

# Pitch and Communicative Intent in Mother's Speech: Adjustments for Age and Sex in the First Year

Christine Kitamura and Denis Burnham

*Macarthur Auditory Research Centre Sydney  
University of Western Sydney*

This study investigated pitch and communicative intent in mothers' infant-directed speech spoken to their infants at birth, 3, 6, 9, and 12 months. Audio recordings of mothers (6 with female, and 6 with male infants) talking to another adult and to their infant at 5 ages were low-pass filtered and rated by 60 adults on 5 scales (Positive or Negative Affect, Express Affection, Encourage Attention, Comfort or Soothe, and Direct Behavior). Mean fundamental frequency ( $F_0$ ) and pitch range of utterances were also measured. Utterances associated with *positive affect* tend to peak at 6 and 12 months, whereas more directive utterances peaked at 9 months. Mean  $F_0$  followed the age trend for affective utterances, and pitch range followed the trend for directive utterances. The results suggest mother speech patterns reflect, complement, and perhaps facilitate infant development.

"Are you my little pumpkin pie?" There are certain aspects of this utterance that signify that it is spoken to an infant: the words used (linguistic), the pitch and prosodic features (acoustic), and the affect conveyed in the voice (affective). The linguistic and acoustic aspects that distinguish infant-directed speech (IDS) from adult-directed speech (ADS) have been well documented: IDS has shorter utterances, longer pauses, slower speech rate, higher pitch, greater pitch modulation, more distinctive pitch contours, and hyperarticulated vowels (Andruski & Kuhl, 1996; Fernald & Simon, 1983; Snow & Ferguson, 1977; Stern, Spieker, Barnett, &

McKain, 1983; Stern, Spieker, & McKain, 1982). Moreover, infants prefer to listen to IDS over ADS (Cooper & Aslin, 1990; Fernald, 1985; Pegg, Werker, & McLeod, 1992; Werker & McLeod, 1989) and are rated to be more emotionally responsive when listening to IDS than ADS (Werker & McLeod, 1989). Infants' selective preference for IDS has been thought to be based on certain acoustic properties: Fernald and Kuhl (1987) found infants' IDS preferences to be based on the pitch of IDS rather than its amplitude or durational characteristics. However, Kitamura and Burnham (1998b) showed that the affective qualities of IDS are important in determining infants' IDS preferences: They found that when pitch is equated and rated positive affect is systematically manipulated, infants prefer high affect to low affect IDS, but that when rated affect is equated and pitch manipulated, there are no preferences. These findings are consonant with those of a study by Fernald (1989), in which it was found that affective intent is more easily interpreted by adults in IDS than ADS.

Among its roles, IDS attracts infants' attention, regulates affective behavior, and rewards the infant (Fernald, 1993; Kitamura & Burnham, 1998b; Werker & McLeod, 1989). It has been suggested that infants come to understand the emotions and intentions of others through the mother's tone of voice in these early interactions (Fernald, 1992) and that young infants learn to associate particular speech patterns with certain contexts and sensory input, such as facial expression (Cooper, 1993). For example, 4-month-olds look longer at faces previously paired with IDS than faces previously paired with ADS (Kaplan, Jung, Ryther, & Zarlengo-Strouse, 1996), and IDS better facilitates discrimination of aspects of the speech environment, such as a change in the gender of the speaker, the speech content, or the temporal synchrony between lips and face (Lewkowicz, 1996). Thus, aspects of IDS attract infants' attention, and it seems that these aspects also facilitate the infant's ability to learn about features of his or her social environment.

If the voice is used to encourage, reward, arouse, and soothe the developing infant, it is probable that other aspects of development are affected by parent–infant conversations. In a review of human and nonhuman studies of mother–infant separation, Hofer (1987) suggested that the rhythm, timing, and intensity of stimulation provided by the mother in the interactional process may have long-term consequences for biological and behavioral regulatory functioning (e.g., behavioral activity, sleep, growth, and the cardiovascular and immune systems). Applied to human infants, this suggests that the distinctive rhythm, timing, and pitch of IDS may provide infants with an important source of auditory input. Malloch (1999) showed that timing and pitch are integral elements of mother–infant interactions and that regular timing intervals coordinate these interactions allowing mother and infant a form of "coordinated companionship" using the musical structure of IDS. In a similar vein, Snow (1977, 1989) proposed that the characteristics of maternal speech help establish mother and child as conversational

**partners by encouraging turn taking.** Within this model, Snow claimed the infant learns the protocols of social interaction and that such a style of interaction facilitates both socialization and language acquisition. More specifically in regard to language development, Locke (1993) argued that "affect is logically necessary—it impels the child to exploit, and therefore to develop linguistic capacity" (p. 330), which implies that affective signaling is the motivating force that leads the infant to acquire language skills. Nevertheless, both Locke and Snow appear to agree that the affective and linguistic roles of IDS are closely related and facilitate language development.

Research to date suggests that IDS has three main functions. First, IDS engages and maintains infant attention (Fernald & Simon, 1984; Papousek, Papousek, & Symmes, 1991; Stern et al., 1982; Sullivan & Horowitz, 1983a, 1983b). Second, it communicates affect and facilitates social interaction (Fernald, 1989, 1993; Papousek, Bornstein, Nuzzo, Papousek, & Symmes, 1990; Werker & McLeod, 1989). Third, it facilitates language acquisition (Fernald & Mazzie, 1991; Hirsh-Pasek et al., 1987; Kemler Nelson, Hirsh-Pasek, Jusczyk, & Wright Cassidy, 1989). The relative strengths of these three functions may vary over the first year of life. For example, Fernald (1992) proposed that IDS changes from being mostly attentional–affective in early infancy to becoming more linguistic at the end of the first year. The study reported here investigates adjustments to pitch and communicative intent in IDS over the first year of life. Equal numbers of mothers speaking to their female and male infants were recorded longitudinally at five infant ages: birth, 3, 6, 9, and 12 months, with a view to examining affective adjustments in speech as a function of infant age and sex.

### IDS BEHAVIOR AS A FUNCTION OF INFANT AGE

There are few published studies that have investigated age-related changes in the acoustic characteristics of speech directed to prelinguistic infants. Stern and colleagues (1983) compared speech to neonates, and 4-, 12- and 24-month-olds using four measures of pitch: maximum  $F_0$ , range  $F_0$ , terminal  $F_0$ , and the transitional difference in  $F_0$ , between the end of one utterance and the beginning of the next. All were found to be higher in speech addressed to 4-month-old infants than speech to neonates, 12-month-olds, and 2-year-olds. Similarly in a longitudinal study with Australian English mothers, mean pitch has been found to peak around 6 months, whereas pitch range increases across infancy (Kitamura, Attapaiboon, Burnham, & Luksaneeyanawin, in press; Kitamura & Burnham, 1998a). When affect is considered, pragmatic content analyses of maternal utterances show a decrease in the use of affective utterances and an increase in the use of informative utterances as infants approach 12 months (Bornstein et al., 1992; Penman, Cross,

Milgrom-Friedman, & Meares, 1983; Sherrod, Crawley, Petersen, & Bennett, 1978). Indeed, younger infants show greater affective preferences for IDS over ADS than older infants (Werker & McLeod, 1989). Although maternal affective expression may be more pertinent at younger ages, expressions of positive vocal affect conveyed by IDS would appear to have relevance at all infant ages. In the study reported here, five ratings (positive or negative vocal affect, express affection, encourage attention, comfort or soothe, and direct behavior) and two measures of fundamental frequency (mean- $F_0$  and pitch range) are applied to the IDS data. The following predictions are based on the expected changes for each of the rating scales and measures of pitch as a function of infant age. First, it is expected that positive affect and express affection, as well as the two pitch measures, will be most evident in IDS at 3 and 6 months when there is an increase in infants' social and interactive behaviors. Second, it is expected that the intention to encourage attention and direct behavior will increase across age as mothers respond to their infants' increasing awareness and attempted mastery of the environment. Finally, it is expected that the intention to comfort or soothe will decrease over infant age due to the child's increasing facility for emotional regulation.

