ACOUSTIC ANALYSIS OF NATURAL MATERNAL SPEECH TO PRESCHOOL LANGUAGE IMPAIRED AND NORMAL CHILDREN

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Acoustic characteristics of the speech of nineteen mothers to their normal and language impaired four year olds during a story reading task were analyzed on four scales of Expressiveness, Rate, Utterance Based Productivity, and Pause Based Productivity. Mother's audiotaped voices were digitized and then band-pass filtered and analyzed by the computer system, VOXCOM. Discriminant function analysis correctly classified 84.2% of the mothers of language impaired children based on values representing the acoustic scales. The Expressiveness and Rate scales contributed the greatest discriminatory power to differentiating between the two groups of mothers. The results were interpreted in light of the importance of expressiveness and rate for focusing attention and consequent cognitive development.

Introduction :

Acoustic analysis of mother's speech to their children has traditionally been limited to speech with young children, those less than three years of age, and particularly, eighteen to twenty-one months of age (Owens, 1988). The purpose of this research has been to document the presence of a specialized speech register used by primary care givers in speaking to young language learning children (Nelson, 1973; Wells, 1981; Snow, Dubber and De Blauw, 1982; Snow and Fergusen, 1977; Schachter and Strange, 1982; Cross, 1977). This register has been called "motherese" and has been interpreted as a consistent and simplified model from which the child can learn language, particularly syntax (Newport, Gleitman and Gleitman, 1977).

Early speech to young children has been generally found to consist of short, grammatically accurate sentences with many exclamations, use of high pitch and special voice qualities such as whispering, slower rate of speech, frequent repetitions, and baby talk words; and frequent use of questions and elaborations of the child's utterances (Garnica, 1977; Snow and Ferguson, 1977; Snow, 1984). Six acoustic features of mother's speech to young children isolated by Garnica (1977) include higher funda-

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mental frequency, greater pitch range, rising terminal frequency, longer duration in speaking separable verbs, and placing two primary syllabic stresses on words calling for one. Acoustic features have been found to be instrumental in focusing attention, differentiating given from new information, differentiating speech acts and syntactic structures, signalling organizational boundaries, and improving intelligibility and retention of meaning (Bates and MacWhinney, 1979; Clark and Clark, 1977; Crystal, 1981; Wode, 1980; Campbell and Shriberg, 1982; Wingfield, Lombardi, and Sokol, 1984).

In spite of the significance of and interest in acoustic analysis of mother's speech to their young children, studies to date have been conducted primarily with children younger than age three, have used imprecise instrumentation and subjective estimations of acoustic characteristics (Shute and Wheldall, 1989), and have not included comparisons across diagnostic categories as regards acoustic features.

The present investigation seeks to analyze acoustic aspects of mother's speech to their four year old children from the perspective of their significance for cognitive development. It is recognized that the child's knowledge structure is fully reorganized between the ages of four and ten years (Carey, 1987). This reorganization is based on prerequisite attention which is tightly connected to linguistic components in regulating activity (Zaporozhets and Elkonin, 1971; Wertsch, 1985). The formation of attention begins with the adult using words in characteristic ways to attract the child's attention to various aspects of reality. Gradually the child learns to organize his own attention based on his interaction with significant others. Acoustic characteristics reflect the reciprocal relationship or lack thereof, between the adult and child. The intonational envelope, as it has been called, signals joint participation between the adult and child (Bruner, 1975). This joint attention is the foundation on which later reorganization of knowledge structures is based (Dimitracopoulou, 1990).

In contrast to the often imprecise instrumentation used in other studies exploring acoustic aspects of mother's speech to young children, it is the purpose of this investigation to identify differences in speech to normal versus language impaired children using a unique computer-based speech analysis system, VOXCOM. VOXCOM is a uniquely precise system using a microcomputer which provides a means to analyze recorded samples of natural speech in real time. The VOXCOM system was originally designed to provide objective and quantitative characterizations of the speech patterns found in various clinical populations. Its primary use thus far has been with schizophrenic and clinically depressed adult patients to identify the patients' ability to express emotion or affect. Initial studies indicate that acoustic cues may differentiate some of these clinical groups. This investigation seeks to extend the application of acoustic analysis using VOXCOM to differentiate between speech by mothers to normal versus language impaired children. Since language impaired children have been found to have deficits in social and linguistic interactional knowledge and competence (Bryan, 1981), acoustic features of maternal speech with normal and clinical populations may initially be a way to differentiate these groups and ultimately, help predict concomitant attentional and subsequent cognitive characteristics.

