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**ABSTRACT** - This study examines the modifications made to the pitch and communicative intent in infant-direct speech (IDS) from birth to 12 months, at 3 monthly intervals. With regard to pitch, mothers use the peak level of mean fundamental frequency ( $F_0$ ) when the infant is 6 months while pitch range is highest at 12 months of age. Sex-based differences were also evident with mothers using higher mean- $F_0$  and pitch range in speech to female than male infants. Furthermore the average shape of the utterance transposes from a fall-flat/rise in speech to newborns to a flat-fall in speech to adults. With respect to communicative intent, two factors were extracted from five ratings scales and these were labelled 'affective' and 'attentional/didactic'. Analysis of these factors showed mothers express more affection at 6 months than other ages while peak levels on the attentional/didactic factor were reached at 9 months of age. Mothers also increase their use of both these components of IDS more in speech to girl than boy infants.

## INTRODUCTION

Infant-directed speech is the speech style used to address infants and young children. Analyses of the prosodic features of IDS show higher overall pitch, higher and wider pitch excursions, a limited set of pitch contours, slower tempo and longer pauses (Stern, Spieker, Barnett & McKain, 1983; Fernald & Simon, 1984).

Fernald (1984) argues that IDS has a prepotent affective basis and therefore plays a central role in the development of sound-meaning associations before speech becomes linguistically meaningful to infants. She found that adults are more able to correctly categorise the communicative/affective intent of speakers in IDS than ADS even with low-pass filtered speech (Fernald, 1989). Furthermore, infants are judged to be more interactive, interested and experiencing more positive emotions when listening to IDS than ADS (Werker & McLeod, 1989), which implies infants are responding at an emotional level to this speech style.

It has been suggested that it is through the attentional and affective qualities of IDS that language first becomes meaningful to the prelinguistic infant (Cooper & Aslin, 1989). Therefore it is important to examine age-related modifications to IDS as the infant develops. Just one study has examined age-related adjustments to the acoustic characteristics of IDS (Stern et al., 1983). However, neither ontogenetic modifications to the expressed affect or intentions of mothers nor the difference between speech directed to female and male infants were investigated. In the current study, speech samples were collected from twelve mothers speaking to their infants at birth (0DS), 3 months (3DS), 6 months (6DS), 9 months (9DS), 12 months (12DS) and to another adult (ADS). These were then compared on measures of: (i) fundamental frequency ( $F_0$ ) and (ii) the level of vocal affect and the communicative intent of the speaker.

## ANALYSIS OF FUNDAMENTAL FREQUENCY

### Method

All speech samples were recorded in the home on audio tape. Forty utterances from each of the twelve mothers speaking to their infants at each of the five infant ages and to an adult were digitised from these tapes.

## STANDARD ANALYSIS

An analysis was conducted using the measures of  $F_0$  most often used in research on intonation in IDS: mean- $F_0$  and  $F_0$ -range. Typically the semitone scale is used to convert  $F_0$  range from absolute to ratio values, as the human listener tends to perceive pitch changes logarithmically (in semitones) rather than linearly (in hertz). As previously mentioned, only one study has examined the pitch adjustments made to speech addressed to infants under 12 months of age (Stern et al., 1983). Stern et al. found all measures of fundamental frequency to be higher in speech addressed to 4-month-olds compared to speech directed to neonates, and to 12-month olds. Similar findings are expected in this study.

### Results

A repeated measures analysis of variance (ANOVA) was conducted on mean- $F_0$  and pitch range with age of the addressee: 0, 3, 6, 9, 12 & adult as the within subjects factor. Orthogonal trend contrasts were used to test linear,

quadratic and cubic age trends. An additional contrast tested the difference between IDS and ADS. The results are shown in Figures 1a and 1b.

IDS versus ADS: The results show that IDS was higher than ADS for mean- $F_0$  ( $F=439.58$ ). Although the results show pitch range was higher in IDS than ADS this difference did not quite reach significance ( $F=4.19$ ).

