1988

A study of the capability of the computerized Visi-Pitch when investigating prosodic features of motherese

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AN ABSTRACT OF THE THESIS OF Denise Leslie Clemens for the
Master of Science in Speech Communication: Emphasis in
Speech-Language Pathology presented October 27, 1988.

Title: A Study of the Capability of the Computerized Visi-
          Pitch When Investigating Prosodic Features of
          Motherese.

APPROVED BY MEMBER OF THE THESIS COMMITTEE:

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      With commercial availability of non-real and real-time
spectrum analyzers, the speech-language pathologist has the
means to objectively extract and measure pitch taken from
speech samples. Though both types of spectrum analyzers
provide the clinician with viable methods of measuring
fundamental frequency and frequency range values, pitch
extraction using real time allows for greater efficiency in
acoustic measurements. The Kay Elemetrics Visi-Pitch is one
such real-time spectrum analyzer that is less expensive and

more accessible than other real time speech science hardware. The purpose of this study was to investigate the capability of a computerized Visi-Pitch to reflect elevation of fundamental frequency and expansion of frequency range by female adults.

Ten mothers and ten non-mothers, between the ages of 20 and 40, were used as subjects in the study. In addition to this subject group, ten of the mother's infants between the ages of 4.0 and 8.0 months of age were used as listeners in the study. Sixty second speech samples were elicited from the female adults while they spoke to: 1) the investigator, and 2) the infant. Forty seconds of these samples were analyzed through a computerized Visi-Pitch in order to determine average fundamental frequency (pitch) and frequency range in each speaking situation.

Analysis of fundamental frequency revealed that both adult subject groups (mothers and non-mothers) elevated their pitch when addressing the child, in comparison to the adult-adult interaction. A one-tailed t-test for dependent measures was used to determine the significant difference between average fundamental frequency used by mothers when addressing the infant and the adult. The same type of t-test was used to determine differences between average fundamental frequency used by non-mothers when addressing the child and the adult. Statistical analysis revealed that

for the average of the ten mothers fundamental frequency,
pitch used when addressing the child was not significantly
higher than pitch used to the adult. The average pitch used
by mother subjects when addressing the child was elevated by
15 Hz. In terms of fundamental frequency outcomes used by
non-mothers addressing the two listeners, it was found that
non-mothers elevated their pitch by an average of 36.8 Hz, a
statistically significant difference.

A t-test for independent measures was used when
comparing mothers and non-mothers fundamental frequency when
addressing the adult listener. Statistical analysis of the
data revealed no significant difference between mothers and
non-mothers use of pitch when speaking to the adult.
Similarly, analysis of pitch levels used by mothers (228.7
Hz) and non-mothers (243.8 Hz) when addressing the infant
listener was found not to be statistically significant.

While it appeared that the computerized Visi-Pitch
allows for comparison and analysis of fundamental frequency
data, the instrument provided questionable frequency range
results. Low points of frequency range were not subjected
to statistical analysis due to spurious data points at the
low end of frequency range, which exceeded the known range
of normal adult female voices.

Results of this study revealed that the real time
computerized Visi-Pitch has the capability to demonstrate

the use of adult female pitch shifting in the same direction as other motherese studies; however, it was found that this instrument is an inadequate tool for frequency range analysis.

It was concluded that more solid evidence on the validity of frequency range outcomes needs to be disseminated by the Visi-Pitch manufacturer before this instrument can be considered of value to the researcher.

A STUDY OF THE CAPABILITY OF THE COMPUTERIZED

VISI-PITCH WHEN INVESTIGATING PROSODIC

FEATURES OF MOTHERESE

by

DENISE LESLIE CLEMENS

A thesis submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE
in
SPEECH COMMUNICATION
with emphasis in
SPEECH-LANGUAGE PATHOLOGY

Portland State University

1988

TO THE OFFICE OF GRADUATE STUDIES:

The members of the Committee approve the thesis of

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ACKNOWLEDGEMENTS

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INTRODUCTION AND STATEMENT OF PURPOSE

INTRODUCTION

Prior to the availability of commercial spectrum analyzers, the Speech-Language Pathologist lacked effective tools to quantitatively measure acoustical parameters of speech. Specifically, fundamental frequency (pitch) could only be assessed using subjective judgements. Subjective decisions were used to determine whether pitch levels were appropriate or inappropriate for: a) speaker's age and sex, b) communicative situation, and c) listener age. Following the judgement by the clinician that a deviation in the use of pitch existed, a treatment program would be initiated. Without adequate means of objectively measuring fundamental frequency and frequency range, gauging progress within a management program was difficult.

