowing	12.94	.001
Widening	25.06	<.001
Bulging	5.14	.028
Tension-flow		
Slopes	13.97	<.001
Reversals	22.30	<.001
Even Flow	9.85	.003
Adjusting Flow	9.87	.003
Vocal		
# Vocal Phrases	12.66	.001
Timbre	3.52	.067

[a] S=1, M=13 1/2, N=10, 55 cases (only vocal phrases)
[b] 1,50 D.F.

Since differences between groups were found on the shape-flow, tension-flow and vocal variables that highly correlated with segment length, even when the effect of segment length was factored out, it is safe to assume that the effect of segment length does not fully explain the differences between the expressions on those variables.

Post-hoc Pairwise Multiple Comparison Tests

Post-hoc analysis of the Univariate F tests were computed in order to find out on just which pairs of facial expressions the body movement and vocal descriptors differed. Since the purpose of the investigation is exploratory, the least conservative post-hoc multiple comparison test was used, namely the Least Significant Difference (LSD) test set at an alpha of .05. Nineteen of the 31 tests passed the more conservative Tukey post-hoc multiple comparison test. Significant results using the LSD test are found in Table 30.

Table 30

Conclusions of Post hoc between group multiple comparisons using Least Significant Difference (LSD) test

Joy varies from Interest in that:			
Interest	has more	Neutral flow	than Joy
Joy	has more	High/Low Intensity	than Interest
Interest	has more	Indulging efforts	than Joy
Joy	has more	Fighting efforts	than Interest
Joy	has more	Lengthening	than Interest
Sadness varies from Joy in that:			
Sadness	has more	Loudness	than Joy
Sadness varies from Interest in that:			
Interest	has more	Slopes	than Sadness
Sadness	has more	Loudness	than Interest
Sadness	has more	Loudness Variance	than Interest
Sadness	has more	Phrase Duration	than Interest
Anger varies from Joy in that:			
Anger	has more	Segment Length	than Joy
Anger	has more	Vocal Phrases	than Joy
Anger	has more	Pitch Range	than Joy
Anger	has more	Loudness	than Joy
Anger	has more	Loudness Variability	than Joy
Anger	has more	Phrase Duration	than Joy
Anger	has more	Rhythmicity	than Joy
Anger	has more	Harmonics	than Joy
Anger varies from Interest in that:			
Anger	has more	Segment Length	than Interest
Interest	has more	Even flow	than Anger
Anger	has more	Adjusting flow	than Interest
Anger	has more	Vocal Phrases	than Interest
Anger	has more	Pitch Range	than Interest
Anger	has more	Pitch Variability	than Interest
Anger	has more	Loudness	than Interest
Anger	has more	Loudness Variance	than Interest
Anger	has more	Phrase Duration	than Interest
Anger	has more	Rhythmicity	than Interest
Anger varies from Sadness in that:			
Anger	has more	Segment Length	than Sadness
Anger	has more	Slopes	than Sadness
Anger	has more	Phrase Duration	than Sadness

Another way of presenting the multiple comparison data is found in Table 31. Data are originally derived from the means and standard deviations presented in Tables 21 and 22 and can be compared to Sherer's findings shown in Table 2. Values labeled as moderate were not found to be significantly different from values labeled as either low or high using the least significant difference test and high and low values were significantly different as were very high and high values and, of course, very high and low values.

Table 31

Summary of results based on least significant difference post hoc multiple comparison

	Facial expression			
Variable	Joy	Interest	Sadness	Anger
# Slopes\Reversals	moderate	high	low	high
Even flow	moderate	high	moderate	low
Adjusting	moderate	low	moderate	high
Neutral Flow	low	high	moderate	moderate
High\Low Intensity	high	low	moderate	moderate
Indulging	low	high	moderate	moderate
Fighting	high	low	moderate	moderate
Lengthening	high	low	moderate	moderate
# Vocal phrases	low	low	moderate	high
Pitch range	low	low	moderate	high
Loudness	low	low	high	high
Loudness variance	low	low	high	high
Phrase duration	low	low	high	very high
Rhythmicity	low	low	moderate	high
Harmonics	low	moderate	moderate	high

Note. Significant differences found between high and low and between very high and high.

