CHAPTER 4

PHONETIC CHARACTERISTICS OF INFANT DIRECTED SPEECH IN THAI

4.1 Introduction

A good deal of past research on maternal speech has been done on phonetic and prosodic aspects of IDS (Cruttenden, 1994). Most earlier studies have focused on the prosodic features of maternal speech to children at older ages, i.e., 16 months to 5 years (Remick, 1976; Garnica, 1977). Some studies have done on the prosody of maternal speech during the first year of life (Fernald, 1978; Greiser & Kuhl, 1988), but no age comparison. However, there is only one work which has been done systematically concerning changes in prosody of maternal speech to infants during the neonatal period and at 4, 12, and 24 months and compared them to speech addressing an adult (Stern et al. 1983). In this study, a longitudinal investigation of infant directed speech will be done systematically and compared to adult directed speech.

In terms of pitch, Ferguson (1964) in his study of Baby Talk in six languages has subjectively remarked that mothers seem to use high pitch and expand its range when talking to young children. A great deal of acoustic studies have tried to verify this claim. Remick (1976) and Garnica (1977) found higher overall pitch in maternal speech to children between the ages of 16 and 30 months. Moreover, an investigation on this aspect has also done on maternal speech to prelinguistic infants (Stern, Spieker, Barnett, & MacKain, 1983; Fernald & Simon, 1984; Greiser & Kuhl, 1988; Fernald, Taeschner, Dunn, Papousek, De Boysson-Bardies & Fukui, 1989; Kitamura, 1992; Khaonoo, 1996). However, among these studies only the study by Stern et al. (1983) has done a longitudinal study, comparing the speech of six mothers to their children at four different age-neonatal period (two to six days), 4, 12 and 24 months. The result shows that a higher mean on all measures of fundamental frequency were highly significant at 4 months than in other age groups.

Concerning the temporal aspects, several studies have suggested that maternal speech contains slower articulation rate of speech, shorter utterances and fewer syllables (Drach, 1969; Broen, 1972; Sachs et al., 1976; Garnica, 1977; Stern et al., 1983; Greiser & Kuhl, 1988; Fernald et al., 1989).

With regard to voice quality, Garnica (1977) has reported that the prosodic aspects of IDS including the use of whispering (less volume in voice). She found that whispering in parts of sentences appear in speech directed to the two-year-olds. This characteristic was absent from speech directed to the adult listener and to the five-year-olds. It is not clear whether whispering is related to the degree of loudness in IDS. This aspect of loudness needs to be explored.

From a brief summary of past research on prosody in IDS above, it has shown that a number of studies have mainly focused on investigating pitch level, pitch range, and tempo. Another aspect, loudness, has hardly been studied. Therefore, in this research we explore whether the presence and distribution of these prosodic aspects of IDS differ systematically from their distribution in ADS.

A total of 720 utterances were analyzed in term of prosodic investigation. That is to say, twenty utterances from each of the six mothers speaking to their infants at each of the five infant ages and to an adult (20 utterances x 6 mothers x 6 age groups).The data were digitized from the audio tapes and were analyzed acoustically using WinCECIL for a pilot study (see details in Appendix C). The main study used Multi-Speech Model 3700 for the measurement of fundamental frequency, duration, and intensity. Then the speech samples were analyzed statistically.

4.2 The Acoustic Analysis of Phonetic Characteristics in IDS and ADS

Since the pitch results from the pilot study did not support the universality hypothesis of speech to children, I concluded that the measurement methodology may not be proper. Since the phonetic features of IDS are more global and superimpose onto mother speech from beginning to end, we decided to use another procedure in the measurement of fundamental frequency, that is, to measure every value of Fø and look at the statistic distribution of Fø in different groups. This is done by using Multi-Speech (MS). Moreover, by using this program, it would be easier to compare our result to Kitamura's work on Australian maternal speech which has already done by using this software program.

4.2.1 Pitch

In this study, 720 utterances were analyzed in term of fundamental frequency. Two measures of fundamental frequency with two variables were presented: (a) mean-Fø and pitch range across ages and (b) mean Fø and pitch range of speech directed to female and male infants.

(a) Mean-Fø and pitch range across age groups

The total number of measurements of fundamental frequency across age groups made was 170,166 and the statistical analysis was given in Table 15.

Table 15 The Descriptive Statistics of Fundamental Frequency across Age Groups

	NB IDS	3MO IDS	6MO IDS	9MO IDS	12MO IDS	Mean IDS	ADS
MEAN	250.23	276.04	278.04	264.81	247.39	263.30	247.99
MEDIAN	245	282.69	275.63	262.5	229.69	259.10	239.67
MODE	256.4	315	324.26	262.5	355.65	302.76	256.4
S.D.	81.68	78.87	80.56	78.75	88.5	81.67	88.09
TOTAL	27835	28974	26192	27318	26296	136615	33550

This table does not include the Fø range because the maximum and minimum which the Multi-Speech automatically measure shows the same values across age groups. This is because the analyzer automatic pick up the display range of Fø at 80-500 Hz for the minimum and maximum values. Therefore, the maximum and minimum of the Fø of each utterance were measured manually by the researcher using the cursor to mark at the highest pitch peak and the lowest pitch peak. This yield a more reliable measure of Fø. Then we convert Fø range from absolute to ratio values or semitone scale (See detail below).