Infant Age: The mean- $F_0$  results show all three trend contrasts were significant. There is an overall linear increase across the five infant ages in the mean level of pitch ( $F=53.99$ ); a quadratic trend showing fundamental frequency reaches its highest level at 6 months of age ( $F=61.37$ ) and a cubic trend indicating that not only is there a peak in 6DS but that mean- $F_0$  increases again in 12DS ( $F=25.43$ ) (see Figure 1a). The trend analysis for pitch range shows there is a significant linear increase in pitch modulation from birth to 12 months ( $F=41.83$ ) complemented by a significant quadratic trend ( $F=8.26$ ). As shown in Figure 1b, initially range increases dramatically but then begins to asymptote.

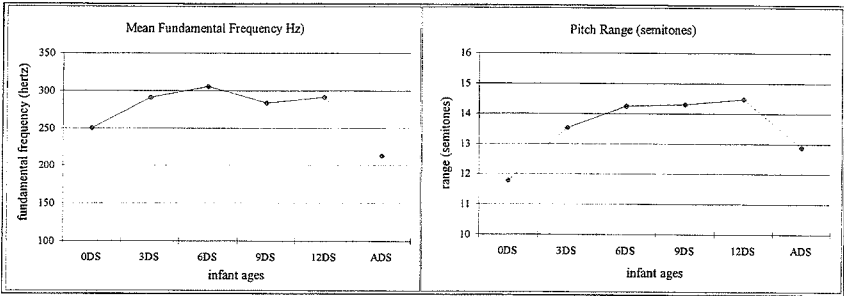


Figure 1a: Mean- $F_0$  across age

Figure 1b: Pitch range in semitones across age

#### SPEECH DIRECTED TO MALE AND FEMALE INFANTS

An analysis was conducted comparing the 6 mothers speaking to their female infants (Female-IDS) and the 6 mothers speaking to their male infants (Male-IDS). To date, no research has directly investigated the differences between the acoustic features of speech to male and female infants, although an early study did find mothers of girls used more and longer utterances and were more likely to ask questions whereas mothers of boys used more directives (Cherry & Lewis, 1976). Therefore, it could be expected that there will be higher  $F_0$  and greater pitch range in Female-IDS than Male-IDS.

#### Results

As there were differences between the mothers in their ADS levels of  $F_0$ , it was necessary to make individual adjustments for each mother. This was accomplished firstly, by calculating average adult levels for mean- $F_0$  and pitch range and then deriving a proportion in which each IDS utterance was divided by the mother's average adult levels of these measures. An ANOVA was conducted on these proportional scores to analyse linear, quadratic and cubic trends across infants ages (0DS, 3DS, 6DS, 9DS and 12DS), with sex of the infant listener as

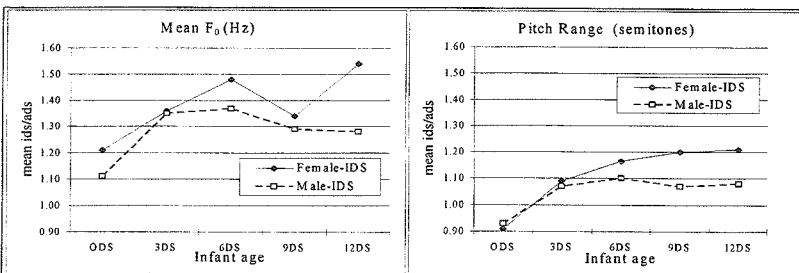


Figure 2a: The difference between Male-IDS and Female-IDS for mean- $F_0$

Figure 2b: The difference between Male-IDS and Female-IDS for pitch range

the between subjects factor. The results are shown in Figures 2a and 2b.

Mean  $F_0$ : The results show that mothers speak to their female infants with higher mean- $F_0$  than when they speak to their male infants ( $F=19.81$ ). There were significant linear ( $F=63.66$ ), quadratic ( $F=66.44$ ) and cubic main effects ( $F=31.28$ ), essentially the same as those described in the standard analysis. Of interest here are the interactions of age trends with the sex of the infant. For these only the quadratic age x sex interaction was significant ( $F=6.57$ ). This shows that in Male-IDS, peak mean- $F_0$  is reached in 3DS and 6DS but thereafter slowly decreases, while in Female-IDS, mean- $F_0$  continues to rise beyond 3DS to reach its first peak in 6DS and has a second stronger peak in 12DS.