Discriminant Function Analysis

A stepwise Discriminant Function Analysis (DFA) was run to identify those vocal and body movement variables that best predicted the facial expressions. This procedure is used to describe the major differences between the groups under study, namely the 4 facial expressions. This method is also called descriptive discriminant analysis. The Wilk's Lambda (Λ) statistic is used in DFA to indicate the degree of association between linear combinations of the dependent variables and the independent or predictor variables. It also can explain, by applying the formula ($1 - \Lambda^2$), the amount of remaining variance accounted for after each variable is entered into the equation. Caution should be used in the interpretation of these results due to the fact that the sample size to number of variables ratio (80:35) is much smaller than the recomended 20:1. The summary is found in Table 32. Univariate ANOVA F values are included for purposes of comparison.

Table 32

Summary of Stepwise Discriminant Function Analysis

			Variance acctd for		Univariate ANOVA	
Step	Entered	Wilks Λ	each	cumulative	F	Sig of F
			55 cases (3,51 D.F.)			
1	Vocal Phrases Duration	.4258	81.9%	81.9%	22.92	<.001
2	Loudness	.3074	8.7%	90.6%	19.50	<.001
3	Neutral Tension Flow	.2522	3.0%	93.6%	3.04	.037
4	Lengthening	.2286	1.2%	94.8%	2.33	.085
5	Pitch Variability	.2059	1.0%	95.8%	2.63	.060
6	Total Shape Flow Changes	.1899	0.6%	96.4%		>.10
7	Number of Flow Reversals	.1752	0.5%	96.9%	2.35	.084
8	Gradual Tension-Flow	.1620	0.5%	97.4%		>.10
9	Pitch Level	.1508	0.3%	97.7%		>.10
			79 cases (3,75 D.F.)			
1	Loudness	.6524	57.4%	57.4%	13.32	<.001
2	Segment Length	.5650	10.7%	68.1%	4.34	.007
3	Neutral Tension Flow	.4914	7.8%	75.9%	3.38	.023
4	Number of Flow Reversals	.4663	2.4%	78.3%	2.47	.068
5	Vocal Phrases Duration	.4430	2.1%	80.4%	11.89	<.001
6	Lengthening	.4047	3.2%	83.6%	1.89	>.10

The best predictor of facial expression among the variables appears to be the duration of the vocal phrases. The second best predictor seems to be loudness of the vocalizations. The third best predictor is the confounding variable segment length. Other possible predictors include the percentage of neutral tension-flow, the number of instances of lengthening, the number of tension-flow reversals, pitch variability, the total number of shape-flow changes, the percentage of gradual tension-flow, and pitch level. Thus, if all you know of a baby's vocalization is how long the phrases are and how loud it is, you have a good chance of predicting what the facial expression the baby is displaying.

Discussion

Conclusions based on between group comparisons:

Joy in the face, as previously described, is expressed with the mouth corners drawn back and up as in a smile and the eyes being squinted. As shown in Tables 21, 30 and 31, the co-occurring expression of Joy by the body can possibly be described as having a great deal of energy as indicated by the high percentage of high intensity tension-flow and sharp reversals of tension resulting in the highest percentage of fighting-type tension-flow attributes of the four affects studied. Joy may even have more fighting-type attributes than Anger. Joy may also be characterized in shape-flow by the least widening and the most lengthening of the four expressions and therefore the least horizontal and most vertical movement. Joy, then, is most often expressed by reaching and stretching up with rapid high intensity jumping up and down. The phrase "Jumping for Joy" can perhaps best describe the findings. When vocalization accompanies the facial expression, the prototypical Joy expression would seem to be only a few high pitched, soft, short, arrhythmic, coos or laughs using the "eh" sound, with few harmonics as seen in Tables 22, 30 and 31.

Interest was found to likely be expressed by the body in the form of having the most tension-flow changes, the highest percentages of even flow fluctuation, neutral flow intensity, and indulging-type attributes of tension-flow. In shape-flow, interest may be expressed with the fewest shortenings, lengthenings and therefore vertical movement, and the least shrinking. The babies, when expressing interest in their faces through knitting their eyebrows and opening or pursing their lips, engaged in a great deal of fine motor movement, most often playing with toys. This yielded observations of many small fluctuations in neutral intensity and even flow with relatively no vertical or shrinking shape changes. The babies were sitting still manipulating objects in which they seemed to be interested. Most often there was no vocalization as they would be playing quietly. When they did express vocally, it would be with very few, low, soft, short, quick, exhales or coos using the "eh" sound, non-variable in pitch and volume. It could be assumed that it is in this state of quiet, still concentration that the most learning and cognitive activity is occurring. It is important to note that this state is not unemotional, it is simply the least salient of the four emotional expressions.