Across infant age groups, there is a large increase of Fø in NB and the 3 MO (250 to 276 Hz). There is a successive decrease of Fø for the IDS of the 6 MO (278 Hz) to the 9MO (265 Hz) and the 12MO (247 Hz). IDS of mothers to the 12MO has the overall pitch which is almost similar to that of ADS (247 Hz vs. 248 Hz) as illustrated in Figure 5 below.

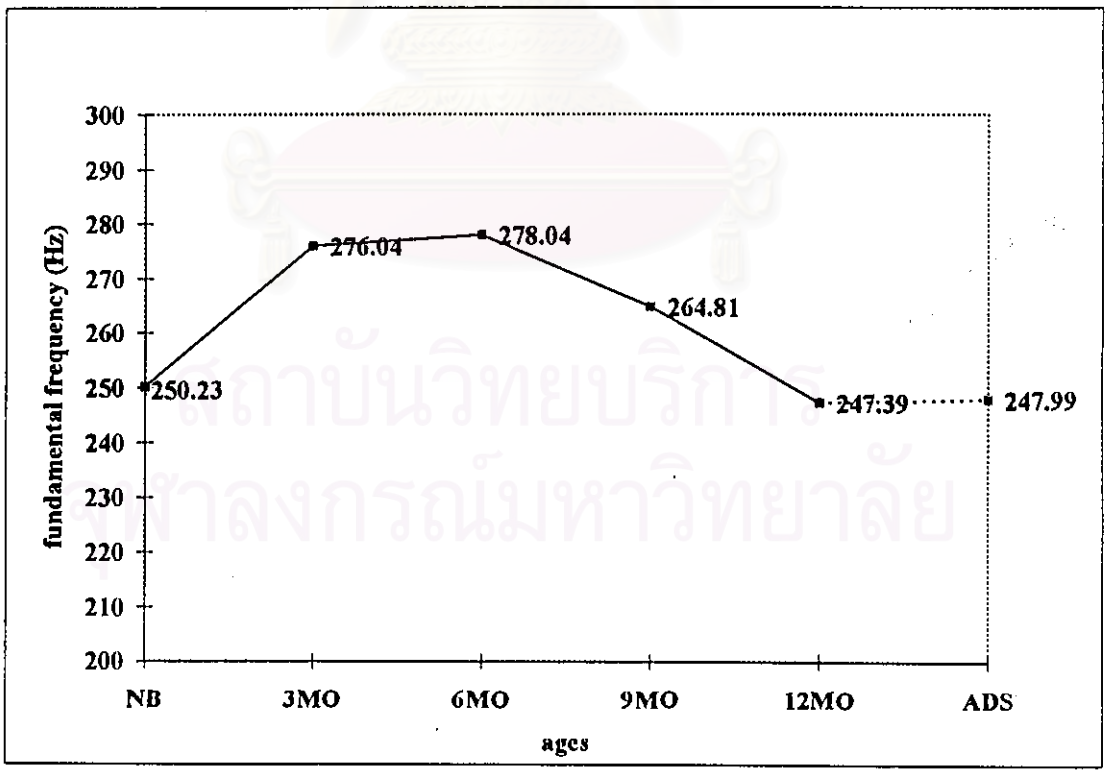

Figure 5 Mean Fundamental Frequency across Age Groups

The Analysis of Variance has been executed to test whether there variations are statistically significant or not. The mean fundamental frequency of IDS is significant higher than ADS which is 263.3 and 247.99 respectively. The average pitch shows significant age changed, $F(5,170154) = 878.220$, $p < 0.05$. Since the number of fundamental frequency is very large. That was 136615 in IDS and 33550 in ADS. Thus, the frequency distribution of IDS and ADS is done as showed by the comparison of frequency polygons in Figure 6 below.