### IDS BEHAVIOR AS A FUNCTION OF INFANTS' SEX

Although a unitary view is often taken of the nature of IDS to infants, the sex of the child has been investigated in some IDS studies. None, however, have found differences. For instance, there are no sex differences on measures of syntax or vocabulary (Fraser & Roberts, 1975; Halverson & Waldrop, 1970; Phillips, 1973), functional content (Bornstein et al., 1992; Sherrod et al., 1978), or pitch in IDS (Fernald & Simon, 1984). There is some evidence, though, that mothers' communication styles differ depending on whether they are talking to sons or daughters (Cherry & Lewis, 1976; Fagot & Hagan, 1991; Holdgrafter, 1991; Lewis & Freedle, 1973; Masur, 1987). Studies show that around 10 to 14 months, mothers of girls most frequently produce speech-relevant information, but that mothers of boys most commonly produce nonlanguage sounds, for example, car noises (Masur, 1987); that mothers are more responsive to communication attempts by girls than boys at 18 months (Fagot & Hagan, 1991); and that at 2 years, mothers of girls talk more, use more repetition, use longer utterances, and are more likely to ask questions, whereas mothers of boys use more directives and requests for action (Cherry & Lewis, 1976). These latter studies are with relatively older infants who are already producing language. The only study so far to investigate gender differences with preverbal infants is a study of  $F_0$  patterns in IDS to newborns, which found no gender differences (Fernald & Simon, 1984). In the study reported here, 6 boys and 6 girls

are studied so that age-related gender differences in pitch and communicative intent may be investigated.

When mother and infant interact, communication takes place not through linguistic means, for the young infant is incapable of understanding the meaning of speech, but rather through affective means. The aim of this study is to chart affective-communicative intent to boys and girls across the infant's first year as it is conveyed by acoustic rather than semantic measures of the content of IDS. The study relies on acoustic rather than semantic analysis because it has been shown that infants respond primarily to prosodic and affective information (Cooper & Aslin, 1994; Fernald & Kuhl, 1987; Kitamura & Burnham, 1998b; Werker & McLeod, 1989) and that it is not until about 9 months that they begin to have some rudimentary understanding of phonetic-linguistic information in speech (Burnham, Kitamura, & Lancuba, 1999; Jusczyk, Cutler, & Redanz, 1993; Jusczyk, Friederici, Wessels, Svenkerud, & Jusczyk, 1993; Morgan & Saffran, 1995).

## METHOD

Age- and gender-related adjustments to fundamental frequency ( $F_0$ ), mean  $F_0$ , pitch range, and communicative intent were measured. Pitch measures were taken by the usual means (discussed later). Communicative intent was measured using five rating scales to represent affective categories in IDS. Participants were asked to rate each speech sample on the strength of those messages using the five scales (Positive or Negative Vocal Affect, Express Affection, Encourage Attention, Comfort or Soothe, and Direct Behavior).

### Raw Data Collection

The raw data were collected from 12 female native Australian speakers, 6 mothers of female infants and 6 mothers of male infants. Mothers were between 25 and 35 years of age, and all had some level of tertiary education. Mothers were recruited from the Royal Women's Hospital in Sydney, Australia. Information packs were circulated to mothers with new babies to give them the opportunity to volunteer for the study. All participating mothers had healthy, full-term infants, with uncomplicated prenatal and perinatal histories. None of the participating mothers suffered health or emotional problems during the 12-month study. Data from an additional 8 mothers were not analyzed because one or more recording sessions were not completed.

Speech samples were collected longitudinally from the mothers at five infant ages: birth, 3, 6, 9, and 12 months. Sony Professional Walkman tape recorders

with ECM T155 lapel microphones (frequency response: 50–15,000 Hz) were used to record the mothers' speech. The general procedure was to deliver the Walkman to the mothers either at the Royal Women's Hospital (in the case of neonates) or their home and ask mothers to record at least 20 min of interaction with their infant. Tape recorders were left with the mothers for 2 or 3 days. Mothers were told that the study concerned face-to-face interactions between mother and infant. Verbal and written instructions were given to the mothers, first to ensure they were proficient in recording speech using the Walkman, and second to outline the rules of interaction. They were instructed to begin recording when their infant was alert and reasonably content, and to engage in face-to-face interaction by placing the infant in a comfortable position in front of them, either in their arms as a newborn, or in a baby seat at older ages. It was stressed that if it was necessary to engage in an activity, this should involve minimal movement to avoid extraneous noise from contact with mothers' clothing. They were also asked to make sure that noisy appliances were turned off, that no one else was present, and to avoid noisy toys. During taping, mothers mostly just talked to their infants, but there were also incidents of feeding, changing, and playing.

Samples of ADS were collected from conversations between the mother and the experimenter. These adult speech samples were collected when the infant was 6 or 9 months old, so the mother was familiar with the experimenter from previous recording sessions.

A recent meta-analysis of gender effects by Leaper, Anderson, and Sanders (1998) concluded that gender effects were more likely to occur in naturalistic home environments than the laboratory. In laboratory-recording procedures the context, conversational topics, and props (e.g., toys) were usually predetermined. The nature of mother–infant interaction changes substantially over the first 12 months due to developmental changes in the infant and with it the contexts, conversational topics, and types of props required. Based on this, and evidence from Leaper et al., (1998), it was decided that recordings in the home environment may be more sensitive to differences in interactional styles and that the purposes of this study are best served by recording in situations in which mothers were relatively free to respond naturally to the behavior of their infants.

## SCALES OF COMMUNICATIVE INTENT

Maternal expressions of communicative intent are an integral feature of IDS, and this study aims to measure this feature over the first year. Although we do not know the extent of infants' affective perception in the auditory domain, we do know that at 6 months IDS preferences are based on heightened positive affect rather than pitch per se (Kitamura & Burnham, 1998b), that 6-month-olds can distinguish comforting and approving utterances (Moore, Spence, & Katz, 1997), and that 5-month-olds

respond appropriately to approving and disapproving contours (Fernald, 1993). There is also evidence from descriptions of IDS contour categories that mothers convey communicative intent using a small set of context-dependent contours. For example, rising contours are generally used to gain infant attention or encourage a conversational turn; bell-shaped contours are used to maintain attention or reward the infant; and falling contours are used soothe or comfort (Papousek et al., 1991; Stern et al., 1982). In IDS, the pitch contours appear to provide some, but not all, the information about communicative intent: A discriminant analysis by Katz, Cohn, and Moore (1996) found that maternal expressions of "comfort," "attention," and "approval" needed both contour shape information and pitch descriptives (mean- $F_0$ , pitch range, duration) entered into the analysis to achieve the best result. From such studies, it appears that variations to a number of acoustic variables contribute to the perception of vocal affect in IDS, as they do in speech to adults. However, vocal affect is most strongly associated with voice quality (Scherer, 1986), which is fundamentally perceptual in nature and often measured using rating scales (Krieman, Gerratt, Kempster, Erman, & Berke, 1993). The rating scales used here are set out in the next section.

### Rating Scales

Construction of the rating scales was guided by infants' (Kitamura & Burnham, 1998b; Moore et al., 1997) and adults' (Fernald, 1989, 1993) perception of affective intent in IDS, and by descriptive studies showing that particular categories of IDS contours tend to be used in particular interactional contexts (Papousek et al., 1991; Stern et al., 1982). The most commonly cited attributes of IDS are approval, attention, comfort (Fernald, 1989, 1992, 1993; Katz et al., 1996; Papousek et al., 1991), directing attention, and prohibition (Fernald, 1989; Papousek et al., 1991). Thus we devised five scales: Positive or Negative Affect, Express Affection, Encourage Attention, Comfort or Soothe, and Direct Behavior. Specifically, Scale 1 evaluated the degree of perceived positive or negative affect to give an overview of mothers' tone of voice at each age and incorporate any negative affect that may be expressed in contexts of prohibition. Scale 2, Intention to Express Affection, was used to encompass categories such as approval and reward, which are most likely conveyed by the affectionate nature of IDS. Scale 3, Intention to Encourage Attention, acted as an overall measure of vocal qualities that engage and maintain infant attention. Scale 4, Intention to Comfort or Soothe, is also frequently reported to be associated with IDS, especially in falling contours. Finally, Scale 5 was labeled Intention to Direct Behavior, and participants were told it included both directive utterances, for example, "look at the doggie" and prohibitive utterances such as "don't do that," noting that prohibitive utterances are directive in nature and may carry a

positive or negative tone. These categories are not intended to be exhaustive, but are intended to encapsulate common affective categories found in previous studies of IDS.