Sadness is expressed in the face with the corners of the mouth drawn down, the chin often raised, the eyes squinted and the eyebrows pulled together and up. These facial expressions were the shortest in duration of the four affects under study. The findings suggest that the sad facial expression is most often accompanied in the body with the least tension flow changes, the most shortening, least hollowing and bulging and therefore least saggital movement, and least growing. The sad-faced babies would often be sitting down with passive use of weight neither advancing nor retreating but simply giving in to gravity, then showing very little movement. The sad vocalizations were on average medium loud, medium long, guttural cries using the vowel "i" or "e".

Anger is expressed in the face with a wide, squarish mouth, eyes squinted or tightly shut with eyebrows pulled sharply together and down. This facial expression was held the longest of the four under study. Along with this facial expression, the body most often showed the most flow adjustments, the most gradual flow transitions, and the most rounded reversals of tension-flow. We normally think of anger as being expressed through aggressive pounding or hitting with clean sharp strikes which would yield very few flow adjustments and sharp reversals. This was not seen in the babies. Instead, as the babies were crying in protest, many flow fluctuations in the form of small increases and decreases of tension were seen while all the while a gradual building or releasing in intensity was occurring. When the overall body tension made its change from building to releasing or vice versa, this change was seen to have been fluid and coded with a rounded reversal. Shape-flow expressions of anger included the most narrowing and widening, therefore the most horizontal movement, and the most hollowing and bulging, therefore the most saggital movement. The angry baby does not do much moving up and down, but rather does a lot of getting bigger and smaller by getting wider and narrower and bulging and hollowing. Angry vocalization is characterized by many very loud, long, rhythmic, nasal phrases of crying and wailing the vowel "a" with many harmonics and greatly varying pitch and volume. The shaking in the body is very related to the production of the vocalization. As the baby cries loudly, and attempts to catch its breath between cries, the body makes many minor adjustments in its tension as it fills and empties with breath.

The discriminant function analyses suggest that many of the vocal and body movement variables under study were significant predictors of facial expression. By taking into account the explained variance of each variable in the two analyses that needed to be done with the different sample sizes, it is likely that the duration of the vocal phrases is the best predictor of facial expression. The length of the vocal phrases is defined as the duration of continual audible sound between noticeable silences usually involved with taking a breath. Phrase duration statistically differentiates anger from sadness, and both anger and sadness from joy and interest. Of importance is the differentiation of sadness from anger because they are two emotions of the same hedonic tone and are both considered "negative" emotions and are difficult to differentiate. Anger has the longest phrases followed by sadness. Interest and joy had very short vocal phrases.

Loudness of the vocal expressions, quite possibly is the second best predictor. Loud vocalizations are associated with emotions of negative hedonic tone, either anger or sadness, while soft vocalizations are associated with either interest or joy.

Segment length, predetermined before any measures were taken, works out to be the next best predictor. This was based on the length that the facial constellation was held without changing.

Other possible predictors of facial expression worth entertaining are neutral tension-flow, number of flow reversals and lengthening. The percentage of neutral tension-flow is found to differentiate the two positive expressions. Interest seems to have more neutral flow than joy. The number of occurrences of lengthening in the body may also differentiate between the expressions of positive hedonic tone, with joy having more lengthening than interest. The number of flow reversals appears to differentiate the two negative expressions with anger having many reversals of tension flow and sadness having very few.

This evidence suggests support for the hypothesis that there are distinct and discernible combinations of vocal and body movement descriptors for each of the four facial expressions under study.

The Relationship of the Findings to Previous Vocal Expression Research

Support for Darwin

Perhaps not surprisingly, given his genius, many of Darwin's observations about the vocal expression of emotion were supported in the findings. He had noticed that joy, enjoyment, or amusement could be signaled by high pitched "e" sound characterized as a laugh. The current findings indicate that joy is the highest pitched of the four expressions studied, that it is most commonly vocalized by babies as an "e" sound, and that when it is not characterized as a coo, it is described as a laugh. Darwin had described the vocalizations of anger, rage, rivalry, or pain as being loud, powerful, prolonged, variable in pitch, and harsh in tone. The current findings support those observations indicating that angry vocalizations by babies are the loudest, longest, most variable in pitch, and the most nasal of the four expressions studied. Darwin did not explicitly mention either sadness or interest, and no clear agreement of the current findings support his observations of the related emotions of loneliness, suffering, or agony, or excitement, passion, or love.