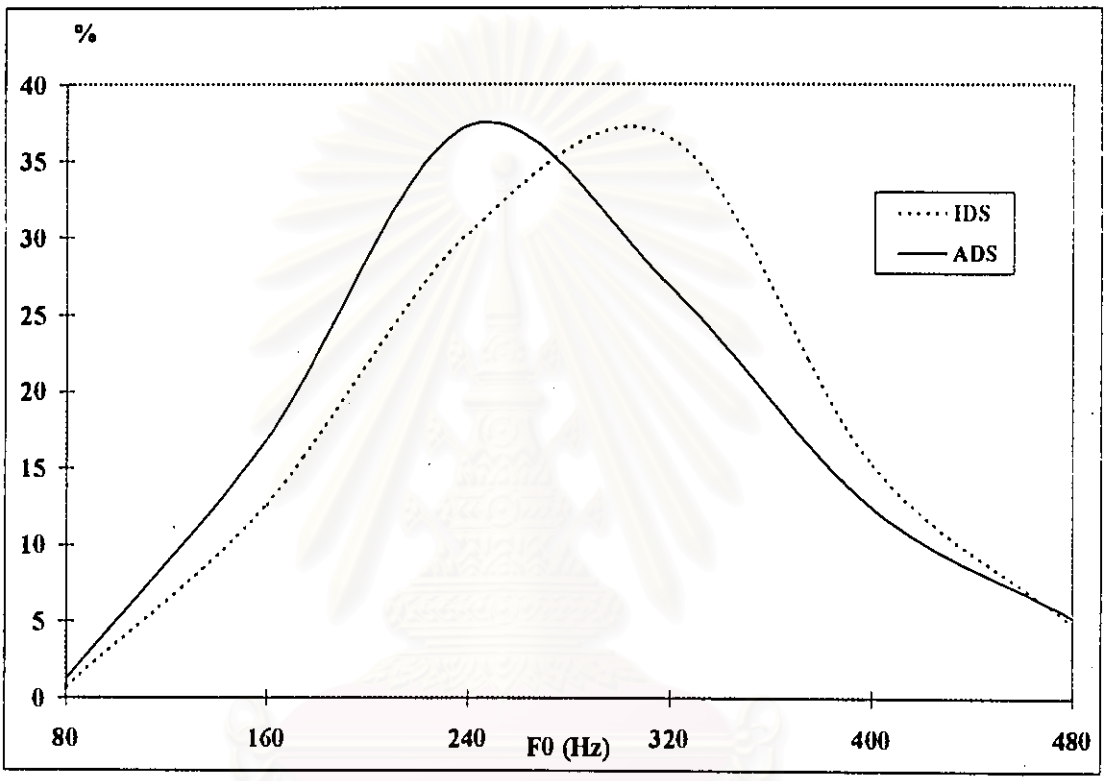

Figure 6 Distribution of Fundamental Frequency of IDS and ADS

From the frequency polygons above, both IDS and ADS are skewed right. But ADS is more skewed right than IDS. Research of IDS in other languages which revealed a very high fundamental frequency of IDS as compared to ADS may have a skewed left distribution compared to IDS in Thai has reported here. The skewness is .256 in IDS and .474 in ADS. It can be said that 50% of fundamental frequency values of ADS are in lower portion than IDS.

For the pitch range across ages which is the difference between minimum and maximum frequencies is converted in semitone scale as shown below.

Table 16 Pitch Range across Age Groups

	NB IDS	3MO IDS	6MO IDS	9MO IDS	12MO IDS	Mean IDS	ADS
MINIMUM	141.13	145.16	158.52	151.46	156.03	150.46	146.72
MAXIMUM	325.75	339.24	374.52	352.12	348.40	340.01	312.29
RANGE (Hz)	184.62	194.08	216	200.66	192.37	197.55	165.57
R A N G E (SEMITONES)	14.89	15.66	15.70	15.14	14.39	15.16	13.5

The findings show that pitch range is expanded when mothers direct their speech to infants as opposed to adults. The average range per utterance is 15.16 in IDS and 13.5 in ADS. A one-way ANOVA shows that the average range per utterance in IDS is significantly higher than ADS, $F(1,718) = 7.394$, $p < 0.05$.

(b) Mean-Fø and pitch range of speech directed to female and male infants

In this study, we are also interested in the mothers' speech directed to female infants and male infants. The average fundamental frequency is given below.

Table 17 Mean Fundamental Frequency of Speech Directed to Female and Male Infants

	FEMALE						MALE					
AGES	N	3	6	9	12	ADS	N	3	6	9	12	ADS
MEAN	218.5	278.3	275.1	283.3	239.5	259.1	263	249.9	281.6	260.6	273.5	265.7
MEAN IDS/ADS	0.88	1.12	1.11	1.08	0.97	X= 1.03	1.09	1.03	1.17	1.08	1.13	X= 1.1

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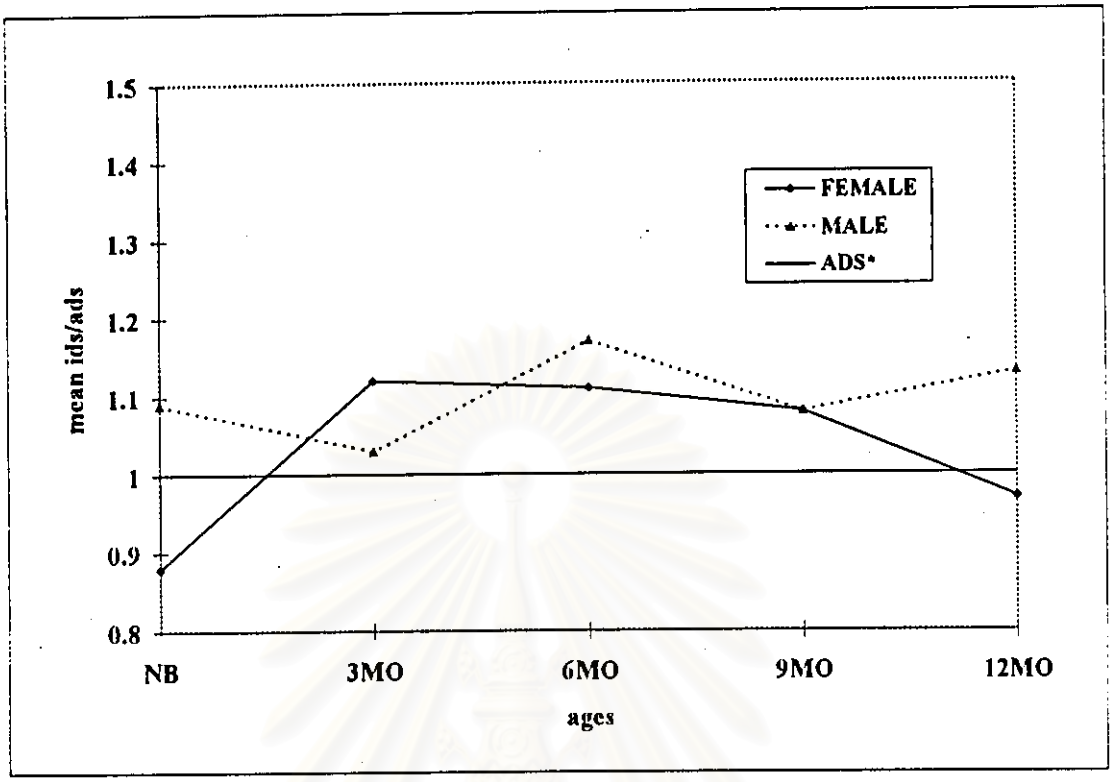