Method :

The subjects for this study are two groups of mother-child dyads, ten normal child-mother pairs and nineteen language impaired children and their mothers. All children participating in the study are between the ages of 4 ; 0 and 5 ; 1, have demonstrated age deviation scores between 90 and 116 on an intelligence measure (Burgemeister, et al., 1972), and are boys. Dyads participating in the study are representative of the middle to upper middle socioeconomic level as determined by Hollingshead's Two Factor Index of Social Position (Meyers and Bean, 1968). Only families whose primary language is English were included in the present investigation, and all mothers and their children were Caucasian in ethnic origin. All subjects had normal auditory acuity and normal or corrected visual acuity. Normal children had demonstrated language competence on a locally devised screening measure which included assessment of expressive and receptive language abilities. No children in this group were known to have any language or emotional disorders and had not been referred for special education services of any kind. Language impaired subjects had been diagnosed by private or public agencies as evidencing a significant language disorder according to the State (of Colorado) guidelines, and were enrolled in an early intervention language program.

Mothers were engaged in a task in which each was given the same book (Crowe, 1980) to read to their preschool child. Reading has been found to be a preferred measure for analyzing acoustic characteristics of speech as it yields a high test-retest correlation and accurately reflects measurements of spontaneous speech (Fitch, 1990). Reading sessions were conducted in the mother's homes in a naturalistic setting and audiotaped. The analog signals from the mother's audiotaped reading of the story text were digitized and then band-pass filtered and analyzed by a computer system, VOXCOM (Alpert, et al., 1986). The range of the band passed filters is adjusted to accommodate specific samples of speech. For men the range extends from 80-140 Hz while women have a range extending 120 to 280 Hz. After filtering, the signal that represents the subjects voice is split into two parallel lines that are analyzed for frequency and amplitude information. In short, variations in voltages across time correlate with changes in loudness or stress that the subject produces. Consequently, usable data can be extrapolated from the raw data through the VOXCOM method. Figure 1 illustrates how the raw data would appear on an oscilloscope screen.

Data is reported in the form of *utterances, gaps,* and *peaks.* In addition, VOXCOM breaks those groups into subgroups representing the number of utterances, gaps, peaks ; the mean and variance of the time durations of utterances, gaps, and peaks ; the mean and variance of the log of the amplitudes of peaks and the frequencies corresponding to those peaks ; the correlation between peak amplitude and peak frequency ; and the distribution of peaks within utterances. The output of VOXCOM is shown in Table 1.

An *utterance* is defined as an amplitude which is above a given threshold of background noise for 100 msec. A *gap* is an amplitude that remains below the threshold for at least 200 msec. A *peak* is a point of maximum amplitude relative to the values of amplitude immediately preceding and following that point. As VOXCOM samples the raw data, it stores the values of amplitude and frequency and then compares each suc-