Support for Scherer

In comparing the current findings with the compilations of Scherer (Scherer & Oshinsky, 1977; Scherer, 1979), some conclusions are supported while others are not. The bulk of the differences can be explained by the fact that most of the vocal expression studies Scherer reviewed were done with adult actors speaking sentences with infused emotional expression while the current findings are taken from babies naturally expressing spontaneous emotion. In examining anger, there is concurrence that anger is expressed with a wide pitch range, loudly, and with many harmonics. There are differences in that baby cries of anger are relatively slow in tempo while adult expressions tend to be fast in tempo. With sadness, there is agreement that sadness is slow in tempo but there is also a contradiction with the current findings showing that a baby's expression of sadness is loud while Scherer presents evidence of adult sadness being soft. As far as joy is concerned, agreement is found in that joy is expressed with high pitch, and a clear tone with few harmonics. Again a difference is found in the acoustic parameter of loudness, where babies softly express joy while adults loudly express joy. Scherer did not review any studies that examined the emotion of interest.

The differences found here is perhaps best explained by the age of the subjects more than by the naturalistic vs. artificial situation. During the course of development of emotional expression, there are certainly changes. Perhaps the function of the emotions in the service of need gratification changes. An adult desiring closeness and comforting while experiencing sadness does not want to drive others away with a loud vocalization. As with joy, adults have been reinforced throughout their lifetimes to express joy and thus express joy more through loud laughter.

Support for Burt

Many of the specified hypotheses set forth at the onset of the project based on Burt's pilot research (1990) were supported with duplicate findings. Referring back to the hypotheses in Table 9, anger does appear to be signaled with the vowel sound "a" as in "pat" while sadness is most likely signaled either with "e" as in "pet" or "i" as in "pit". Referring to Table 6, anger does seem to be signaled with a wide range of pitch while interest and sadness are more likely expressed with narrow pitch range. Interest is probably soft while anger is usually loud. Joy and interest seem to have small variability in their pitch variability while sadness seems to have moderate variability. Joy and interest are most likely signaled with short phrases while sadness is usually signaled with longer phrases. Joy and interest appear to have very little rhythmicity. Joy also seems to have very few harmonics making it clear in tone while anger more likely has many making it harsh in tone. All of the hypotheses presented in Table 7 were supported with the exception of timbre which did not pass the post hoc multiple comparisons test. Hedonic tone can, in all liklihood, be distinguished by pitch range, loudness, loudness variability, duration, rhythmicity, and harmonics with anger and sadness having more of each of the parameters. Of the hypotheses posited in Table 8, anger was found to have the widest pitch range and variability, while interest had the smallest pitch variability. Anger was the loudest while interest was the softest. Anger was the longest and had the most harmonics. A contradiction with my previous research was found in that anger was judged to be the slowest of the four expressions in the current study when it was found to be the fastest in the previous study. Regarding the hypotheses presented in Table 9, none of the vocal descriptors were found to discriminate joy from interest, and none of the expected vocal variables distinguished anger from sadness, although vocal phrase duration did.

With this support of the previous findings, more evidence is mounting in support of the hypothesis that there are distinguishable vocal signals of the discrete emotions. The presence of some contradictions points to the need for further refinement of methods and further studies.

The Relationship of the Findings to Previous Body Movement Expression Research

Support for Kestenberg

As stated before, Kestenberg (1975) believes that the full movement efforts of weight, space, and time have natural affinities for each of the elements in unidirectional shape-flow. The elements of unipolar shape-flow have developmental precursors in bipolar shape-flow while the movement efforts have developmental precursors in the elements of tension-flow. The affinities are listed in Table 33.

Table 33

Affinities between full movement efforts and their precursors in tension-flow (t-f) and unipolar and bipolar shape-flow (s-f)

Full effort Element	T-f precursor Attribute	Plane Unipolar s-f	Plane Bipolar s-f	Effort/Shape-flow
weight	intensity	vertical	vertical	
strength	high	sinking	shortening	fighting/shrinking
lightness	low	rising	lengthening	indulging/growing
space	consistency	horizontal	horizontal	
direct	even flow	enclosing	narrowing	fighting/shrinking
indirect	flow adjustment	spreading	widening	indulging/growing
time	slope	saggital	saggital	
quick	abrupt	retreating	hollowing	fighting/shrinking
sustained	gradual	advancing	bulging	indulging/growing

Two of Kestenberg's six affinities are supported by the correlational data while one of them is refuted. Widening with flow adjustment and shortening with high intensity are supported. The theoretical affinity of narrowing with even flow was contradicted with the finding of narrowing with flow adjustment. These may be important findings for the field of movement observation.