Figure 7 Proportion Mean Fundamental Frequency of Speech Directed to Female and Male Infants
*ADS is a reference line

To compare the mean Fø and pitch range of IDS of female and male infants clearly, a proportional mean fundamental frequency of IDS to ADS (IDS/ADS) will be used. The proportional mean of ADS (ADS/ADS) which equals 1 is used as a reference. The results reveal that in Male-IDS, mean Fø decreases in the 3 MO and highest in the 6MO. Then, it is found an increase of mean Fø again in the 12MO. The proportion scores of Male-IDS display the score more than 1 in every age groups. It means that mean Fø of Male-IDS is higher than that of ADS. In Female-IDS, mean Fø exhibits a large increase from NB to the 3MO and has a successive decrease for the 6MO to the 9MO and the 12MO. However, mean Fø of Female-IDS in NB and the 12MO is lower than 1. It can be said that mean Fø of both age groups, i.e., NB and 12MO for female infants is lower than that of ADS. For mean Fø, no significant age effects were found. $F(4,20) = .744$, $p > 0.05$, sex effects, $F(1,20) = 1.401$, or age x sex interaction, $F(4,20) = .868$, $p > 0.05$ were found.

Table 18 Range Fundamental Frequency of Speech Directed to Female and Male Infants

	FEMALE						MALE					
AGES	N	3	6	9	12	ADS	N	3	6	9	12	ADS
RANGE	15.3	15.1	11.8	13.2	15.4	13.7	13.6	14.7	18.1	16.1	12.7	12.5
RANGE IDS/ADS	1.12	1.1	0.86	0.96	1.12	X= 1.03	1.1	1.17	1.45	1.28	1.01	X= 1.2