### Participants

Sixty undergraduate students participated. Their mean age was 21.5 years. The students were enrolled in Introduction to Psychology at the University of New South Wales and participated in the study to obtain course credit. Testing took place in six groups with 10 participants in each group.

### Auditory Stimulus Materials

There were 72 speech samples, 12 of ADS and 60 of IDS. The latter consisted of the 12 mothers speaking to their infants at each of the five ages—0, 3, 6, 9, and 12 months. Each speech sample was the first 25 sec of each mother's recording, unless there was some environmental sound impinging on the sample. For example, one speech sample had the sound of a plane passing overhead at the start. In such cases, the first 25 sec of clear speech was used. Kitamura et al. (in press) found that there were no differences in mean  $F_0$  or pitch range between 20 utterances taken from the start of the same set of mother–infant recordings used here and 20 utterances taken 5 min into these interactions. On average, the duration of the speech samples was 26.8 sec ( $SD = 1.99$ , range = 25.1–30.35). These differences are due to the inclusion of the whole utterances rather than having truncated final utterances. A repeated-measures analysis of variance (ANOVA) showed there were no significant age trend differences (linear, quadratic, or cubic) in the length of the speech samples in IDS, nor was there a difference between IDS and ADS samples. The duration (around 26 sec) was chosen because samples of speech needed to be long enough to identify any age- and gender-related differences between speech samples, but not so long as to induce fatigue and boredom in the raters, given there were 72 samples to rate.

The speech samples were low-pass filtered at 400 Hz with a Hamming filter order of 0.8 using a Kay CSL 4300 system. Low-pass filtering removes segmental information, rendering the utterances unintelligible while leaving the intonation contour intact. In this way, participants must rely on intonation, rather than linguistic content, to make their ratings. Twelve samples were recorded onto each of six TDK SA Type II audiotapes. Six samples from each of two mothers were recorded onto each tape to provide raters with a perceptual standard on which to base their judgments. Order constraints included not having the same mother's utterances more than twice in a row, or IDS to the same age infants more than twice in a row.

### Procedure

Participants were required to rate each of the 72 speech samples on each of the five rating scales. The first, positive or negative vocal affect, was rated on a scale from -4 (*very high negative affect*) to +4 (*very high positive affect*). The other four scales, the intention of the speaker to express affection, encourage attention, comfort or soothe, and direct behavior were each rated on scales from 1 (*not at all*) to 5 (*extremely*). At the beginning of the testing session, the participants were seated in a room and given a response sheet consisting of a set of instructions and 72 sets of the five rating scales. The main substance of the instructions was as follows:

In this task, you will be asked to rate a large number of 25-sec speech samples on a series of scales. These scales measure the emotions and intentions mothers can convey to their infants. The speech has been filtered, and this means the intonation contour is left intact but the speech is unintelligible. Your ratings of these samples should be based on qualities expressed in the intonation patterns in the speaker's voice. Try to focus on the implicit message or tone of voice in each speech sample, as the speech samples can convey more than one message.

Four practice trials followed, after which participants were given the opportunity to ask questions. Once the four practice trials were completed and all questions were answered, testing began. Each of the six groups of participants was played the six audiotapes in a different counterbalanced order. Ten-second between-trial pauses were included on the audiotapes to allow the scales to be completed. Together with a 10-min coffee and cookie break midway through testing, the task took each group of participants 45 min to complete.

### ACOUSTIC MEASURES

Measures of mean  $F_0$  and pitch range were made of the utterances in each of the 72 speech samples. Utterances were defined as segments of speech (sentence, single word, phrase, or sentence fragment) separated by more than 300 msec of non-speech. The number of utterances in each speech sample varied. The mean and standard deviation of the number of utterances at each age were: birth ( $M = 11.9$ ,  $SD = 2.1$ ); 3 months ( $M = 12.9$ ,  $SD = 2.1$ ); 6 months ( $M = 13.25$ ,  $SD = 2.5$ ); 9 months ( $M = 13.7$ ,  $SD = 2.0$ ); 12 months ( $M = 13.3$ ,  $SD = 2.0$ ); ADS ( $M = 6.4$ ,  $SD = 1.8$ ), and for gender were: female ( $M = 71.3$ ,  $SD = 4.0$ ) and male ( $M = 71.0$ ,  $SD = 4.5$ ). In total, 854 utterances were measured. The taped speech samples were digitized at a sampling rate of 10,000 Hz using the Kay Elemetrics Computerized Speech Laboratory (CSL). Samples were filtered at 1000 Hz to maximize the operation of the CSL's automatic peak-picking algorithm, which places impulse

markers on amplitude peaks in the waveform (Snell, Dickson, & Olleck, 1993). This method of extraction is pitch synchronous, as it estimates fundamental frequency on a cycle-by-cycle basis rather than in a sequence of fixed frames of the same duration. Impulse marking and pitch analysis were conducted with an analysis and display range of 70 to 700 Hz.

Pitch range was calculated using the difference between maximum- $F_0$  and minimum- $F_0$  of each utterance. Pitch range was converted from absolute Hertz values to ratio pitch values using the semitone scale. When strictly applied, this transformation should be conducted on all measures of fundamental frequency. However, other studies of IDS–ADS tend to use semitones for range and Hertz for other measures (Fernald, 1989; Fernald & Simon, 1984). In this study, range  $F_0$  was converted from Hertz to semitones (12 semitones = 1 octave) using the formula, semitones =  $12\log_2(\text{maximum-}F_0/\text{mininum-}F_0)$ . Mean  $F_0$  remained in Hertz.

## RESULTS

All ratings and measures of fundamental frequency were analyzed using a series of ANOVAs. Planned orthogonal contrasts within the ANOVAs were used to test linear, quadratic, and cubic trends over infant ages (birth, 3, 6, 9, and 12 months), and any differences between IDS and ADS. Given that this was the first time there have been five infant ages in this type of study, quadratic and cubic contrast coefficients were included to test the possibility that there may be one or two shifts in direction across age. Quartic contrasts were not tested to avoid complicated patterns that may be statistically reliable but descriptively meaningless. An alpha level of .05 was used throughout.

### Scales of Communicative Intent

Preliminary ANOVAs were conducted to evaluate the (a) number of words in each of the speech samples, (b) number of utterances in each of the speech samples, and (c) effect of fatigue on the rater. For the number of words and number of utterances in each of the 72 speech samples, two  $2 \times 6$  ANOVAs were conducted with gender as the between-subject factor and age (birth, 3, 6, 9, 12 months and ADS) as the within-subjects factor. For the number of words, there were no significant linear, quadratic, or cubic trends over infant ages, nor were there any sex differences. Not unexpectedly, there were more words in ADS ( $M = 74.25$ ,  $SD = 14.9$ ) than IDS ( $M = 58.35$ ,  $SD = 14.1$ ) samples,  $F(1, 10) = 15.86$ ,  $p = .003$ . For the number of utterances, the ANOVA showed that irrespective of gender, the number of utterances increased linearly over infant age,  $F(1, 10) = 12.36$ ,  $p = .006$ . In addition there were more utterances in IDS speech samples than ADS samples,  $F(1, 10) = 223.81$ ,