In regards to Kestenberg's hypotheses about which body movements signal which emotions, support is found for her thought that poise if thought of as interest has the most even flow, pleasure and content if thought of as joy is signaled by the most lengthening, strain if thought of as sadness has the most shortening, and impatience if thought of as anger has the most hollowing.

Some discrepancies are found when comparing the results with the combined hypotheses of Goodill, Kestenberg, and Burt found in Table 11. Three of the four hypothesized tension-flow attributes thought to be indicative of anger were not supported. Instead, the best combination of tension-flow attributes to describe the movements during anger include adjusting flow, high intensity, gradual transitions, and rounded reversals which taken together form no clearly distinguishable tension-flow rhythm but could be seen as a combination of the urethral libidinal or running rhythm and the inner genital sadistic or large wave rhythm (see Table 3 for the attributes that make up the tension-flow rhythms). Two of the three hypothesized attributes indicating sadness were supported. Sadness seems to be best indicated by even flow, high intensity, gradual transitions, and rounded reversals which makes up the inner genital sadistic or large wave rhythm as opposed to the hypothesized outer genital libidinal jumping or leaping rhythm. The findings for interest were in complete agreement with the hypotheses. Interest is signaled through the use of even flow, neutral (or low) intensity, gradual transitions and rounded reversals which is the inner genital libidinal or undulating rhythm. Only one of the four expected attributes of joy was found. Joy appears to have a combination of even flow, high intensity, abrupt transitions, and sharp reversals which is the outer genital sadistic or leaping rhythm not the anal libidinal twisting rhythm expected. Keeping in mind that the inter-observer agreement was quite low for these measures, caution should be taken in the interpretation of these findings.

With the indications found pairing shape-flow elements to the four emotions studied, again, there is some support and some contradiction found between the results and the hypotheses found in Table 12. The most clearly supported expectation was that joy is signaled with lengthening. The expectations that sadness would have the most shortening, and that anger would have the most widening and hollowing were confirmed. No support was found for the hypotheses regarding the shape-flow of interest.

A possible explanation for any failures to find distinct body movement expressions could be that the nervous system develops in a cephalo-caudal fashion, meaning from head to tail. The fine motor movements at the extremities and in the lower half of the body at thirteen months may not be developed to enough of an extent to produce controlled expressive movements.

Implications and Significance of the Findings

Implications of the findings for emotional development

The current findings support Izard's Differential Emotions theory (1972, 1992). Just as the face has been shown to do, it appears that the body and the voice also both signal the different affective expressions in unique ways. Clearly differential signaling of different emotional states is an adaptive response passed on through humanity as a method for the survival of the species. As human infants are totally dependent on their caregivers for their survival, they must have a means for communicating their needs. Anger, sadness, interest, and joy, as well as the other fundamental expressions, indicate to the caregivers the needs of the infant and continues to affect natural selection.

Implications of the findings for nonverbal expression

The findings of this study indicate that there may be an inter-connected if not unified emotional expression system. The many correlations and clear differences between the expression of the four emotions support the notion that expression of emotion is developed simultaneously in the three emotional expression systems. Further research of this type would be necessary to establish possible variations in the developmental course of the three systems. Infants of 13 months, however, appear to differentially express their feelings using all three systems.

Implications of the findings for psychotherapy

The best application of these findings are in the fields of early childhood intervention and parent training. Therapists working with developmentally delayed children, children with physical disabilities, or babies born of mothers with cocaine addiction, could use these findings to base their judgements about the signals that the babies are expressing. In working with mothers and fathers in parenting classes, the signals of emotion coming from the face, voice, and body movement could be better identified, thus cueing the parents to respond appropriately to the needs of the child. The only way that babies can express their needs is through emotional expression. Knowledge of infant emotional expression is fundamental information that all parents should have. By examining the emotional signals, parents could also be taught to be more expressive themselves and well as responsive to the needs of the baby.