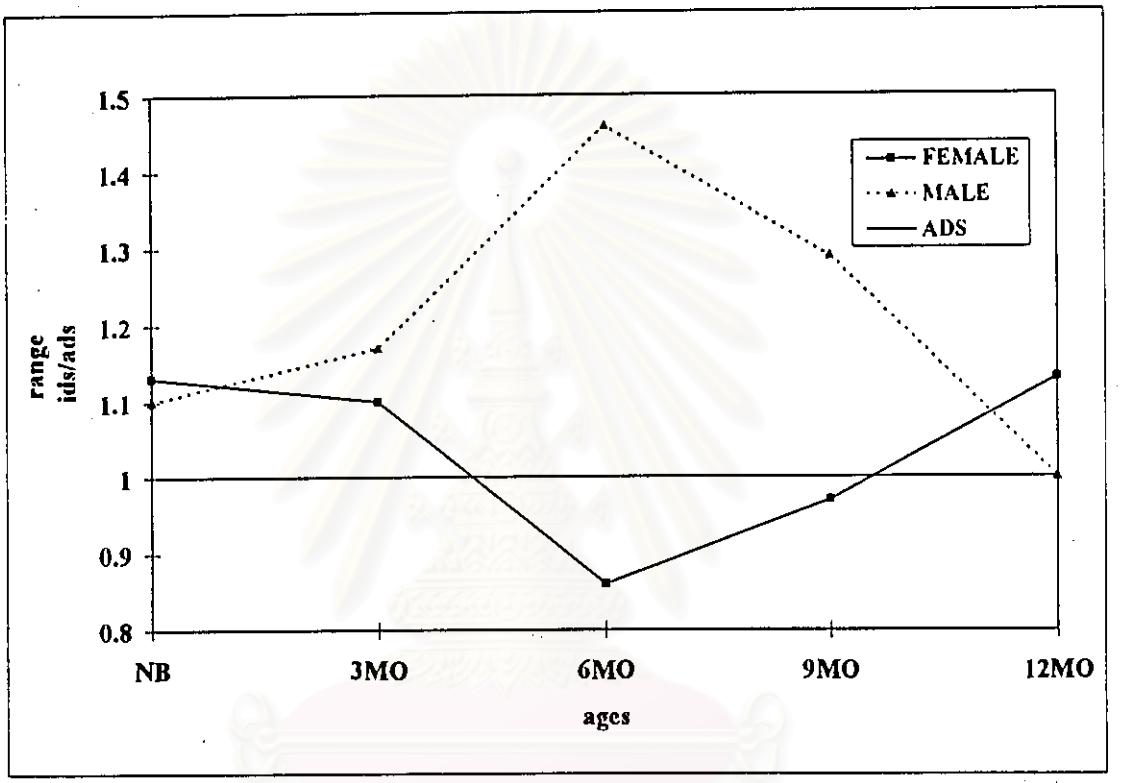

Figure 8 Proportion Semitones of Speech Directed to Female and Male Infants

The findings show that mothers use a higher overall pitch range when speaking to male compared to female infants. In Male-IDS, there is an increase of pitch modulation in NB and the 3MO. The Fø range reaches the highest peak in the 6MO and continually decreases in the 9MO and 12MO. However, in Female-IDS the results show the opposite direction. There is a smaller decrease from NB to the 3MO, and the largest decrease in the 6MO. Then the pitch modulation gradually increase from 9MO to 12MO. For Fø range no significant age effects were found. $F(4,20) = .190$, $p > 0.05$, but sex and age x sex interaction show significant effects, $F(1,20) = 5.670$, $p < 0.05$, and $F(4,20) = 3.531$, $p < 0.05$.

It can be concluded here that Thai mothers use higher mean Fø and pitch range when speaking to male than female infants. The results of mean Fø and Fø range in this study are different from those of Kitamura (in progress). She found that mothers speak to their female infants with higher mean Fø and Fø range than

when they speak to their male infants. This case may be explained in terms of articulatory aspects of mothers speaking to their male infants. It can be said that Thai mothers speak louder to male infants than to female infants. The stronger energy can be related to the subglottal air pressure which correlates the rate of vibration of vocal cords. That is to say, the increase of intensity which causes an increase in the degree of loudness correlates with the increase of Fø. So, Male-IDS uses higher mean Fø and Fø range than Female-IDS.

4.2.2 Tempo

Three measures of tempo across six age groups were done: utterance duration, syllable duration, and numbers of syllable per utterance. It is expected that the rate and tempo of ADS will be perceived as much faster than IDS.

4.2.2.1 Duration of utterance

Average utterance duration was measured by placing the cursor at the beginning and end of each utterance using auditory judgment. Then the computer calculated time in seconds that emerged between each cursor. Then, time in seconds was converted to milliseconds as illustrated in Table 19 below.

Table 19 The Descriptive Statistics of Utterance Duration across Age Groups

	NB IDS	3 MO IDS	6MO IDS	9MO IDS	12MO IDS	MEAN IDS	ADS
MEAN	1262	1115	950	1102	1104	1106	1506
MEDIAN	1164	929	658	996	863	916	1603
MODE	1354	302	307	485	283	283	956
S.D.	748	784	855	814	876	820	1383
MIN	84	101	67	82	37	37	33
MAX	3307	4048	3972	4140	4637	4637	8658
RANGE	3223	3947	3905	4058	4600	4600	8625
TOTAL	120	120	120	120	120	600	120

The results reveal that mean utterance duration was longer in ADS (1506 ms)than IDS (1106 ms). A one-way ANOVA reveals that average utterance duration in ADS is significant higher than IDS, $F(1,718) = 18.203$, $p < 0.05$. The utterance duration also changes significantly with infant age, $F(5,708) = 5.176$, $p < 0.05$. The distribution of the duration of utterance in IDS and ADS is shown below.