Pitch Range: Mothers use higher overall pitch range when speaking to female than male infants ( $F=5.53$ ). As would be expected, the same overall linear ( $F=42.27$ ) and quadratic trends ( $F=12.92$ ) as in the standard analysis are also evident here. Of more relevance is the significant linear trend interaction with the sex of the infant ( $F=6.57$ ). This shows that in Female-IDS, the level of pitch modulation continues to increase from birth to 12 months. However in Male-IDS, the largest increment is from birth to three months with pitch range thereafter remaining relatively stable except for a small peak in 6DS. It is evident from Figure 2b that as the infant develops the difference in pitch modulation between Female- and Male-IDS gradually increases and this difference is at its greatest magnitude at 9 and 12 months of age.

### UTTERANCE CONTOURS

An interesting characterisation of the pitch contours for utterances across the infant ages can be obtained by looking at the initial, mean and terminal fundamental frequency in combination. This gives a characterisation of the utterance shape at each age, but more importantly provides information about modifications across the first twelve months of the infant's life. Past research has shown that there is a limited set of expanded intonation contours most frequently occurring in IDS which consist of rising, falling, level, bell-shaped and complex contours (Fernald & Simon, 1984). However, a different interpretation must be placed on the data reported here as they represent an overview of general utterance shapes and not prototypes of typical utterances at each infant age and in adult speech.

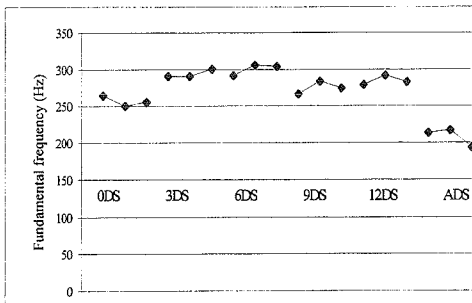


Figure 3: Initial-, mean- and terminal- $F_0$  shown in combination showing an outline of utterance contours across infant ages and adult.

ages. The data are graphically displayed in Figure 3. For newborns the fall-flat/fall-rise pattern evident in Figure 3 is revealed as a significant quadratic trend ( $F=9.29$ ) in the absence of a significant linear decrease. At 3 months, the small overall rise was not significant, which indicates that the 3DS contour can be characterised as being reasonably flat. The data points for the contours in 6DS, 9DS and 12DS show significant quadratic trends ( $F=7.48$ ;  $F=24.45$ ;  $F=13.25$  respectively). As can be seen in Figure 3, the average utterance shape at these ages is generally a rise-fall pattern with a sharper rise-fall for 9- and 12-month-olds and a more a rise-flat contour in 6DS. In ADS the contour was a flat-fall pattern with both the linear ( $F=23.19$ ) and quadratic trends ( $F=33.37$ ) being significant. Most conspicuous in these results is the gradual change in the contour characteristics of IDS as the infant develops, with the fall-flat/rise pattern at birth gradually converting to a rise-fall contour when the infant is 9 and 12 months, a pattern similar to the end-fall ADS contour typical of declarative statements.

### EMOTIONAL AND COMMUNICATIVE INTENT IN IDS

The expression of vocal affect by mothers has been acknowledged as an integral component of IDS (Fernald, 1984) to which infants are affectively responsive (Werker & Mcleod, 1989). However, in maternal production studies of IDS, vocal affect has never before been measured. A number of frequency variables may contribute to the perception of vocal affect, therefore, adults were asked to rate the level of positive or negative affect being

expressed in IDS. To supplement this, adults also rated the mothers' intention to *express affection*, *encourage attention*, *soothe or comfort* their infant and *direct behaviour*.