Dance/Movement therapists, movement analysts and choreographers will be able to use the information derived from this study in more accurately interpreting the emotional significance of movement, especially that of infants. It may be a stretch to apply the findings of this study to the observation of adult movement, but the findings might point to a helpful starting point for further research and theory about the expressive movements of adults. Therapists, both verbal and non-verbal, knowing that we all displayed certain movement constellations to signal particular affective states in infancy, may be able to use the information to begin to lead a therapy session toward a therapeutic goal. In Dance/movement therapy, where free expression using the body is encouraged, the movement constellations would be apparent. Assuming a developmental model, a therapist could better interpret the emotional state of the client and if wishing to foster a particular emotional state could encourage the use of the movement that was found to signal that particular emotion. The findings have much better significance and applicability to the practice of infant and child dance/movement therapy.

As with the implications for dance/movement therapy, music therapy practice can benefit from the use of the vocal correlates of the different facial expressions. Since musical expression is most likely originally rooted in vocal expression, a particular constellation of musical elements heard in a therapy session, especially with children, could be interpreted as would the vocal elements. For instance, if a music therapy client is improvising on a drum and is playing loud, long rhythmic phrases, a hypothesis of their expression of anger could be supported. If on the other hand, if the client is playing high pitched, soft and short arrhythmic phrases, an expression of joy could be suggested. Since the creative arts therapies deal so directly with affective state, this objective knowledge of emotional signaling could be invaluable.

Verbal therapists as well, armed with this knowledge, could observe the subtle movements of their clients as they sit and talk. Knowing, for instance that anger in infancy is signaled with many more subtle tension-flow adjustments rather than clear fighting efforts, the therapist can interpret the behavior of adjustments during slow hand-clenching as a possible indicator of anger. Seeing a person lengthen in their chair may be an indicator of joy, while sinking is an indicator of sadness.

Limitations of the Present Study

It must be kept in mind that many of the conclusions were based on evidence that should be viewed as having threatened validity. The low ratio between the number of subjects and the number of measures and statistical tests is a drawback of the study. A much higher sample size would be needed to have good confidence in the findings, however, in the spirit of exploratory research, the lower sample size was used.

The inter-rater reliability was lower than would be acceptable in vigorous research. Having more training of the body movement coders in particular would have made for more conclusive results.

The wide range of segment lengths from between .4 to 28.2 seconds is a potential drawback as there is likely to be more accurate information derived from the longer segments which tended to be the anger expression and less accurate information derived from the shorter segments which tended to be the sadness expressions. This was a trade-off in an attempt to get the highest sample size possible.

Suggestions for Further Study

More studies of this design with certain improvements are needed to help chart the differential signaling of emotion through the three modes of expression. Using a higher number of segments, with fewer measures and fewer statistical tests, with better inter-rater reliability and making use of segments of mean or longer duration for each expression would be recommended.

Computerized digital spectrographic and sonographic analysis could be used to analyze the vocal segments. Computer programs are being developed to measure volume, pitch, and harmonics across time. This sort of analysis could help remove the subjectivity inherent in human ratings and imporve the validity of the measures. The potential drawback is introducing more technical problems. For instance the human ear can compensate for babies having been different distances from the microphone and can filter out background noise as being non-relevant. A well-controlled set up with good recording equipment would optimize this promising method.

More projects need to be done to test the inter-observer reliability of movement observation. Martha Davis, a prominent movement analyst, has identified this as a priority in dance/movement therapy research. This study shows even more evidence for that need. It is clear that while training body movement coders, a reliability criteria must be met before final coding on a project is undertaken. If the raters are trained to observe in the same way and are required to meet an 80% agreement in their ratings, reliability during the study would be better and more confidence could be had in the results.

Finally, as previously suggested, a longitudinal investigation of the development of the three expressional systems should be done to investigate the possible differential developmental course of the systems and to better look into the question of the presence or absence of a single unified expressional system.

Summary and Conclusions

The most statistically supported conclusions using only variables that met acceptable levels of inter-observer reliability, and significant support from the correlational findings of the discriminant function analyses or the between group comparisons are as follows:

1. Infant facial expressions of anger are accompanied by many changes in tension-flow and many occurrences of widening and narrowing in the body and the vocal use of a very long rhythmic phrases with wide range of pitch, high volume and many harmonics making for a harsh tone.

2. Infant facial expressions of sadness are accompanied by very few changes in tension-flow and the vocal use of long phrases and with high volume.

3. Infant facial expressions of joy are accompanied by the use of many of the fighting qualities in tension-flow and the vocal use of short arhythmic phrases with narrow range of pitch, low volume, and few harmonics making for a clear tone.

4. Infant facial expressions of interest are accompanied by the use of many changes in tension-flow making use of many of the indulging tension-flow qualities in the body and short arhythmic phrases with narrow range of pitch, and low volume.