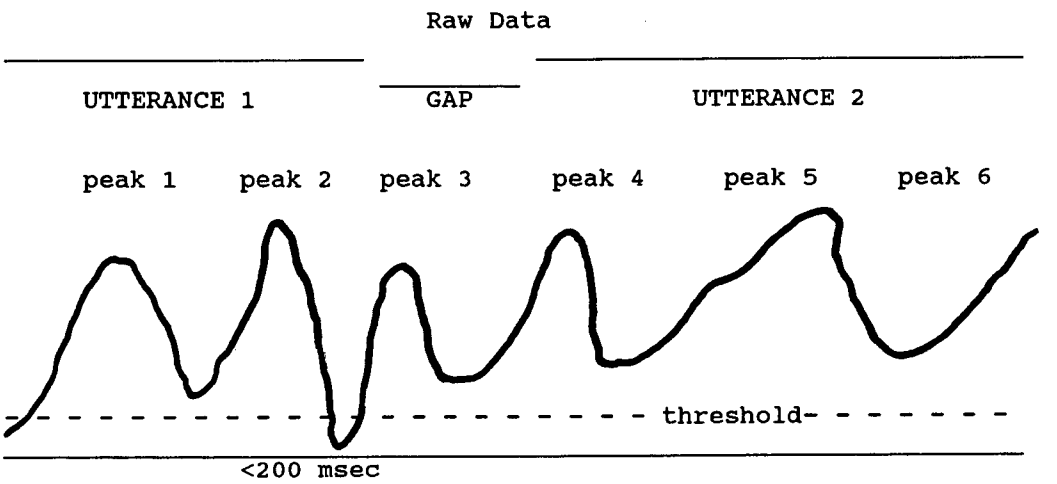

FIGURE 1 Hypothetical oscilloscopic tracings of two samples of speech to illustrate how VOXCOM detects a gap between utterance.

TABLE 1
VOXCOM Output

Parameters: id1=2 id2=32005 id3=2
gapmin=20 utrmin=10 pkminh=51
thresh=48 fmin=200 fmax=800
acalib=0 fcalib=0 fcalib2=0 uttkccp=5

Total Time: 436 seconds

Utterances: N=114
Mean Duration=244.54 Variance=32569.15
Frequency Distribution:
3 2 6 11 5 4 6 7 3 8 5 5 5 4 4 4 32

Gaps: N=113
Mean Duration=111.71 Variance=20331.29
Frequency Distribution
0 29 19 11 9 4 9 8 3 3 0 2 1 0 2 1 4

All peak Data: N=1141 r=0.397

Duration		Amplitude		Frequency	
Mean	Var	Mean	Var	Mean	Var
23.8	119.77	536.5	131.33	491.9	95.88

Duration of n peak utterances:

#pk	N	mean	var
1 utt	7	28.3	189.1
3 utt	18	68.0	223.1
5 utt	13	126.3	848.1
7 utt	14	169.1	926.1
9 utt	10	202.8	949.1
11 utt	14	263.1	1020.1
13 utt	11	309.4	1021.1
15 utt	5	348.8	2024.1

ceeding value with the previous one. This identifies whether or not amplitude increases or decreases. Measures of uttmin and gapmin (minimum time duration for detecting whether an utterance or gap has occurred), pkminh (the minimum decrement in amplitude needed for a peak to be detected), thresh (the threshold or minimum amplitude that is considered usable signal by the peak detection routine), and fmin and fmax (minimum and maximum values of peak frequency accepted after band passing) are further used as criterion values against which analyze the data. With the use of frequency parameters, the VOXCOM system becomes a more precise method of controlling peak frequencies that are accepted as values of fundamental frequency.

From the computer-based VOXCOM speech analysis system, scales of Expressiveness, Utterance and Pause Based Productivity, and Rate have been developed. These scales represent average values derived from duration, variance, gap, rate, and peak information. Table 2 summarizes the components which comprise each of the scales.

TABLE 2

Variable Scale Components

Pause-Based Productivity (PRD-P)
Subject pause duration
Variance of subject pause duration
Gap at the 90th %ile
Gap at the 50th %ile
Rate of peaks per total time
Utterance-Based Productivity (PRD-U)
Subject vocalization duration
Variance of vocalization duration
Utterance duration at 90th %ile
Utterance duration at 50th %ile
Percent of 1 peak monosyllabic utterances/total utterances
Rate
Rate of peaks per time talking
Average duration of 3 peak utterances
Average duration of 4 peak utterances
Average duration of 5 peak utterances
Average duration of 6 peak utterances
Average duration of 7 peak utterances
Average duration of a peak
Variance of peak duration
Expressiveness
Frequency variance in 100ths of an octave
Amplitude variance
Variance of 1 peak amplitude
Variance of 2 peak amplitudes
Variance of 3 peak amplitudes
Variance of 4 peak amplitudes
Variance of 5 peak amplitudes
Variance of 1 peak frequency
Variance of 2 peak frequencies
Variance of 3 peak frequencies
Variance of 4 peak frequencies
Variance of 5 peak frequencies

The data generated from VOXCOM was analyzed using the SPSS/PC+ statistical software application. Table 3 shows the standardized means (i. e. converted to z scores) for both groups, the language impaired child-mother dyads and the normal child-mother dyads representing the dependent variables.