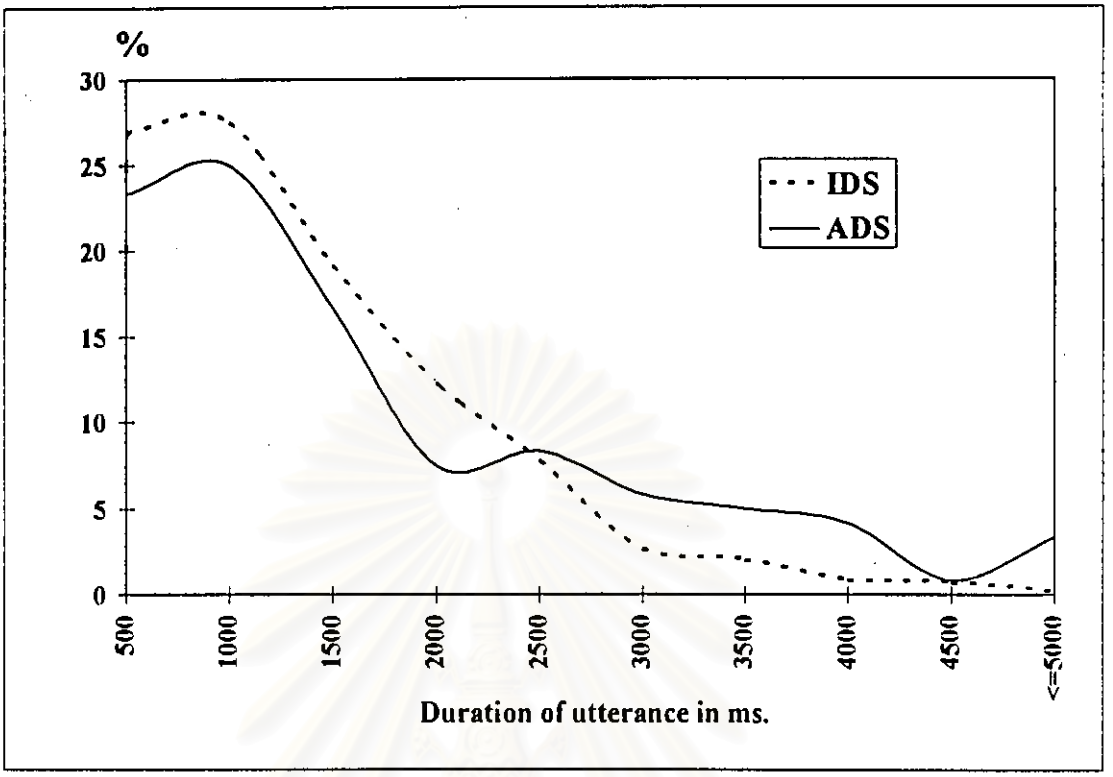

Figure 9 Distribution of Utterance Duration (ms) in IDS and ADS

As expected, the utterance duration of ADS was longer than IDS. These findings are parallel to those of Fernald and Simon, 1984; Stern et al., 1983; Greiser and Kuhl, 1988; Fernald et al. 1989; Kitamura (in progress).

4.2.2.2 Duration of syllable

Previous work on timing has always been done on the duration of utterance. There is a very few work investigating the duration of syllable such as the study by the author (Authapaiboon, 1996), and Khaonoo, 1996. Average syllable duration was calculated by measuring utterance length in seconds and then dividing by the number of syllables per utterance. Average syllable duration of IDS is significantly longer than ADS.

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Table 20 The Descriptive Statistics of Syllable Duration across Age Groups

	NB IDS	IMO IDS	6MO IDS	9MO IDS	12MO IDS	Mean IDS	ADS
MEAN	359	351	333	341	328	343	220
MEDIAN	278	293	307	271	247	287	202
MODE	222	121	307	252	176	161	236
S.D.	245	242	183	228	275	236	101
MIN	84	69	67	42	37	37	33
MAX	1697	1439	936	1225	1824	1824	839
RANGE	1613	1370	869	1183	1787	1781	806
TOTAL	120	120	120	120	120	600	120

The frequency distribution of syllable duration of IDS and ADS is shown in Figure 10 below.

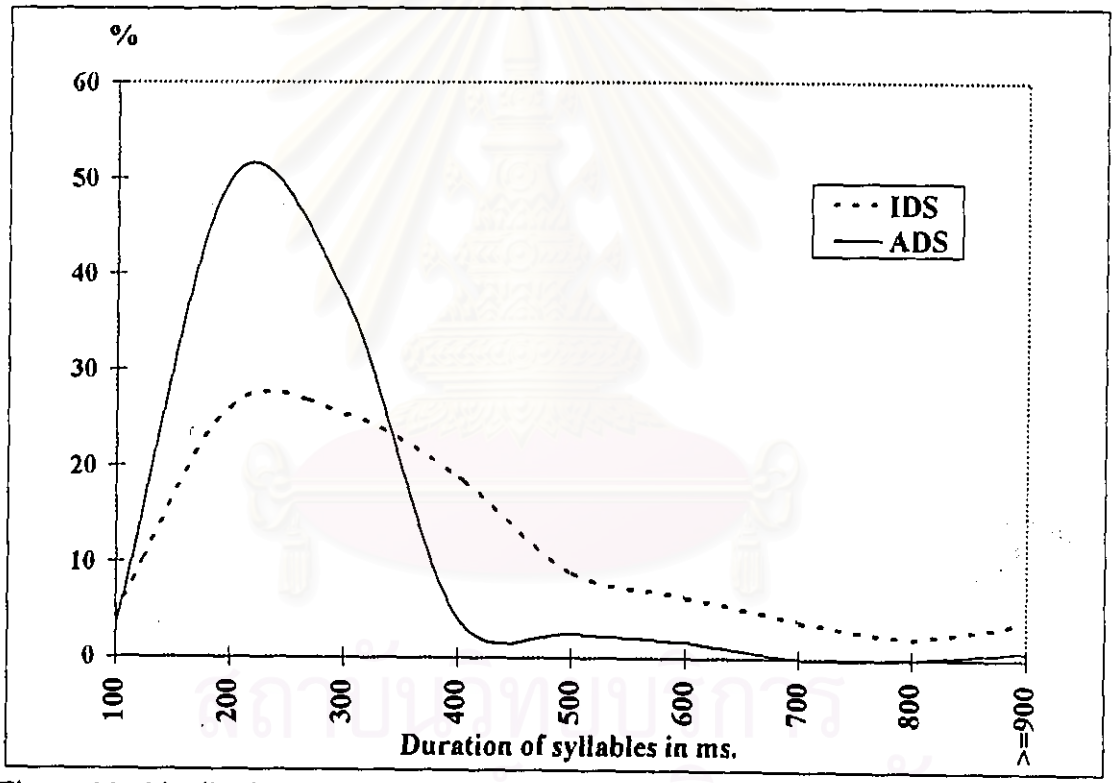

Figure 10 Distribution of the Duration of Syllables (ms) in IDS and ADS

It can be said that the syllable duration of IDS is longer than ADS. As we can see from the above figure syllable duration in IDS is equal or longer than 900 ms. An ANOVA test displays that IDS is significantly longer than ADS, $F(1,718)= 31.025$, $p < 0.05$. Moreover, the overall age effect for syllable duration measures is significant, $F(5,708) = 6.509$, $p < 0.05$.