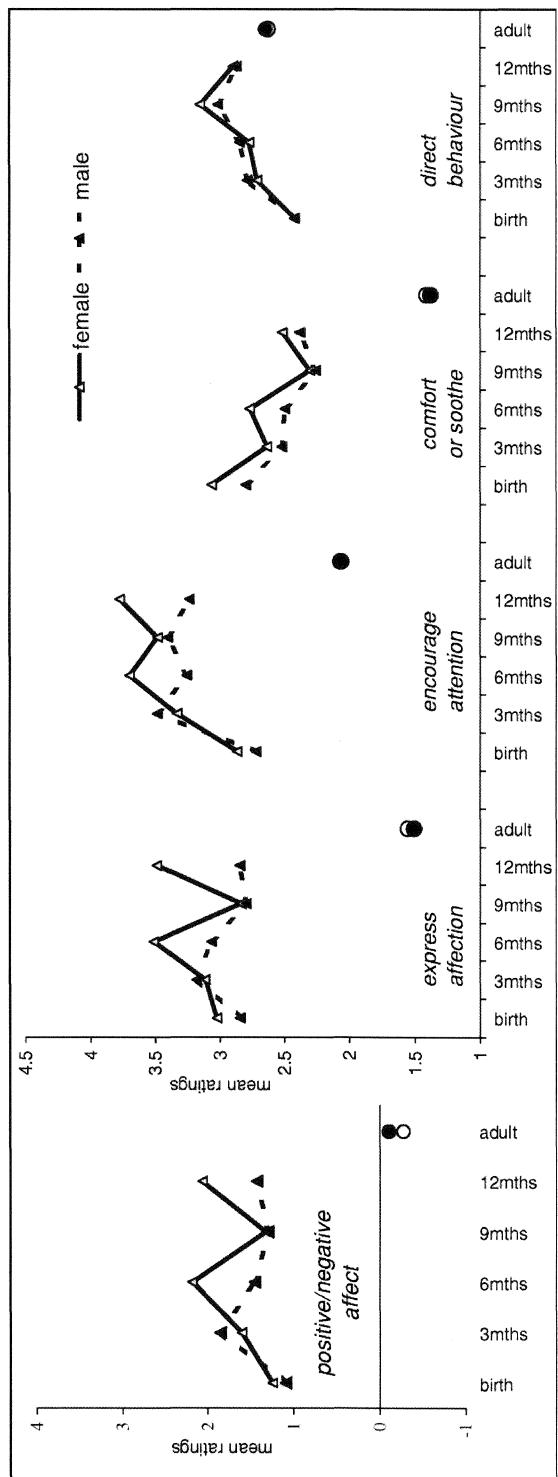
$p < .0001$ ). Despite counterbalancing tape order between groups, fatigue is a consideration with such a large number of ratings ( $5 \text{ scales} \times 12 \text{ mothers} \times 6 \text{ ages} = 360$  ratings). To test the fatigue effect, the raters' standard deviations for their first 120 ratings ( $SD = 1.47$ ) were compared to the standard deviations of their last 120 ratings ( $SD = 1.44$ ). A  $t$  test showed this was not significant.

Each of the five rating scales (Positive Affect, Express Affection, Encourage Attention, Comfort or Soothe, and Direct Behavior) was subjected to a repeated-measures ( $6 \times 2 \times 6$ ) ANOVA with age, gender, and mother as within-subjects variables and rater as a covariate. The results are shown in Figure 1 and Table 1. There were no significant main effects for mother or rater on any of the five scales even with Greenhouse-Geisser corrections for mother on the Direct Behavior scale. The main effects for rater on each of the scales were similarly nonsignificant. Assumptions of homogeneity of covariance for age were met for all scales, except Encouraging Attention and Comfort or Soothe. Greenhouse-Geisser corrections were made to the degrees of freedom for these scales. For each rating scale, statistical probabilities are reported in Table 1, and when the result is significant, the magnitude of effect statistic, partial eta squared, is also reported.

***IDS versus ADS.*** As expected, IDS was rated higher than ADS on the Positive or Negative Affect scale, on the intention to Express Affection, Encourage Attention, and Comfort or Soothe scales. There were no significant differences between ADS and IDS on the Direct Behavior scale.

***IDS—Positive or Negative Affect.*** For the degree of Positive or Negative Affect there were significant linear, quadratic, and cubic age trends. As can be seen in Figure 1, there is an overall increase in the ratings of positive vocal affect from birth to 12 months, with peaks occurring at 6 and 12 months. Most descriptive is the significant cubic trend that highlights the resurgence of positive vocal affect at 12 months after its relatively depressed level at 9 months. Although there is no main effect for gender, the significant Age  $\times$  Gender and linear Age  $\times$  Gender interactions show greater increases over age for positive affect in speech to girls than to boys.

***IDS—Expressing Affection.*** For the intention to Express Affection, there were significant linear and cubic age trends but no significant quadratic trend. As with the Positive Affect scale, raters generally perceive mothers to express increasingly more affection to their infants over age. Figure 1 shows expressed affection peaks at 6 months, declines at 9 months, and increases again at 12 months. The main effect for gender and the Gender  $\times$  Age interaction show that mothers express more affection in speech to girls than boys, and as revealed by the linear Age  $\times$  Sex interaction, that this difference increases with age. This age and gender trend is remarkably similar to that for the degree of positive or negative vocal



**FIGURE 1** Ratings of positive or negative vocal affect, and intention to express affection, encourage attention, soothe or comfort and direct behavior at birth, 3, 6, 9, and 12 months for speech directed to female and male infants.

TABLE 1  
 Probabilities and Partial Eta Squared for the Main Effects, Polynomial Trend Contrasts, and Interactions on the Five Rating Scales of  
 Affective Intent (Positive Affect, Affection, Attention, Comfort, and Direct Behavior)

	Positive Affect		Affection		Attention		Comfort		Direct Behavior	
	Probability	$\eta^2$	Probability	$\eta^2$	Probability	$\eta^2$	Probability	$\eta^2$	Probability	$\eta^2$
Age	.000	.144	.000	.132	.000	.251	.008	.059	.000	.153
Linear	.001	.190	.019	.092	.000	.513	.022	.089	.000	.287
Quadratic	.012	.114	.204		.000	.284	.895		.027	.082
Cubic	.001	.182	.000	.302	.000	.199	.027	.083	.769	
IDS vs. ADS	.000	.043	.000	.043	.000	.373	.000	.456	.291	
Gender	.225		.002	.156	.017	.096	.147		.895	
Age × Gender	.002	.080	.013	.053	.067		.405		.354	
Linear × Gender	.000	.212	.008	.115	.006	.124	.164		.935	
Quadratic × Gender	.216		.396		.014	.101	.261		.111	
Cubic × Gender	.591		.062		.823		.843		.175	

affect. It would appear that both scales are measuring similar parameters of communicative intent.

*IDS—Encouraging Attention.* For the intention to encourage attention, the linear, quadratic, and cubic age trends were significant. The results reveal an overall increase in the intention to encourage attention from birth to 12 months, but this quality generally asymptotes at 3 months. Nevertheless, the cubic trend shows encouraging attention decreases at 9 months. As with expressing affection, mothers tend to use IDS to encourage attention more with female than male infants, and, again, the linear Age  $\times$  Gender interaction shows this difference increases as the infant develops. However, the Quadratic  $\times$  Gender interaction for this scale shows that for male infants encouraging attention asymptotes at 3 months and then remains relatively stable, whereas for female infants it asymptotes at 6 months and then shows a small increase.

*IDS—Comforting or Soothing.* For the raters' perception of the intention to comfort or soothe, the linear and cubic age trend were significant. Figure 1 shows that mothers communicate the greatest degree of comfort to their infants when they are newborns, and although this progressively diminishes over age, the cubic trend shows it increases at 6 and 12 months. There were no gender effects or significant trends for Age  $\times$  Gender; that is, mothers show the same general level of comfort and the same age trends in their speech to boys and girls.

*IDS—Directing Behavior.* In almost direct contrast to comfort or soothe, raters' perceptions of the intention to direct behavior show a significant linear increase from birth to 12 months. In addition, there is a significant quadratic trend showing this scale reaches its peak at 9 months. There were no significant effects of gender or Age  $\times$  Gender. These results indicate that there is an increase in directive messages until 9 months but that they reduce somewhat by 12 months, and this does not differ for boys or girls.

At 9 months, IDS shows some unique features. The peak at 9 months on the Intention to Direct Behavior scale seems to complement the relatively low values of Positive Affect, Encourage Attention, and Express Affection at this age. Further, the lack of difference between IDS and ADS for Direct Behavior suggests that adultlike vocal features are used for this purpose when speaking to infants. However, a post hoc contrast shows that ADS was rated less directive than speech to 9-month-olds,  $F(1, 58) = 5.6, p = .002$ . This indicates that IDS does not simply develop in a linear fashion; the distinctive features in maternal speech at 9 months suggest that mothers attune their speech to their infants' developmental changes rather than simply become more adultlike in their speech style as their infant matures. The findings suggest that certain features of IDS serve particular communicative functions depending on the age of the infant.