These means were compared across each of the four independent variables, Expressiveness, Rate, Pause and Utterance-Based Productivity. A one-way analysis of variance (ANOVA) was used to compare the two groups in terms of their mean scores on each of the acoustic variables. Further manipulation of the data required the application of discriminant function analysis.

Results :

Results of the statistical anlaysis using a one-way analysis of variance (ANOVA) to compare the two groups across the four acoustic variables was not significant. Discriminant analysis of the four acoustic variables did not produce a significant deqree of separation between the two groups of mothers of language impaired versus mothers of normal children (Wilk's lambda=.81 $p<.05$). However, predictions as to category membership based on the four acoustic variables suggest trends which are noteworthy.

The discriminant procedure computes a linear composite of predictor variables that were used to classify children into either the normal or language impaired child-mother dyads. The results are presented in Table 4.

Inspection of Table 4 shows that the probability of correctly classifying a mother as speaking to a language impaired versus a normal child based on the four acoustic variables, is 84.2%. The probability of identifying a mother speaking to a normal child is 70%. The extent to which each acoustic measure contributes to the differentiation between the two groups is shown by the resulting discriminant

TABLE 3

Standardized Means

	Normal	L. D.
Expressiveness	.1897	−.0999
PRD-P	−.1018	.0536
PRD-U	.0681	−.0358
Rate	.2416	−.1271

TABLE 4

Classification Results

Actual Group	No. of Cases	Predicted Correct Gp.	Membership Incorrect
Normal	10	7	3
		70%	30%
L. D.	19	16	3
		84.2%	15.8%

coefficients for each variable, presented in Table 5.

As shown in Table 5, the variables most associated with group differernces are Rate and Expressiveness. Pause-Based Productivity and Utterance-Based Productivity contribute in that order of importance, to further differentiating the groups. Table 3 provides the mean scores on the four acoustic scales as a function of group membership for the normal child-mother dyads, and the language impaired child-mother dyads. As

TABLE 5

Discriminant Function Coefficients

PRD-P	−.21076
PRD-U	.13147
Rate	.65657
Expressiveness	.46111

TABLE 6

Z-Scores

Subject Number	Group	PRD P	PRD U	EXP	RATE
1	0	− .13	− .86	− .70	− .01
2	0	− .88	− .76	1.06	.33
3	0	− .10	− .03	− .32	.01
4	0	−1.43	.42	.48	− .68
5	0	− .93	.54	− .64	.23
6	0	1.06	− .01	.10	.70
7	0	.06	− .27	.22	.32
8	0	.82	− .56	2.05	1.98
9	0	− .98	− .92	− .54	.29
10	0	1.48	3.11	.17	− .76
1	1	− .06	− .82	− .70	.59
2	1	.83	− .12	.12	− .49
3	1	.11	− .07	.42	− .59
4	1	.39	− .33	− .38	− .94
5	1	− .06	.55	1.25	− .55
6	1	− .04	.74	− .57	− .32
7	1	.29	− .54	− .14	− .02
8	1	.44	.67	− .18	− .48
9	1	.07	− .28	.04	.06
10	1	.96	.33	.16	− .22
11	1	− .19	.77	.83	− .25
12	1	− .30	.33	− .73	− .59
13	1	− .15	.26	.15	− .24
14	1	− .23	− .53	− .59	.40
15	1	.31	− .64	− .58	.11
16		not available			
17	1	−1.67	− .63	.00	.66
18	1	.14	.59	− .51	− .55
19	1	−1.00	.07	− .55	.60
20	1	1.19	−1.04	.04	.41

TABLE 7

Discriminant Scores (**) Misclassified

Subject Number	Classified Group	Highest Group	Probability	Discriminate Score
1**	0	1	.4625	−1.0640
2	0	0	.8788	.7780
3**	0	1	.8124	− .0920
4	0	0	.6740	.2049
5	0	0	.5898	1.1646
6	0	0	.9587	.6773
7	0	0	.7998	.3720
8	0	0	.0065	3.3445
9**	0	1	.7930	− .0668
10	0	0	.7555	.9370
1	1	1	.7538	− .0156
2	1	1	.2961	−1.3740
3	1	1	.5117	− .9854
4	1	1	.0443	−2.3404
5	1	1	.6422	.1354
6	1	1	.7834	− .0543
7	1	1	.6521	− .7801
8	1	1	.8497	− .5187
9	1	1	.8878	− .1882
10	1	1	.8335	− .5394
11**	1	0	.8900	.7639
12	1	1	.6030	− .8493
13	1	1	.7584	− .0216
14	1	1	.6898	.0699
15	1	1	.6045	− .8472
16		not available		
17**	1	0	.3976	1.4715
18	1	1	.7117	− .6988
19**	1	0	.4161	1.4387
20	1	1	.5536	− .9217

shown in Table 3, mothers reading to their language impaired children evidenced a slower rate of reading than mothers of normal children, lower utterance-based productivity, higher pause-based productivity, and depressed expressiveness.