This study supports the idea that there are distinguishable basic emotions and that these emotions are signaled differentially by vocal and body movement channels as well as by facial expression.

Glossary

Aggressive/sadistic rhythms - Half of all tension-flow rhythms. Rhythms from each developmental stage can exhibit an aggressive or sadistic quality by having either higher intensity or more abruptness in the changes of the tension-flow than libidinal rhythms.

Amplitude - loudness, volume, or intensity.

Anal rhythms - tension-flow rhythms learned through the development of control over the retention and elimination of feces by the anus.

Attributes of tension-flow - the elements involved in determining the tension-flow rhythms, which include consistency, intensity, change/slope, and reversal.

Change in the tension-flow - an attribute of tension-flow, the speed of the modulations in the tension-flow as defined by the *slope* of the tracing from nadir to zenith and vice-versa, gradual change being a line of less than 45 degrees, abrupt change being a line of greater than 45 degrees.

Consistency - the even or adjusting quality of the change in tension-flow as defined by the presence or absence in the tracing of the tension-flow of reversals of tension-flow while maintaining a primarily bound or free quality.

Defecating rhythm - the anal aggressive/sadistic rhythm that consists of even flow consistency, high intensity, gradual change, and sharp reversals.

Duration - the relative average length of the vocalization phrases in the sample as judged by the raters.

Envelope - the shape of the sinusoidal sound wave (Scherer, 1982).

First formant mean - frequency of the first (or lowest) formant averaged over an utterance (Scherer, 1986).

Flow - tension-flow.

Formant - a significant energy concentration in a spectrum (Scherer, 1986).

Formant bandwidth - width of the spectral band containing significant formant energy (Scherer, 1986).

Formant precision - degree to which formant frequencies attain values prescribed by the phonological system of a language (Scherer, 1986).

Fundamental frequency - vibration rate of vocal folds (Scherer, 1986).

Fundamental frequency contour - fundamental frequency values plotted over time (intonation) (Scherer, 1986).

Fundamental frequency mean - fundamental frequency as averaged over a speech utterance (Scherer, 1986).

Fundamental frequency perturbation - slight variations in the duration of glottal cycles (Scherer, 1986)

Fundamental frequency range - difference between highest and lowest fundamental frequency in an utterance (Scherer, 1986).

Fundamental frequency variability - measure of dispersion (e.g., standard deviation of fundamental frequency) (Scherer, 1986).

Harmonics - the relative number of overtones included in the voice tone as judged by the raters. Many harmonics sound nasal or like a reed instrument; few harmonics sound clear like a French horn.

High-frequency energy - relative proportion of energy in the upper frequency portion (e.g., > 1 kHz) (Scherer, 1986).

Inner genital rhythms - have their prototype in the slow undulations of the birth canal in women that is evident during sex and childbirth.

Intensity of tension-flow - the degree to which a movement exhibits either free or bound tension-flow, as shown by the location of the reversal in tension-flow on the tracing, high intensity reversing beyond the high intensity line, low intensity reversing within the high intensity line.

Intensity - Loudness, volume, or amplitude.

Intensity mean - energy values for a speech sound wave averaged over an utterance (Scherer, 1986).

Intensity variability - measure of dispersion of intensity values in an utterance (e.g., standard deviation) (Scherer, 1986).

Jumping rhythm - the outer-genital libidinal rhythm consisting of even flow consistency, high intensity, abrupt change, and round reversals.

Large wave rhythm - the inner-genital aggressive rhythm consisting of even flow consistency, high intensity, gradual change, and round reversals.

Leaping rhythm - the aggressive/sadistic outer genital rhythm characterized by even consistency, high intensity, abrupt change and sharp reversals

Libidinal rhythms - Half of all tension-flow rhythms. Rhythms from each developmental stage can exhibit a libidinal quality by having either lower intensity or more graduality in the changes of the tension-flow than aggressive/sadistic rhythms.

Loudness - Volume, intensity, or amplitude.

Loudness mean - the intensity mean or the relative mean volume of the sample vocalization as judged by the raters.

Loudness variability - intensity variability or the relative standard deviation of the vocalized decibel points from the mean volume of the sample as judged by the raters.

Oral rhythms - established through the functions of sucking and biting used in early infant feeding.

Outer genital rhythms - have their origins in the thrusting of the male during sexual intercourse.

Pitch level - fundamental frequency mean or the relative mean frequency of the vocalization as subjectively judged by the raters.