### Acoustic Measures

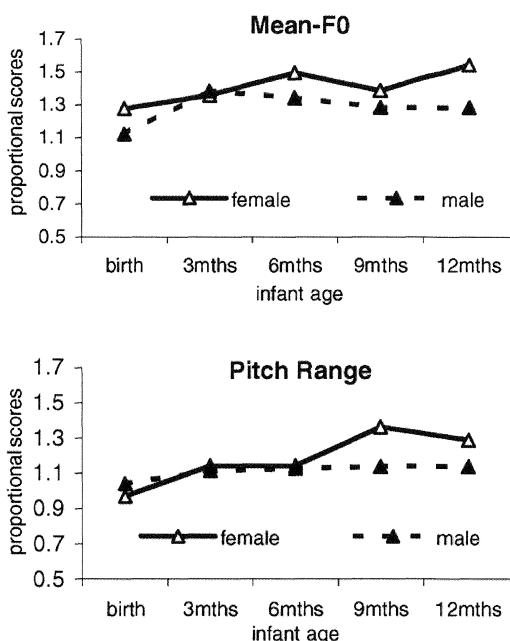
Differences in the 12 mothers' base  $F_0$  values could disguise any real differences in mean  $F_0$  and pitch range of speech to male and female infants. For example, if mothers of girls tended to have higher pitched voices, this would inflate the results for female infants. Thus, to normalize these acoustic measures, average levels of mean  $F_0$  and pitch range were calculated from each mother's adult-to-adult utterances. Proportions were then derived by dividing mean  $F_0$  and pitch range of each IDS utterance of each mother at each infant age by her average adult levels of these measures.

The normalized data for both mean  $F_0$  and pitch range were subjected to repeated-measures ANOVAs with age (0, 3, 6, 9, and 12 months) as the within-subjects variable, gender as the between-subject variable, and mother as a covariate. For both mean  $F_0$  and pitch range, Mauchly's test showed sphericity can be assumed for age, and Levene's test of homogeneity of variance when there are unequal groups also proved nonsignificant.

**Mean  $F_0$ .** The results for mean  $F_0$  are shown in Figure 2. The ANOVA revealed no significant main effects for mother. There was a significant main effect; IDS had higher mean  $F_0$  than ADS, and there were also significant linear and cubic age trends. Despite an overall increase in mean  $F_0$  across infant ages, the cubic trend highlights the peak at 6 months, decrease at 9 months, and increase again at 12 months. There was also a significant main effect for gender, and for the linear Age  $\times$  Gender interaction. The latter indicates that the increase in mean  $F_0$  from birth to 12 months is greater for females than males.

TABLE 2  
Probabilities and Partial Eta Squared for the Main Effects, Polynomial Trend Contrasts,  
and Interactions on the Two Acoustic Measures (Mean  $F_0$  and Pitch Range)

	Mean $F_0$		Range $F_0$	
	Probability	$\eta^2$	Probability	$\eta^2$
Age	.000	.047	.004	.032
Linear	.041	.032	.002	.027
Quadratic	.165		.071	
Cubic	.000	.117	.591	
IDS vs. ADS	.000	.416	.000	.170
Gender	.005	.061	.056	
Age $\times$ Gender	.015	.024	.011	.027
Linear $\times$ Gender	.029	.037	.032	.038
Quadratic $\times$ Gender	.106		.696	
Cubic $\times$ Gender	.377		.442	



**FIGURE 2** Mean  $F_0$  and pitch range at birth, 3, 6, 9, and 12 months for speech directed to male and female infants.

**Pitch range.** The age trends for pitch range are present in Figure 2. There were no main effects for mother, but there was a significant effect for age and a significant linear age trend. Notably, the difference between IDS and ADS was not significant. When gender was taken into account, there was an Age  $\times$  Gender and linear Age  $\times$  Gender interaction showing that, again, mothers use greater pitch range to speak to female than male infants and that the difference increases as the infant develops.

### Correlations

Pearson correlation coefficients were produced to investigate the relationship between the five scales of communicative intent and the two measures of pitch. In this analysis, the correlations represent the relationship between each mother's scores at each age ( $n = 72$ ) on each of the variates. For the five scales of communicative intent, correlation coefficients were calculated separately for each of the six groups of raters. The correlations reported in Table 3 are averaged and represent the median of the six groups' sets of coefficients. As shown in Table 3, there was a strong association between ratings of Positive Affect and Express Affection, Comfort or Soothe, and Encourage Attention. As would be expected, the Express Affection scale was also correlated with Comfort or Soothe and Encourage Attention, as was Comfort or Soothe and Encourage Attention correlated. Direct Behavior, on the other hand, was negatively correlated with Comfort or Soothe

TABLE 3  
 Pearson Correlation Coefficients for Measures of Pitch (Mean- $F_0$  and Pitch Range)  
 and Communicative Intent (Positive Affect, Affection, Comfort, Attention, Direct)  
 and for Utterance Number

	<i>Positive Affect</i>	<i>Affection</i>	<i>Comfort</i>	<i>Attention</i>	<i>Direct</i>	<i>Mean F<sub>0</sub></i>	<i>Range</i>
Affection	.92**						
Comfort	.72**	.82**					
Attention	.79**	.78**	.53**				
Direct	-.07	-.12	-.31**	.31**			
Mean $F_0$	.61**	.59**	.40**	.69**	.13		
Range	-.05	-.07	-.08	.21*	.28**	.36**	
Utterance number	.38**	.41**	.34**	.29**	-.12	.21*	-.19

\* $p < .05$ , two-tailed. \*\* $p < .01$ , two-tailed.

and positively correlated with Encourage Attention. Correlations between the acoustic measures, mean  $F_0$  and pitch range, and the ratings showed mean  $F_0$  was correlated with the same scales that showed strong positive interrelationships: Positive Affect, Express Affection, Comfort or Soothe, and Encourage Attention. The second pitch measure, pitch range, was correlated with the Encourage Attention and Direct Behavior scales, which are themselves related. Utterance duration was correlated with most measures: Positive Affect, Express Affection, Comfort or Soothe, Encourage Attention, and mean  $F_0$ , but not Direct Behavior and pitch range.

## DISCUSSION

This study provides evidence that mothers' speech carries messages of communicative intent to their infants and that mothers adapt these messages according to the age and gender of their infants. Four of the five rating scales of communicative intent are correlated—Positive Affect, Express Affection, Encourage Attention and Comfort or Soothe—and show prominent peaks at 6 and 12 months, although Comfort or Soothe decreases across ages and is most conspicuous at birth. Of the five scales, Direct Behavior is the exception, as it shows a peak at 9 months, an age at which the other four scales decline. Encourage Attention is correlated to all other scales, including Direct Behavior, suggesting that the attentional characteristics in IDS are used for both affective and directive purposes. It is interesting that pitch range here is correlated with Direct Behavior and Encourage Attention. Further, pitch range and Direct Behavior follow similar age trends, with a peak at 9 months. Pitch range is reported to be a particularly powerful cue for raters who

perceive it to be most related to arousal levels (Ladd, Silverman, Tolkmitt, Bergmann, & Scherer, 1985; Scherer, 1995). Thus, it may be the case that the speaker's level of arousal and the raters' perception of this underlies the ratings data here for Direct Behavior and, to a lesser extent, Encourage Attention. Although pitch range is associated with Direct Behavior and Encourage Attention, mean  $F_0$  shows a strong relationship with the four scales Positive Affect, Express Affection, Encourage Attention, and Comfort or Soothe. Notably, only Encourage Attention is correlated with both pitch range and mean  $F_0$ .

Together, the results suggest that mothers differentially adjust mean  $F_0$  and pitch range to express various nuances of communicative intent. Mean  $F_0$  is mostly associated with affective-type utterances (Positive Affect, Express Affection, Encourage Attention, and Comfort or Soothe) and pitch range with more directive ones (Encourage Attention and Direct Behavior). This bears resemblance to the two functions "approval" and "attention" identified by Katz et al. (1996), and Werker and McLeod commented on the "affective" and "attentional" roles of IDS evident in the differential nature of affective and attentional responses by infants to IDS and ADS (McLeod, 1993; Werker & McLeod, 1989). Further, these two dimensions for IDS are concordant with the notion that adult vocal affect is perceived along two dimensions: hedonic valence and level of arousal (Scherer, 1986).