### Method

Emotional and communicative intent were measured on five scales: (i) *Positive/negative affect*, on a scale from -4 (very negative affect) to +4 (very high positive affect) and the intention of the speaker to (ii) *express affection*, (iii) *encourage attention*, iv) *soothe or comfort* and (v) *direct behaviour*. The latter were measured on a scale from 1 (not at all) to 5 (extremely). Seventy-one undergraduate students from the University of NSW participated in the rating task. In total, there were 72 speech samples from 12 mothers speaking to listeners at the six ages: 0, 3, 6, 9, 12 and adult. Each speech sample was between 25 and 28 seconds in duration. Speech samples were low-pass filtered with an upper level of 400 Hz and then recorded in a quasi-random order onto six audio tapes with 12 speech samples from two mothers on each tape. The six tapes were played in six quasi-random orders and each group of subjects was asked to rate each speech sample based on each of the five scales.

### Results

The repeated measures analysis of variance used age of the addressee (0, 3, 6, 9, 12 and adult) as the within subjects factor. Again, trends were tested across infant ages and the IDS/ADS difference. The results are presented in Figure 4.

IDS versus ADS: As expected IDS was rated to be more positive on the *positive/negative affect* scale than ADS ( $F=249.16$ ). IDS was also rated higher than ADS on the intention to *express affection* ( $F=512.99$ ), *encourage attention* ( $F=214.42$ ), and *soothe or comfort* ( $F=45.55$ ). However, raters perceived no difference between IDS and ADS on the intention to *direct behaviour* scale.

Infant Age: For the degree of *positive/negative affect* there were significant linear ( $F=15.83$ ), quadratic ( $F=18.23$ ) and cubic ( $F=107.92$ ) trends. As can be seen in Figure 4, there is an overall increase in the rated degree of positive vocal affect from birth to 12 months with the highest level of *positive/negative affect* discerned in 6DS. Most descriptive is the cubic trend which highlights the resurgence of positive vocal affect in 12DS after its relatively depressed level in 9DS. The results for intention to *express affection* show a similar pattern, with significant quadratic ( $F=8.92$ ) and cubic trends ( $F=108.89$ ) but no significant linear trend. Raters perceive mothers to express increasingly more affection from birth to six months with the peak level reached in 6DS. The cubic trend shows that although affection declines at 9 months, it rises to similar heights in 12DS as in 6DS, an age trend not unlike that for the degree of *positive/negative affect*. Hence both these scales appear to be

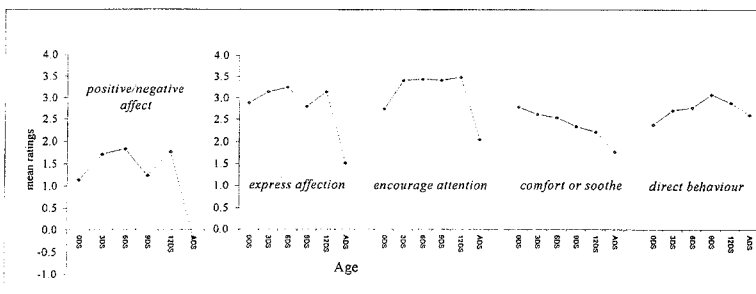


Figure 4: Ratings of positive/ negative affect, intention to *express affection*, *encourage attention*, *soothe or comfort* and *direct behaviour* for 0DS, 3DS, 6DS, 9DS, 12DS and ADS.

measuring similar parameters of affective intent. With regard to the intention to *encourage attention*, the linear ( $F=214.76$ ), quadratic ( $F=115.24$ ) and cubic trends ( $F=58.35$ ) were significant. Raters perceive an overall increase in the intention to *encourage attention* from birth to 12 months. The quadratic trend better elaborates the raters' perception of the intention to *encourage attention* as this characteristic rises steeply from 0DS to 3DS but attention-getting vocal behaviour on the part of the mother becomes more uniform from 3 to 12 months. From the age trend pattern evident in Figure 4 it was surprising that the cubic trend was significant. This may be due to the fact that there is relatively less variance associated with the intention to *encourage attention* than there is with the other rating scales. Nevertheless, there is a peak in 6DS, although this is small relative to the neighboring ages, and raters perceive that mothers are encouraging attention to the greatest degree when the infant reaches 12 months. It should be stressed that the largest increment is from 0DS to 3DS and the differences between 3DS, 6DS, 9DS and 12DS are relatively small, albeit perceptible.