The discriminant scores were used to classify the subjects according to group membership across the four acoustic scales.

Discussion :

Acoustic characteristics of mother's speech to normal or handicapped children have not been extensively studied. When they have been the subject of inquiry, they have often been described subjectively and with respect to children younger than age three learning language. The significance of the present investigation is in applying precise instrumentation to analysis of acoustic characteristics of mother's speech to children across normal and language impaired categories after they have passed the traditional "motherese" language learning years. The results are significant in that

they document that characteristic acoustic features of mother's speech to children persist beyond the initial language learning years and that these features may be absent or less pronounced in mother's speech to language impaired children, thus helping to discriminate normal from clinically diagnosed children.

The concept of intersubjectivity as discussed by Bruner (1977), Schaffer (1977) and Trevarthen (1979) is instructive in interpreting the results of the present study. These authors suggest that mothers and their children seek to achieve a degree of shared emotional and intellectual understanding within their interactions. Intersubjectivity may be disrupted or changed by interactions in which the mother's responsiveness to the child is compromised. Solmit and Stark (1961), Emde and Brown (1978) and others have documented the presence of negative emotional maternal responsiveness to their handicapped children due to a violation of maternal expectations within the interaction. Depending on etiologic differences and severity of the disorder, a mourning process often occurs resulting in less frequent and positive mother-child interactions.

Another factor which may affect the intersubjectivity or shared intellectual and emotional understanding between mothers and their language impaired children is that mothers of handicapped children have been observed to be generally directive in their interactions. For example, Jones (1980) found that mothers of Down Syndrome children often referred to interactive sessions as teaching sessions and considered a good interaction to be one in which the children had been successfully instructed. In contrast, mothers of non-handicapped children considered a good interaction to be one in which a playful experience had been shared. MacDonald and Gillette (1988) conclude that there are considerable differences between the manner that mothers interact with language handicapped and normally developing children and that these differences are not well suited for either engaging these children in interaction or promoting their development. Specifically, adults seem to expect a delayed child not to stay engaged in a given conversation. Parents often communicate rhetorically, that is, at the child rather than for a response, suggesting that some adults may view the function of their talk as being to deposit language in the child rather than to teach the child how to use language. Decreased responsiveness and increased maternal dominance and directiveness are often the result, which may have specific cognitive outcomes for the child.

Abundant correlational research exists to suggest that maternal behavior influences young children's cognitive development (e. g. Feshbach, 1973; Schachter, 1979; White and Watts, 1973). Research linking the nature of mother-child interactions to later outcomes suggests that handicapped children are less likely to tackle difficult problems, show lower self images, and adopt a problem solving style characterized by looking to others for solutions (Zigler, 1971; Hodapp, 1988). Mahoney (1988) suggests that the interactional characteristics, including decreased parental responsiveness, he observed in mother-handicapped child dyads, appear to be related to phenomenon that affect the child's motivation to achieve competence. These phonomenon include locus of control, feelings of competence, and interest level.

Four years of age, the age of the children in the present study, is considered a crucial point in the development of the child in that expanded language and abstract reasoning skills tend to emerge at this time (Bruner, 1973). In his study with four

year olds and their mothers, Slater (1986) found that children whose mothers employed a concrete, directive, nonresponsive form of interaction, evidenced depressed scores on a standardized aptitude measure, as compared with children of mothers who employed a more responsive interaction style. Similarly, Pianta and Erickson (1990) found that mother-child interaction variables, including negative affect on the part of the mother, predicted referral for special services at 42 months and that referred children performed significantly more poorly on a standardized aptitude measure than non-referred children.