Overall, the results suggest mothers adjust pitch and communicative intent in response to outward signs of development in the infant. At birth, the sound of mother's voice is familiar to the infant because of in utero experience with the prosodic characteristics of their mother's voice (DeCasper & Fifer, 1980; Fifer & Moon, 1989). After birth (in the newborn sample here) the comforting tone in mother's voice features more strongly than at older ages. Newborns' ability to regulate their own levels of arousal is fairly primitive and limited to sucking behavior (Kopp, 1989). Hence, it seems that mothers use their voices primarily to soothe and calm the infant in a way that accommodates the limitations of the newborn's perceptual abilities and gently initiates the infant into social interactions.

By 3 months, the perception of comfort in the voice begins to abate, and the four other scales and both pitch measures incrementally increase, conceivably in response to an emerging social responsiveness in the infant. By 6 months, when mean  $F_0$  and the affective-type scales (Positive Affect, Express Affection, Encourage Attention, and Comfort or Soothe) peak, it has been shown that mothers initiate more interaction (Cohn & Tronick, 1987) and infants express more interest and joy than at other infant ages (Malatesta, Grigoryev, Lamb, Albin, & Culver, 1986). In this study, mothers respond with an age-specific configuration of intonation that may help optimize interaction between mother and infant. Further, Kitamura and Burnham (1998b) showed that it is the highly affectionate nature of IDS that 6-month-old infants attend to, rather than just its exaggerated pitch characteristics.

Thus the production of highly affective speech by mothers, and preferences by infants based on the affective salience of IDS, may result in a reciprocity between mother and infant that facilitates socialization and emotional development (Snow, 1977, 1989).

Around 9 months, there is a marked decline in mean  $F_0$  and certain affective features associated with positive affect, and a steep increase in pitch range and the incidence of directive utterances. Intuitively, it might have been expected that this pattern should emerge at 12 months, when infants begin to produce their first utterances, and become more noticeably mobile. However, these results suggest that 9 months is a crucial age. Around this age, infants' perception of native speech sounds is becoming more selective and adultlike (Jusczyk et al., 1993; Lalonde & Werker, 1995; Polka & Werker, 1994; Werker & Tees, 1984), social referencing is emerging (Feinman, Roberts, Hsieh, Sawyer, & Swanson, 1993), and infants can follow pointing gestures (Murphy & Messer, 1977) and simple instructions (Hubley & Trevarthen, 1979). These changes co-occur with certain cognitive and perceptual developments, such as the ability to perceive correlations amongst individual attributes and integrate them into visual categories (Younger, 1993), and the ability to coordinate sensorimotor skills in means-ends relations (Lalonde & Werker, 1995; Piaget, 1963). Indeed, there is a relationship between infants' ability to perceive native over non-native speech sounds and their ability to solve a Piagetian object search task, and visual categorization (Lalonde & Werker, 1995). At this age, infants may not need such exaggerated forms of vocal affect; indeed, a reduction in vocal affect could facilitate developmental change by allowing infants to concentrate on speech processing and higher order analysis without the distraction of exaggerated affective characteristics (Lacerda, Sundberg, Andersson, & Rex, 1995). The resurgence of affective qualities in IDS at around 12 months could be seen to offer encouragement to infants who now have heightened awareness of the segmental information in speech and are beginning to master their own language productions (Polka & Werker, 1994; Werker & Tees, 1984). Given the complex of events occurring for 12-month-olds, further longitudinal studies of IDS in the second year would be extremely informative.

Scores on the scales of communicative intent tended to be higher for girls than boys, and there was increasing differentiation between girls and boys as they get older on the degree of Positive Affect, Express Affection, and Encourage Attention in the mother's voice, and also in the acoustic variables, mean  $F_0$  and pitch range. The results show that gender differences in the mother's voice emerge between 3 and 6 months, and there is a gradual widening of the difference between speech to male and female infants until 12 months (see Figures 1 & 2). This is the first time such gender differences have been found in IDS, although previous studies do show that mothers' communication styles differ for girls and boys, and suggests that these different styles have the potential to influence verbal expression

and social skills (Cherry & Lewis, 1976; Fagot & Hagan, 1991; Holdgrafer, 1991; Lewis & Freedle, 1973; Masur, 1987).

The results here support the hypothesis that there is a developing differentiation between interactional styles by girl and boy infants, and also suggest that mothers are responsive to such changes. Although it is likely that mothers intuitively respond, or learn to respond to gender-specific changes in their infants' behavior, it is also possible that mothers are use gender-appropriate stereotypes in their interactional styles with male and female infants. However, if this were so, then gender differences should be apparent from birth, and here it is found that there are negligible differences between speech to boys and girls at birth and 3 months. It is interesting that around 9 months the sex differences on all five scales and both pitch measures are ameliorated. If it is the case that speech to 9-month-olds is particularly tuned to emerging receptive language abilities, then these results support the hypothesis that at this age both girls and boys are given similar exposure to an IDS style that is most likely to advance their linguistic competence. That is, at this age the linguistic needs of the infants may override any differences in gender stereotypes.

We suggest that the gender differences found here show that mothers adapt their IDS register in response to the infant's developmental needs. That is, mothers respond, albeit unconsciously, to cues from female and male infants at different ages. In this regard, Burnham and Harris (1992) investigated both mothers' and students' judgments of gender-related characteristics of 4- to 6-month-old infants presented in short video samples. Mothers and students judged female infants to be more feminine, sensitive, and weaker than male infants, and male infants to be more masculine, stronger, and less sensitive than female infants. These results were obtained even when the child's name misled the raters regarding the child's gender. More important, this study showed that gender was most accurately predicted by ratings of sensitivity; that is, the more sensitive an infant was judged to be, the more likely it was in fact a girl. These results show that there are subtle and perceivable differences between male and female infants, even at 4 months, even when the baby is not one's own, and even when the judges are not parents. Given these findings by Burnham and Harris, it would not be surprising that mothers in this study adapt their speech style to the gender of their infants. Moreover, it is not inconceivable that these adjustments are in response to their infant's behavior, not imposed gender stereotypes. Given the complexity of this issue, this hypothesis certainly needs further investigation, as it is possible that mothers' responses are a combination of sensitive maternal responding and socially determined gender-specific stereotypes.

A critical feature of sensitive parental responding is harmony of gesture, expression, and timing, which may enhance the child's ability to modulate feeling states (Bell & Ainsworth, 1972; Isabella & Belsky, 1991) and express a range of

emotions (Cassidy, 1994; Tronick, 1989). Stern (1985) called this "affect attunement," and with others, found that mothers use vocalizations more than facial or bodily gestures in all attunements, suggesting that the mother is keenly aware of her infant's emotional states (Stern, Hofer, Haft, & Dore, 1985). It has been proposed that mothers "fine-tune" IDS to postlinguistic children to facilitate the acquisition of grammatical, semantic, and pragmatic aspects of speech (Cross, 1977; Furrow, Nelson, & Benedict, 1979; Newport, Gleitman, & Gleitman, 1977). Our results suggest that IDS to prelinguistic infants is also fine-tuned to accommodate other overt aspects of infant development. In a social environment reminiscent of Vygotsky's (1978) zone of proximal development, adjustments to communicative intent in speech may regulate infants' arousal levels, facilitate socialization or exploration of the environment, and, perhaps, later feed into linguistic development.

Although these results improve our understanding of mother–infant interaction, there are potentially biasing features in the method of data collection and the selection of the first 25 sec or more of mothers' recordings as speech samples. As mothers were relatively free to begin recording anytime, it may be the case that giving them the optimal conditions to record natural and intimate interactions also introduces some biases that qualify the findings. It is possible that due to the relatively unstructured context, the results reflect the mother's choice of when to begin recording rather than mother's true speech behavior at each age. However, due to the differences found over age, this criticism implies that mothers' biases change systematically across age. We believe that this is a more unlikely explanation than one of developmentally driven age differences. It is also possible that other factors may account for the age and gender findings. For instance, number of utterances increased across age and was correlated with all scales of communicative intent except Direct Behavior, and mean  $F_0$  but not pitch range. Thus it is possible that number of utterances is more related to affective than directive utterances. Utterances also appear to become slightly shorter over age, and this may be due to mothers' use of single-word utterances such as, "Hey, *infant name*," or other single-word encouragers. However, it is equally likely that the degree of affect, utterance length, and utterance frequency are all caused by a common factor. A speech acts analysis of 15 min of each mother's recordings is currently being conducted to investigate these issues.