4.2.2.3 Numbers of syllable per utterance

In terms of the distribution of syllables in one utterance, it is assumed that IDS should contain fewer syllables than ADS. The results display that the average numbers of syllable per utterance of IDS- the NB, the 3MO, the 9MO, and the 12 MO is equal at 4 syllables per utterance except that of the 6MO which is equal at 3 syllables per utterance. In contrast, the numbers of syllable per utterance in ADS is higher at 7.63 syllables per utterance which is the same result proposed by Laver (1970)- (7-8 syllables per utterance) and Luksaneeyanawin (1988) in her study of pauses in reading style ($\bar{x} = 8$, sd = 4).

Table 21 The Descriptive Statistics of Numbers of Syllables per Utterance across Age Groups

	NB IDS	3MO IDS	6MO IDS	9MO IDS	12MO IDS	Mean IDS	ADS
MEAN	4.36	3.75	3.08	3.87	4.33	3.85	7.63
MEDIAN	4	3	2	3	3.5	3	6
MODE	1	1	1	1	1	1	1
S.D.	3.08	2.63	2.44	2.89	3.38	2.94	6.71
MIN	1	1	1	1	1	1	1
MAX	16	12	15	16	15	16	39
RANGE	15	11	14	15	14	15	38
TOTAL	120	120	120	120	120	600	120

It can be concluded that the utterance of ADS contains more average syllables than IDS. As we can see from the figure below, ADS has wider range of number of syllables per utterance. The rate of speaking of ADS is one to thirty-nine syllables per utterance whereas that of IDS is one to sixteen syllables per utterance. That is to say, utterance directed to infants have a slower rate than utterances to adult. In addition, numbers of one syllable utterance is very high in IDS (26%) and ADS (15%). The ANOVA reveal that the condition effect on the numbers of syllable per utterance of IDS and ADS is significant , $F(1,718) = 87.494$, $p < 0.05$. The numbers of syllable per utterance also shows significant age changed, $F(5,708) = 21.781$, $p < 0.05$.

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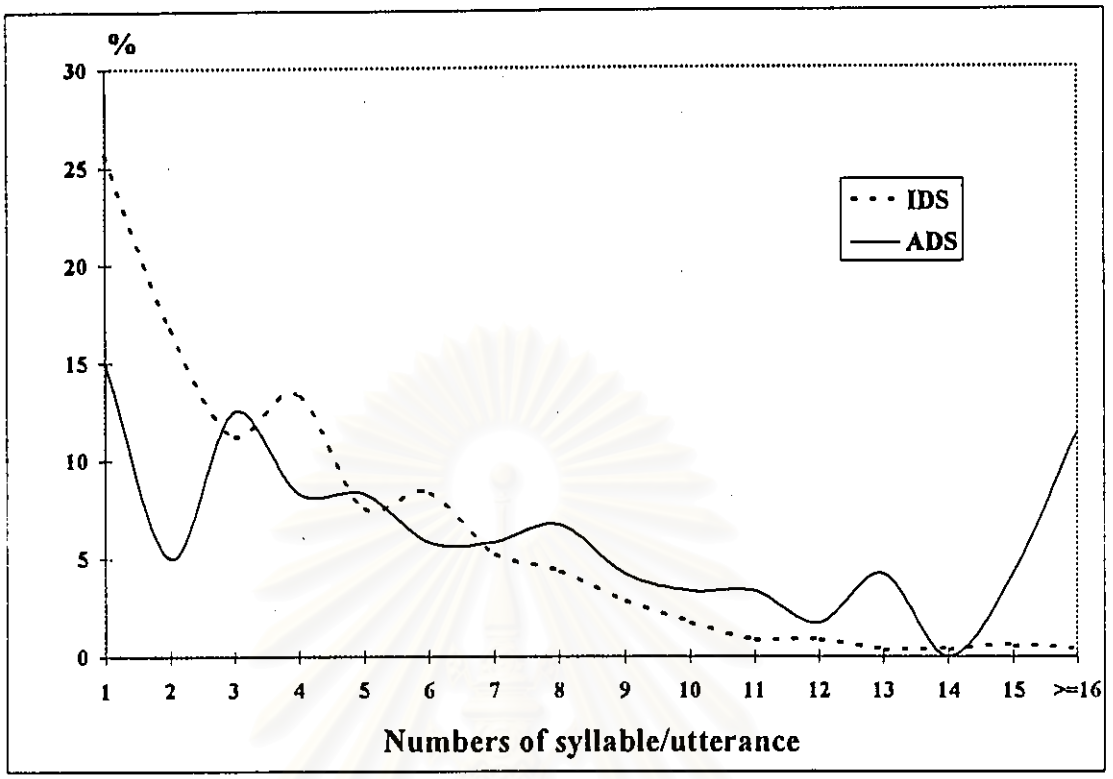

Figure 11 Distribution of Numbers of Syllable per Utterance in IDS and ADS

4.2.3 Loudness

The 720 speech samples were digitized into the acoustic analyzer. We need to adjust the input volume range manually until the machine can register the signal. Then, the average intensity was calculated automatically in dB. The total values measured is 176,499. The results of descriptive statistical analysis are as presented below.