In the present study, mothers of the language impaired children showed a trend toward a slower rate of speech, lower verbal productivity, more pause time, and depressed expressiveness with their children than mothers of normal children. Based on related research, it appears that some of these characteristics may have important negative implications for developing a shared intellectual and emotional context between mothers and their language impaired children within which cognitive development is nurtured and shaped. Current understanding of prosodic features of mother's speech to children, specifically, exaggerated expressiveness relates to holding the attention of the child. Given the lack of expressiveness in mothers speaking to their language impaired children identified in the current study, implications are clear for altered attention which is the foundation for cognitive development. It appears that while mothers are slowing down the rate of their verbal presentation for their language impaired children, they may be compromising expression and hence attention and cognitive development, as well.

Given the present descriptive study, future investigations with larger subject pools and digital data collection methodology may help reduce some of the variability characterizing the present data set. Further, future studies may focus on correlating acoustic features with attentional or cognitive variables in members of communicative dyads under scrutiny. Finally, the results of the present investigation add to information used to discriminate diagnostic categories and predict subsequent cognitive characteristics.

REFERENCES

Alpert, M., Merewether, F., Homel, P., Martz, J., and Lomask, M. (1986). Voxcom: A system for analyzing natural speech in real time. *Behavior, Research Methods, Instruments and Computers,* **18** (2), 267-272.

Bates, E., and MacWhinney, B. (1979). A functionalist approach to the acquisition of grammar. In E. Ochs and B. Scheffelin (Eds.), *Developmental Pragmatics* (pp. 167-211). New York: Academic Press.

Bruner, J. (1973). *On knowing : Essay for the left hand.* New York: Antheneum.

Bruner, J. (1975). From communication to language: A psychological perspective. *Cognition,* **3**, 255-287.

Bruner, J. (1977). Early social interaction and language acquisition. In H. R. Schaffer (Ed.), *Studies in mother-infant interactions.* New York: Academic Press.

Bryan, J. H. (1981). Social behaviors of learning disabled children. In J. Gottlieb & S. Strichart (Eds.), *Developmental theory and research in learning disabilities.* Baltimore, Md.: University Park Press.

Burgemeister, B., Blum, I., & Lorge, I. (1972). Columbia mental maturity scale. New York: Harcourt, Brace, Jovanovich.

Campbell, T. & Shriberg, L. D. (1982). Associations among pragmatic functions, linguistic stress, and natural phonological process in speech-delayed children. *Journal of Speech and Hearing Research,* **25**, 547-553.

Carey, S. (1987). *Conceptual Change in Childhood.* Cambridge, Massachusetts: M. I. T. Press.

Clark, H. H. and Clark, E. V. (1977). *Psychology and language : An introduction to psycholinguistics.* New York: Harcourt, Brace, Jovanovich.

Cross, T. G. (1977). Mothers speech adjustments: The contribution of selected child-listener variables. In C. E. Snow and C. A. Ferguson (Eds.), *Talking to children : Language input and acquisition.* New York: Cambridge University Press.

Crowe, R. (1980). *Tyler toad and the thunder.* New York: Dutton.

Crystal, D. (1981). *Clinical linguistics.* New York: Springer-Verlag.

Dimitracopoulou, I. (1990). *Conversational competence and social development.* Cambridge: Cambridge University Press.

Emde, R., and Brown, C. (1978). Adaptation to the birth of a Down's Syndrome infant: Grieving and maternal attachment. *Journal of the American Academy of Child Psychiatry,* **17**, 299-323.

Feshbach, N. (1973). Cross-cultural studies of teaching styles in four-year-olds and their mothers. In A. D. Pick (Ed.), *Minnesota symposia on child psychology* (Vol. 7, pp. 86-116). Minneapolis: University of Minnesota Press.

Fitch, J. (1990). Consistency of fundamental frequency and perturbation in repeated phonations of sustained vowels, reading, and connected speech. *Journal of Speech and Hearing Disorders,* **55**, 360-363.

Garnica, O. K. (19777). Some prosodic and paralinguistic features of speech to young children. In C. Snow and C. Ferguson (Eds.), *Talking to children : Language input and acquisition* (pp. 63-88). Cambridge: Cambridge University Press.

Hodapp, R. (1988). The role of maternal emotions and perceptions in interactions with young handicapped children. In K. Marfo (Ed.), *Parent-Child interaction and developmental disabilities* (pp. 32-46). New York: Praeger.