For the raters' perception of the intention to *soothe or comfort* only the linear trend was significant ( $F=64.18$ ). It is clearly shown in Figure 4 that mothers communicate the greatest degree of comfort to their infants when they are newborns. This progressively diminishes over infant ages to reach its lowest level in speech to 12-month-old infants. In direct contrast, raters' perceptions of the intention to *direct behaviour* shows there is a significant linear increase from birth to 12 months ( $F=97.07$ ). In addition to the linear trend, there was a significant quadratic trend showing that raters perceive mothers to be most directive in 9DS ( $F=41.62$ ). These results show that mothers become more instructive as the infant gets older, however, at 9 months, more than any other age, mothers appear to be particularly intent on directing the behaviour of their infant.

## FACTOR ANALYSIS

A factor analysis was conducted to investigate any qualitative differences or similarities between raters' perceptions of each of the scales. Varimax rotation extracted two factors and Table 1 contains the factor loadings. *Positive/negative affect*, the intention to *express affection*, and *soothe or comfort* loaded highly on

SCALE	AFFECTIVE	ATTENTIONAL/ DIDACTIC
pos/neg affect	.81754	.15121
express affection	.87746	.07856
encourage attention	.45014	.73826
soothe or comfort	.72091	-.15280
direct behaviour	.22329	.85111

Table 1: Factor loadings for the scales: *positive/negative affect*, intention to *express affection*, *encourage attention*, *soothe or comfort* and *direct behaviour*

the first factor, labelled 'affective', while the intention to *encourage attention* and *direct behaviour* loaded most strongly on the second factor, labelled 'attentional/didactic'. The affective factor seems to contain a quality associated mostly with the intention to *express affection* as this scale accounts for nearly half the variance (45.3%). Also related to this affective quality but to a lesser degree, is the intention to *encourage attention*, which has a lower but appreciable loading on the first factor. So while affection, emotion and comfort are perceived to be closely related

characteristics of maternal intonation, this emotive quality may, to some degree, encourage infant attention. For the attentional/didactic factor, the intention to *encourage attention* accounted for 25.5% of the variance. Raters perceived mothers to use a different tone when seeking the infant's attention which was most related to mothers relaying instructions to their infant. Therefore, there seems to be an affective quality in IDS that is independent to its attentional/didactic component.

Factor scores derived from the factor analysis were entered into two ( $5 \times 2$ ) (age of infant  $\times$  sex of infant) ANOVAs, one each for the Affective and the Attentional/Didactic factors. Results for both variates are shown in Figures 5a and 5b.

**Affective Factor:** The results show that for the affective factor only the cubic trend was significant. This indicates that, irrespective of the sex of the infant, raters perceived there were two ages when mothers use heightened vocal affect: at 6 and 12 months of age ( $F=83.15$ ) (see Figure 5a). When taking the sex of the infant into account, raters perceived mothers to be more emotive when speaking to female infants than when speaking to male infants, irrespective of age ( $F=63.44$ ). More importantly, there was the significant linear interaction with the sex of the infant ( $F=15.64$ ) indicating that in Female-IDS there is a larger increase in the affective component over infant ages than in Male-IDS. For Male-IDS there is little or no overall increase across age. While the age trends show that the level of vocal affect peaks in 6DS and 12DS for Female-IDS, the single highpoint for Male-IDS is at 3 months of age with another smaller increase at 12 months. Thus overall raters perceive mothers to emphasise the emotional message more in Female-IDS than in Male-IDS, especially in 6DS and 12DS.