Table 22 The Descriptive Statistics of Intensity across Age Groups

	NB IDS	3MO IDS	6MO IDS	9MO IDS	12MO IDS	Mean IDS	ADS
MEAN	75.35	72.17	72.32	68.13	68.15	71.28	69.07
MEDIAN	78.03	71.78	73.08	68.74	69.01	71.1	69.51
MODE	81.1	70.09	78.09	69.88	70.23	69.49	70.01
S.D.	6.65	5.73	7.06	5.63	5.86	6.8	5.59
MIN	40.41	45.55	35.56	41.27	36.93	35.56	48.74
MAX	84.99	84.81	84.79	84.78	85	85	84.86
RANGE	44.58	39.26	49.23	43.51	48.07	49.44	36.12
TOTAL	29726	29662	26841	28064	27126	141419	35080

In intensity analysis, there is the same problem in the measurement methodology as in the pilot study. From table 22 above, it is shown that the

average intensity is highest in newborn and lowest in nine months. This reveals the opposite way to the auditory judgment. Indeed, in auditory terms I notice very soft degree of loudness in the newborns and the degree of loudness seems to increase with the age. This is because the speech to the newborns has very low intensity. It cannot be registered by the acoustic analyzer. I have to increase the speech intensity by increasing the input volume until the machine registers the signal. Therefore, the intensity results are not valid. This is a problem which is needed to be solved by improving the acoustic analyzer so that a wide range of intensity from very low to very high can be registered without increasing the input volume.

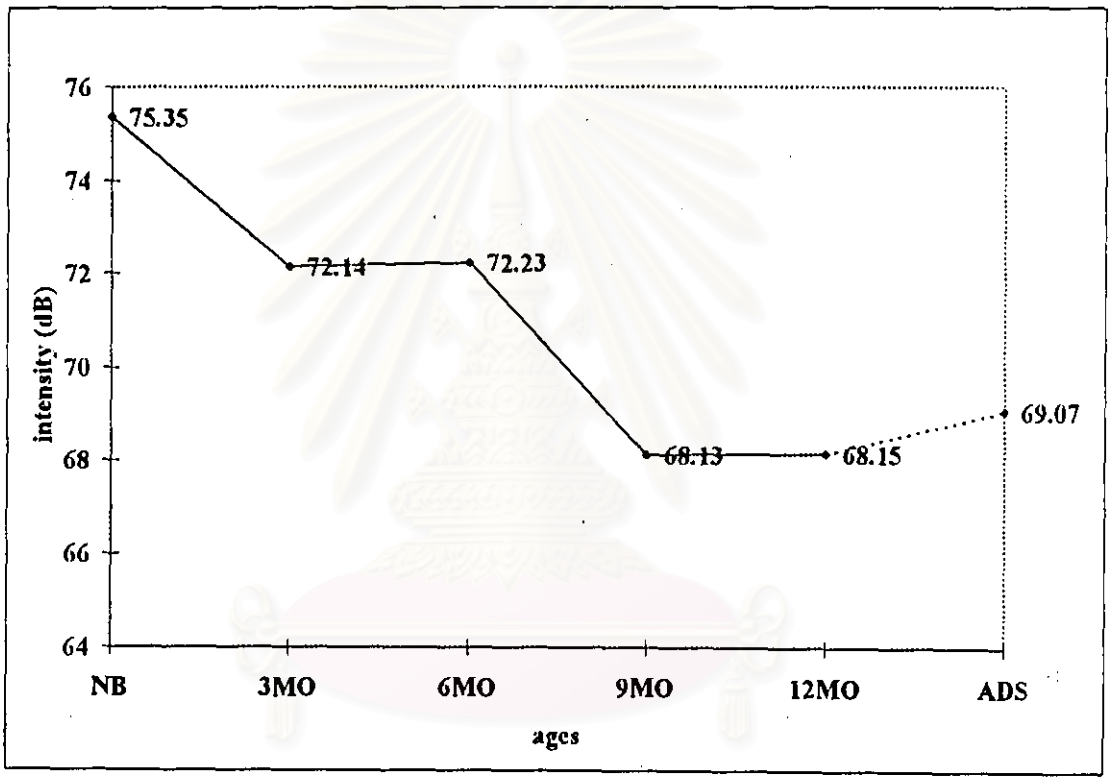

Figure 12 Mean Intensity across Age Groups

4.3 Conclusion

Six prosodic features- fundamental frequency, frequency range, utterance duration, syllable duration, number of syllable per utterance and intensity are performed on samples of speech directed to infant listeners of five ages: newborns, 3 months, 6 months, 9 months and twelve months and to adult listeners. Speech to infant listeners show different modification. The average pitch and pitch range are highest at 6 months. Moreover, the average pitch of 12 months is very close to that ADS. That is to say, pitch feature of 12MO IDS becomes the most adult like. For rate and tempo analysis, utterance of IDS is shorter in utterance duration, longer in syllable duration and contains more syllables than ADS. With regard to

intensity, it is found that IDS used higher intensity than ADS. Thus, in accord with the hypothesis variations across age were obtained for all phonetic variables. However, the study of intensity values in IDS fail to reveal any significant variation due to a general phonetic problem in the instrumental study of the degree of loudness in speech.

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