Jones, O. (1980). Prelinguistic communication skills in Down's Syndrome and normal infants. In Y. M. Field, S. Goldberg, D. Stern, and A. Sostek (Eds.), *High-risk infants and children : Adult and peer interactions.* New York: Academic Press.

MacDonald, J., and Gillette, Y. (1988). Communicating partners: A conversational model for building parent-child relationships with handicapped children. In K. Marfo (Ed.), *Parent-Child interaction and developmental disabilities* (pp. 220-241). New York: Praeger.

Mahoney, G. (1988). Enhancing the developmental competence of handicapped infants. In K. Marfo (Ed.), *Parent-child interactions and developmental disabilities* (pp. 203-219). New York: Praeger.

Myers, J., and Bean, L. (1968). *A decade later : A followup of social class and mental illness.* New York: Wiley.

Nelson, K. (1973). Structure and strategy in learning to talk. Monographs of the society for research in child development, **38** (1-2, Serial No. 149).

Newport, E., Gleitman, A., & Gleitman, L. (1977). Mother, I'd rather do it myself: Some effects and noneffects of maternal speech style. In C. Snow & C. Ferguson (Eds.), *Talking to children : Language input and acquisition.* New Yerk: Cambridge University Press.

Owens, R. (1988). *Language development : An introduction.* Columbus, Ohio: Merrill Publishing.

Pianta, R., Erickson, M., Wagner, N., Kreutzer, T., and Egeland, B. (1990). Early Predictors of referral and special services: Child-based measures versus motherchild interaction. *School*

Psychology Review, **19** (2), 240-250.

Schachter, F. F. (1979). *Everyday mother talk to toddlers : Early intervention.* New York : Academic Press.

Schachter, F. F., and Strage, A. (1982). Adults' talk and children's language development. In S. Moore & C. Cooper (Eds.), *The young child : Reviews of research* (Vol. 3). Washington, D. C. : National Association for the Education of Children.

Schaffer, H. (Ed.). (1977). *Studies in mother-infant interaction.* New York : Academic Press.

Shute, B., & Wheldall, K. (1988). Pitch alterations in British motherese : Some preliminary acoustic data. *Journal of Child Language,* **16**, 503-512.

Slater, M. (1986). Modification of mother-child interaction processes in families with children at risk for mental retardation. *American Journal of Mental Deficiency,* **91** (3), 257-267.

Snow, C. E., and Ferguson, C. A. (1977). *Talking to children : Language input and acquisition.* Cambridge : Cambridge University Press.

Snow, C. E., Dubber, C. & De Blauw, A. (1982). Routines in mother-child interaction. In L. Feagans & D. C. Farran (Eds.), *The language of children reared in poverty : Implications for evaluation and intervention.* New York : Academic Press.

Snow, C. E. (1984). Parent-child interaction and the development of communicative ability. In R. L. Schiefelbusch and J. Pickar (Eds.), *The acquisition of communicative competence* (pp. 69-108). Baltimore : Md. : University Park Press.

Solnit, A., and Stark, M. (1961). Mourning and the birth of a defective child. *The Psychoanalytic Study of the Child,* **16**, 523-537.

Trevarthen, C. (1979). Communication and cooperation in early infancy. In M. Bullowa (Ed.), *Before speech.* Cambridge : Cambridge University Press.

Wells, G. (1981). *Learning through interaction. The study of language development.* New York : Cambridge University Press.

Wertch, J. (1985). *Vygotsky and the social formation of mind.* Cambridge : Harvard University Press.

White, B., and Watts, J. (1973). *Experience and environment* (Vol. 1). Englewood Cliffs, New Jersey : Prentice Hall.

Wingfield, A., Lombardi, L., and Sokol, S. (1984). Prosodic features and the intelligibility of accelerated speech : syntactic versus periodic segmentation. *Journal of Speech and Hearing Research,* **27**, 128-134.

Zaporozhets, A. and Elkonin, D. (1971). *The psychology of preschool children.* Cambridge, Massachusetts : M. I. T. Press.

Zigler, E. (1971). The retarded child as a whole person. In H. E. Adams and W. K. Boardman (Eds.), *Advances in Experimental Clinical Psychology.* New York : Pergamon Press.