Pitch range - fundamental frequency range or the relative range of frequencies between the highest and the lowest vocalized pitches as judged by the raters.

Pitch contour - fundamental frequency contour.

Pitch variability - fundamental frequency variability or the relative standard deviation of the vocalized pitches from the mean frequency of the vocal sample as judged by the raters.

Reversal of the tension-flow - the manner in which tension-flow transitions between becoming bound to becoming free or vice-versa. Round reversals are characterized by a curvilinear line at the point of direction change in the tension-flow tracing, and sharp reversals are characterized by the presence of an angle at the point of direction change in the tracing.

Rhythms - particular patterns of tension-flow that are particular combinations of the attributes of the tension-flow.

Rhythmicity - the relative degree to which the vocalization exhibits a regular, even, and rhythmic pulse as judged by the raters.

Run-stop-go rhythm - the urethral aggressive rhythm consisting of adjusting flow consistency, low intensity, gradual change, and sharp reversals.

Running rhythm - the urethral libidinal rhythm consisting of adjusting flow consistency, low intensity, gradual change, and round reversals.

Second formant mean - mean frequency of the second formant (Scherer, 1986).

Sequence - the speed of alternations between sound and silence units in an utterance (Scherer, 1982).

Snapping rhythm - the oral aggressive rhythm consisting of even flow consistency, low intensity, abrupt change, and sharp reversals.

Spectral noise - aperiodic energy components in the spectrum (Scherer, 1986).

Spectrum - a frequency by amplitude plot (Scherer, 1982).

Speech rate - number of speech segments per time unit (Scherer, 1986).

Sucking rhythm - the oral libidinal rhythm consisting of even flow consistency, low intensity, abrupt change, and round reversals.

Tempo - the speech rate or the relative speed that the vocalization utterances are articulated as judged by the raters.

Tension-flow - the movement or flow of muscle tension in the muscles of the body alternating between binding and freeing of the muscular tension.

Timbre - the tone of the voice from guttural to nasal, which is determined by the placement of the vocal energy in the voice passageway of the vocalizer, as judged by the raters.

Twisting rhythm - the anal libidinal rhythm consisting of adjusting flow consistency, low intensity, abrupt change, and round reversals.

Undulating rhythm - the inner-genital libidinal rhythm consisting of even flow consistency, low intensity, gradual change, and round reversals.

Urethral rhythms - develop through the use of the muscles involved with the urethra to allow for either the interruption or fluid release of urine.

Volume - loudness, amplitude, or intensity.

Volume contour - loudness or intensity values plotted over time.

**except where noted, all definitions were written by the present author for the purposes of SAAAPIV operational definitions.*

Appendix A

A System for the Auditory Assessment of Acoustic Parameters in Vocalization (SAAAPIV)

Tape # _____ Vocalization Episode # _____ Your Name ___________

Pitch Level (Mean Fundamental Frequency)							
High Pitched	1	2	3	4	5	6	Low Pitched
Pitch Range							
Wide Range	1	2	3	4	5	6	Narrow Range
Pitch Variability							
Large (Melodious)	1	2	3	4	5	6	Small (Monotonal)
Loudness (Mean Volume)							
Loud	1	2	3	4	5	6	Soft
Loudness Variability							
Large	1	2	3	4	5	6	Small
Duration							
Long	1	2	3	4	5	6	Short
Tempo							
Fast	1	2	3	4	5	6	Slow
Rhythmicity							
Rhythmic	1	2	3	4	5	6	Arrhythmic
Harmonics							
Many	1	2	3	4	5	6	Few
Timbre							
Nasal	1	2	3	4	5	6	Guttural

Characterization

Squeal Laugh Shout Call Word Babble
Coo Sigh Exhale Inhale Gasp
Cough Fret Whine Sob Cry Wail

Appendix B
Kestenberg Movement Profile (KMP) - Burt Abridgment

Writing/Tracing of Segment

- -

- -

Tension-Flow Attributes - Tallies

	Indulging	Fighting
Consistency.....	Flow Adjustment ________	Even Flow ________
Intensity.......	Low ____________________	High _____________
Change/Slope....	Gradual ________________	Abrupt ___________
Reversal........	Rounded ________________	Sharp ____________

Shape-Flow - Tallies

	Growing	Shrinking
Horizontal.....	Widening ________	Narrowing ________
Vertical.......	Lengthening _____	Shortening _______
Saggital.......	Bulging _________	Hollowing ________

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