**Attentional/Didactic Factor:** For the attentional/didactic component of IDS, both the overall linear ( $F=235.99$ ) and cubic ( $F=94.08$ ) trends were significant. There was a linear increase in the attentional characteristic from 0DS to 12DS, irrespective of the sex of the infant. The cubic trend highlights the two peaks in the attentional/didactic component, a main peak in 9DS and a smaller one in 3DS. When the sex of infant is taken into account, the attentional quality in mothers' voices is greater when speaking to female rather than male infants ( $F=11.04$ ). An interaction of sex with the linear trend shows that mothers increase their use of this vocal characteristic more in Female-IDS than Male-IDS across infant ages ( $F=9.99$ ). None of the other main effects or

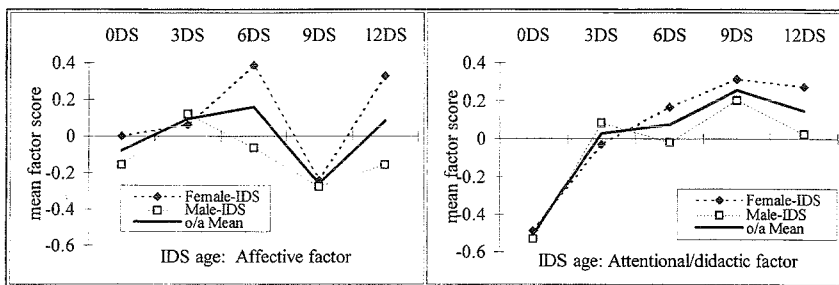


Figure 5a: Mean factor scores for the Affective factor for Male-IDS & Female-IDS and the overall mean across infant ages

Figure 5b: Mean factor scores for the Attentional/Didactic factor for Male-IDS & Female-IDS and the overall mean across infant ages.

interactions were significant. Overall the results show that the attentional/didactic aspect of IDS increases from birth to 12 months, but with 9-month-olds, mothers tend to use this characteristic more than at the other ages. The results for both Female- and Male-IDS tend to follow this same pattern.

## CONCLUSION

Most conspicuous from the above results is that the Affective factor shows a similar trend across infant ages to the age patterns for mean- $F_0$  while the age trend for the Attentional/Didactic factor tends to resemble the results for pitch modulation (see Figures 1 & 5). However, the trends for communicative intent are more distinctive than those for pitch, especially in respect to the Affective factor where the peaks are more pronounced than those for mean- $F_0$ . Not only does this study offer the first quantifiable data on the communicative characteristics of IDS but also may provide some insight into the particular cues provided by the pitch measures.

It seems that mothers' communication with their infants revolves around the effective use of intonation to convey affect and encourage attention of their infants. More importantly, the affect expressed in IDS is dependent on the age of the infant. Learning to speak is not just about phonology and syntax but using words and sentences to communicate within particular social and communicative contexts. The prosodic aspects of speech are particularly useful for this as they express the emotions, intentions and attitudes of the speaker. Thus the frequently researched pitch characteristics in IDS may be communicative tools that mothers use to motivate their infants to socialise and communicate before the task of learning to speak.

## REFERENCES

- Cooper, R.P., & Aslin, R.N. (1989). The language environment of the young infant: Implications for early perceptual development. *Canadian Journal of Psychology*, 43, 247-265.
- Cherry, L. & Lewis, M. (1978). 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*. Wiley & Sons.
- Fernald, A. (1984). The perceptual and affective salience of mothers' speech to infants. In L. Feagans, C. Garvey & R. Golinkoff (Eds.), *The origins and growth of communication*. Ablex: Norwood, N.J.
- Fernald, A. (1989). Intonation and communicative intent in mothers' speech to infants: Is the melody the message? *Child Development*, 60, 1497-1510.
- Fernald, A., & Simon, T., (1984). Expanded intonation contours in mother's speech to newborns. *Developmental Psychology*, 20, 104-113.
- Stern, D.N., Spieker, S., Barnett, R.K., & MacKain, K. (1983). The prosody of maternal speech: infant age and context related changes. *Journal of Child Language*, 10, 1-15.
- Werker, J.F., & McLeod, P.J. (1989). Infant preferences for both male and female infant-directed talk: a developmental study of attentional affective responsiveness. *Canadian Journal of Psychology*, 43, 230-246.