Another concern in this study is the selection of the particular scales. Research of this nature has not been attempted before, and although we can draw on other research paradigms to understand mothers' intentions when they are interacting with infants there may be categories of maternal speech behavior that have been neglected. It is also the case that in this study ratings of communicative intent were made by adults rather than infants, and that infants' and adults' ability to perceive emotion may be qualitatively different. Some validation is provided by a

study by Moore et al. (1997), who showed that when 6-month-olds are played different tokens from either comforting or approving utterances, they can discriminate between and within tokens from the two categories. This, together with evidence that infants respond with appropriate emotional expression to approving and disapproving utterances (Fernald, 1993), suggests that infants, to some extent, are perceptually equipped to distinguish between, and respond appropriately, to gross categories of their mother's communicative intent. Nevertheless, it cannot be assumed that infants perceive the five scales of communicative intent in the same way as adults.

The results from this study show mothers convey many different kinds of affective messages to their infants using their tone of voice, and suggest that mothers' speech patterns may be very much attuned to the infant's state of development across the first year but not simply with respect to linguistic variables (e.g., Cross, 1977; Furrow et al., 1979; Newport et al., 1977). In addition, the results show that mothers use different speech registers for boy and girl infants. Together they suggest that mother's primary aim is to communicate affect to the young infant to facilitate social interaction, with the acquisition of language and communicative skills following as a consequence of this. The method of evaluating IDS communicative intent used in this study, although new, offers exciting future possibilities for the detailed analysis of the subtle nuances in IDS.

## REFERENCES

- Andruski, J., & Kuhl, P. K. (1996). The acoustic structure of vowels in mothers' speech to infants and children. In *Proceedings of the Fourth International Conference on Spoken Language Processing* (pp. 1545–1548). Philadelphia, PA.
- Bell, S. M., & Ainsworth, M. D. (1972). Infant crying and maternal responsiveness. *Child Development*, 43, 1171–1190.
- Bornstein, M. H., Tal, J., Rahn, C., Galperin, C. Z., Pecheux, M.-G., Lamour, M., et al. (1992). Functional analysis of the contents of maternal speech in infants of 5 and 13 months in four cultures: Argentina, France, Japan, and the United States. *Developmental Psychology*, 28, 593–603.
- Burnham, D., & Harris, M. (1992). Effects of real gender and labelled gender on adults' perceptions of infants. *The Journal of Genetic Psychology*, 153, 165–183.
- Burnham, D., Kitamura, C., & Lancia, V. (1999). The development of linguistic attention in early infancy: The role of prosodic and phonetic information. In J. J. Ohala, Y. Hasegawa, M. Ohala, D. Granville, & A. C. Bailey (Eds.), *Proceedings of the 14th International Congress of Phonetic Sciences* (pp. 1197–1200). Berkeley: University of California.
- Cassidy, J. (1994). Emotional regulation: Influences of attachment relationships. In N. Fox (Ed.), *The development of emotion regulation: biological and behavioural considerations. Monographs for the society for Research in Child Development*, 59 (2–3, Serial No. 240).
- Cherry, L., & Lewis, M. (1976). Mothers and two-year-olds: A study of sex differentiated verbal interactions. In N. Waterson & C. Snow (Eds.), *The development of communication: Social and pragmatic factors in language acquisition*. New York: Wiley.

- Cohn, J. F., & Tronick, E. Z. (1987). Mother-infant face-to-face interaction: The sequence of dyadic state at 3, 6, and 9 months. *Developmental Psychology, 23*, 68-77.
- Cooper, R. P. (1993). The effect of prosody on young infants' speech perception. In C. Rovee-Collier & L. P. Lipsitt (Eds.), *Advances in infancy research*. Norwood, NJ: Ablex.
- Cooper, R. P., & Aslin, R. N. (1990). Preference for infant-directed speech in the first month after birth. *Child Development, 61*, 1584-1595.
- Cooper, R. P., & Aslin, R. N. (1994). Developmental differences in infant attention to the spectral characteristics of infant-directed speech. *Child Development, 65*, 1663-1677.
- Cross, T. G. (1977). Mothers' speech adjustments: The contribution of selected child listener variables. In C. E. Snow & C. A. Ferguson (Eds.), *Talking to children: Language input and acquisition*. Cambridge, England: Cambridge University Press.
- DeCasper, A. J., & Fifer, W. P. (1980). Of human bonding: Newborns prefer their mothers' voices. *Science, 208*, 1174-1176.
- Fagot, B., & Hagan, R. (1991). Observations of parent reactions to sex-stereotyped behaviors: Age and sex effects. *Child Development, 62*, 617-628.
- Feinman, S., Roberts, D., Hsieh, K., Sawyer, D., & Swanson, D. (1993). A critical review of social referencing in infancy. In S. Feinman (Ed.), *Social referencing and the social construction of reality in infancy*. New York: Plenum.
- Fernald, A. (1985). Four-month-old infants prefer to listen to motherese. *Infant Behavior and Development, 8*, 181-195.
- Fernald, A. (1989). Intonation and communicative intent in mothers' speech to infants: Is the melody the message? *Child Development, 60*, 1497-1510.
- Fernald, A. (1992). Meaningful melodies in mothers' speech to infants. In H. Papousek, U. Jurgens, & M. Papousek (Eds.), *Nonverbal vocal behavior*. New York: Cambridge University Press.
- Fernald, A. (1993). Approval and disapproval: Infant responsiveness to vocal affect in familiar and unfamiliar languages. *Child Development, 64*, 657-674.
- Fernald, A., & Kuhl, P. (1987). Acoustic determinants of infant preference for motherese speech. *Infant Behavior and Development, 10*, 279-293.
- Fernald, A., & Mazzie, C. (1991). Prosody and focus in speech to infants and adults. *Developmental Psychology, 27*, 209-221.
- Fernald, A., & Simon, T. (1984). Expanded intonation contours in mother's speech to newborns. *Developmental Psychology, 20*, 104-113.
- Fifer, W., & Moon, C. (1989). Early voice discrimination. In C. von Euler, H. Forssberg, & H. Lagercrantz (Eds.), *Neurobiology of early infant behavior: Proceedings of an international Wallenberg symposium at the Wenner-Gren Center, Stockholm*. London: Stockton.
- Fraser, C., & Roberts, A. (1975). Mothers' speech to children of different ages. *Journal of Psycholinguistic Research, 4*, 9-16.
- Furrow, D., Nelson, K., & Benedict, H. (1979). Mothers' speech to children and syntactic development: Some simple relationships. *Journal of Child Language, 6*, 423-442.
- Grieser, D. L., & Kuhl, P. K. (1988). Maternal speech to infants in a tonal language: Support for universal prosodic features in motherese. *Developmental Psychology, 24*, 14-20.
- Halverson, C., & Waldrop, M. (1970). Maternal behavior toward own and other preschool children: The problem of "ownness." *Child Development, 41*, 839-845.
- Hirsh-Pasek, K., Kemler Nelson, D. G., Jusczyk, P. W., Wright Cassidy, K., Druss, B., Kennedy, L. (1987). Clauses are perceptual units for young infants. *Cognition, 26*, 269-286.
- Hofer, M. (1987). Early social relationships. *Child Development, 58*, 633-647.
- Holdgrafter, G. (1991). Quantity of communicative behavior in children from birth to 30 months. *Perceptual and Motor Skills, 72*, 803-806.
- Hubley, P., & Trevarthen, C. (1979). Sharing a task in infancy. *New Directions for Child Development, 4*, 57-80.

- Isabella, R. A., & Belsky, J. (1991). Interactional synchrony and the origins of infant-mother attachment: A replication study. *Child Development*, 62, 373-384.
- Jusczyk, P. W., Cutler, A., & Redanz, N. J. (1993). Infants' preference for the predominant stress patterns of English words. *Child Development*, 23, 648-654.
- Jusczyk, P. W., Friederici, A. D., Wessels, J. M., Svenkerud, V., & Jusczyk, A. M. (1993). Infants' sensitivity to the sound patterns of native language words. *Journal of Memory and Language*, 32, 402-420.
- Kaplan, P. S., Jung, P. C., Ryther, J. S., & Zarlengo-Strouse, P. (1996). Infant-directed versus adult-directed speech as signals for faces. *Developmental Psychology*, 32, 880-891.
- Karzon, R. (1985). Discrimination of polysyllabic sequences by one- to four-month-old infants. *Journal of Experimental Child Psychology*, 39, 326-342.
- Katz, G. S., Cohn, J. F., & Moore, C. A. (1996). A combination of vocal  $F_0$  dynamic and summary features discriminates between three pragmatic categories of infant-attention speech. *Child Development*, 67, 205-217.
- Kemler Nelson, D. G., Hirsh-Pasek, K., Jusczyk, P. W., & Wright Cassidy, K. (1989). How the prosodic cues in motherese might assist language learning. *Journal of Child Language*, 16, 55-68.
- Kitamura, C., Attapaiboon, C., Burnham, D., & Luksaneeyanawin, S. (in press). *Universal pitch modifications in infant-directed speech: A prelinguistic longitudinal study in a tonal and non-tonal language*.
- Kitamura, C., & Burnham, D. (1998a). Acoustic and affective qualities of IDS in English. In R. Mannell & J. Robert-Ribes (Eds.), *Proceedings of the fifth International Conference on Spoken Language Processing: ICSLP 98* (Vol. 2, pp. 441-444). Sydney: Australian Speech Science and Technology Association.
- Kitamura, C., & Burnham, D. (1998b). The infant's response to vocal affect in maternal speech. *Advances in Infancy Research*, 12, 221-236.
- Kopp, C. (1989). Regulation of distress and negative emotions: A developmental view. *Developmental Psychology*, 25, 343-354.
- Krieman, J., Gerratt, B. R., Kempster, G. B., Erman, A., & Berke, G. S. (1993). Perceptual evaluation of voice quality: Review, tutorial, and a framework for future research. *Journal of Speech and Hearing Research*, 36, 21-40.
- Lacerda, F., Sundberg, U., Andersson, C., & Rex, A. (1995). Young infant's perception of segmental and suprasegmental information: Preliminary results. *Proceedings of the International Conference of Phonetic Science*, 3, 408-411.
- Ladd, D. R., Silverman, K. E., Tolkmitt, F., Bergmann, G., & Scherer, K. R. (1985). Evidence for the independent function of intonation contour type, voice quality, and  $F_0$  range in signalling speaker affect. *Journal of the Acoustical Society of America*, 78, 435-444.
- Lalonde, C. E., & Werker, J. F. (1995). Cognitive influences on cross-language speech perception in infancy. *Infant Behavior and Development*, 18, 459-475.
- Leaper, C., Anderson, K., & Sanders, P. (1998). Moderators of gender effects on parents' talk to their children: A meta-analysis. *Developmental Psychology*, 34, 1-27.
- Lewis, M., & Freedle, R. (1973). Mother-infant dyad: The cradle of meaning. In P. Pliner, L. Krames, & T. Alloway (Eds.), *Communication and affect, language and thought*. New York: Academic.
- Lewkowicz, D. J. (1996). Infants' response to the audible and visible properties of the human face: 1. Role of lexical-syntactic content, temporal synchrony, gender, and manner of speech. *Developmental Psychology*, 32, 347-366.
- Locke, J. L. (1993). *The child's path to spoken language*. Cambridge, MA: Harvard University Press.
- Malatesta, C. Z., Grigoryev, P., Lamb, C., Albin, M., & Culver, C. (1986). Emotion socialization and expressive development in preterm and full-term infants. *Child Development*, 57, 316-330.
- Malloch, S. (1999). Mothers and infants and communicative musicality. *Musicae Scientiae*, 29-57.

- Masur, E. (1987). Imitative exchanges in a social context: Mother–infant matching behavior at the beginning of the second year. *Merrill-Palmer Quarterly*, 33, 453–472.
- McLeod, P. J. (1993). What studies of communication with infants ask us about psychology: Baby talk and other speech registers. *Canadian Journal of Psychology*, 34, 282–292.
- Moore, D., Spence, M., & Katz, G. (1997). Six-month-olds' categorization of natural infant-directed utterances. *Developmental Psychology*, 33, 980–989.
- Morgan, J. L., & Saffran, J. R. (1995). Emerging integration of sequential and suprasegmental information in preverbal speech segmentation. *Child Development*, 66, 911–936.
- Murphy, D. J., & Messer, D. J. (1977). Mothers, infants and pointing: A study of a gesture. In H. R. Schaffer (Ed.), *Studies in mother–infant interaction*. New York: Academic.
- Newport, E. L., Gleitman, H., & Gleitman, L. R. (1977). Mother I'd rather do it myself: Some effects and noneffects of maternal speech style. In C. E. Snow & C. A. Ferguson (Eds.), *Talking to children: Language input and acquisition*. Cambridge, England: Cambridge University Press.
- Papousek, M., Bornstein, M. H., Nuzzo, C., Papousek, H., & Symmes, D. (1990). Infant responses to prototypical melodic contours in parental speech. *Infant Behavior and Development*, 13, 539–545.
- Papousek, M., Papousek, H., & Symmes (1991). The meaning of melodies in motherese in tone and stress languages. *Infant Behavior and Development*, 14, 415–440.
- Pegg, J. E., Werker, J. F., & McLeod, P. J., (1992). Preference for infant-directed over adult-directed speech: Evidence from 7-week-old infants. *Infant Behavior and Development*, 15, 325–345.
- Penman, R., Cross, T., Milgrom-Friedman, J., & Meares, R. (1983). Mother's speech to prelingual infants: A pragmatic analysis. *Journal of Child Language*, 10, 17–34.
- Phillips, J. (1973). Syntax and vocabulary of mothers' speech to young children: Age and sex comparisons. *Child Development*, 44, 182–185.
- Piaget, J. (1963). *The origins of intelligence in children*. New York: Norton.
- Polka, L., & Werker, J. F. (1994). Development changes in perception of nonnative vowel contrasts. *Journal of Experimental Psychology: Human Perception and Performance*, 19, 421–435.
- Scherer, K. R. (1986). Vocal affect expression: A review and model for future research. *Psychological Bulletin*, 99, 143–165.
- Scherer, K. R. (1995). How emotion is expressed in speech and singing. *Proceedings of the International Conferences of Phonetic Science*, 3, 90–96.
- Sherrod, K. B., Crawley, S., Petersen, G., & Bennett, P. (1978). Maternal language to prelinguistic infants: Semantic aspects. *Infant Behavior and Development*, 1, 335–345.
- Snow, C. E. (1977). The development of conversation between mothers and babies. *Journal of Child Language*, 4, 1–22.
- Snow, C. E. (1989). Understanding social interaction and language acquisition: Sentences are not enough. In M. H. Bornstein & J. S. Bruner (Eds.), *Human interaction*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.
- Snow, C. E., & Ferguson, C. A. (1977). *Talking to children: Language input and acquisition*. Cambridge, England: Cambridge University Press.
- Stern, D. (1985). *The interpersonal world of the infant*. New York: Basic Books.
- Stern, D., Hofer, L., Haft, W., & Dore, J. (1985). Affect attunement: The sharing of feeling states between mother and infant by means of inter-modal fluency. In T. M. Field & N. A. Fox (Eds.), *Social perception in infants*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.
- Stern, D., Spieker, S., Barnett, R. K., & McKain, K. (1983). The prosody of maternal speech: Infant age and context related changes. *Journal of Child Language*, 10, 1–15.
- Stern, D., Spieker, S., & McKain, K. (1982). Intonation contours as signals in maternal speech to prelinguistic infants. *Developmental Psychology*, 18, 727–735.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

- Werker, J. F., & McLeod, P. J. (1989). Infant preference for both male and female infant-directed talk: A developmental study of attentional affective responsiveness. *Canadian Journal of Psychology*, 43, 230–246.
- Werker, J. F., & Tees, R. C. (1984). Cross-language speech perception: Evidence for perceptual reorganisation during the first year of life. *Infant Behavior and Development*, 7, 49–63.
- Younger, B. A. (1993). Understanding category members as “the same sort of thing”: Explicit categorisation in 10-month-olds. *Child Development*, 54, 309–320.