With an increase of availability of acoustic analysis systems, the Speech-Language Pathologist could make measurements of fundamental frequency and frequency range much more effectively. Spectrum analyzers have provided the clinician with means to objectively extract and measure fundamental frequency and frequency range data from speech

samples. Off-line/non-real-time spectrum analyzers and real-time spectrum analyzers have the capacity to precisely extract these two parameters from speech. Though both methods provide viable data, pitch extraction utilizing real time allows for greater efficiency in pitch measurement. The Kay Elemetrics Visi-Pitch is one such real-time analyzer that extracts and measures fundamental frequency and frequency range information from speech.

One aspect of language use that has been analyzed with reference to fundamental frequency and frequency range is the special register used to address very young children. This special register has been known by several names: "motherese," "baby talk," and "child-directed speech" (Berko-Gleason, 1973; Ferguson, 1964; Snow, 1977). Motherese research has illustrated the unique and often dramatic differences between speech directed to adults and speech directed to children. Two prosodic features of motherese that have special relevance and are consistently reported: adults shift fundamental frequency and expand frequency range when speaking to young children. Pitch shifting has long been reported in the literature across styles of speakers (Remick, 1971; Snow and Ferguson, 1977). Researchers who have studied speech directed to babies have noticed that mothers tend to use higher overall pitch levels, as well as expanded ranges when addressing children

(Berko-Gleason, 1973; Fernald and Simon, 1984; Garnica, 1974 and 1977; Remick, 1971). These features can be found across several languages, including English, Arabic, Spanish Marathi, and Latvian (Drach, 1969; Ferguson, 1964; Kelkar, 1964; Ruke-Dravina, 1977).

These paralinguistic features have been documented through the use of subjective judgement, non-real-time analysis, and real-time spectrum analyzers. The Visi-Pitch is less expensive and more assessable than other real time speech science hardware. There is a need to find appropriate clinical hardware which has a broader availability to clinicians who need to make real time judgements regarding the appropriateness of fundamental frequency and frequency range registers of speech models used in interacting with young children.

STATEMENT OF PURPOSE

The purpose of this study was to investigate the capability of a real-time computerized Visi-Pitch to reflect elevation of fundamental frequency and expansion of frequency range by female adults when speaking to infants.

This investigation will seek to answer the following questions, with regard to the outcome of computerized Visi-Pitch results:

1. Does the average fundamental frequency used by mothers when speaking to infants differ significantly from the average fundamental frequency used in adult-adult interactions?

2. Does the average fundamental frequency used by non-mothers when speaking to infants differ significantly from the average fundamental frequency used in adult-adult interactions?

3. Does the average fundamental frequency used by mothers when speaking to adults differ significantly from the average fundamental frequency used by non-mothers when speaking to adults?

4. Does the average fundamental frequency used by mothers when speaking to children differ significantly from the average fundamental frequency used by non-mothers when speaking to children?

5. Does the frequency range used by mothers when speaking to infants differ significantly from the frequency range used in adult-adult interactions?

6. Does the frequency range used by non-mothers when speaking to infants differ significantly from the frequency range used in adult-adult interactions?

7. Does the frequency range used by mothers when speaking to adults differ significantly from the frequency range used by non-mothers when speaking to adults?

8. Does the frequency range used by mothers when speaking to children differ significantly from the frequency range used by non-mothers when speaking to children?

HYPOTHESIS

Since it is well established that pitch shifting in adult speech does occur when young children are addressed, it is hypothesized that, when investigating elevation of fundamental frequency and expansion of frequency range used in child-directed speech, a real time computerized Visi-Pitch will yield similar results to those found in studies utilizing subjective judgement, non-real time, and other real time forms of analysis.

DEFINITION OF TERMS

Fundamental Frequency: The lowest frequency component of a complex tone that has the same frequency as the vocal fold's frequency of vibration (Borden and Harris, 1980).

Pitch Shift: The difference, in Hertz, between baseline pitch in adult-adult interactions and pitch data obtained during adult-child interaction.

Prelinguistic: Within an infant's first year of life when he/she is not using words to communicate intentions (Nicolosi, et al., 1983).

Range: Represents the difference, in Hertz, between the highest and lowest fundamental frequency recorded within an utterance (Stern et al., 1983).

Real Time Spectrum Analyzer: An instrument which displays an almost instantaneous changing spectrum of complex signals (Borden and Harris, 1980). One example of a real time spectrum analyzer is the Kay Elemetrics Visi-Pitch.

CHAPTER II

REVIEW OF THE LITERATURE

METHODS OF MEASURING FUNDAMENTAL FREQUENCY

In an attempt to quantify acoustic parameters of motherese, researchers have measured fundamental frequency and frequency range utilizing three types of methodology used in acoustical analysis (Table I).

Subjective Analysis

Subjective analysis of fundamental frequency does not require the use of specific apparatus or instrumentation, rather a subjective decision is made by the listener.

Blout and Padgug (1976), as well as the Sachs et al. (1976) study employed the use of subjective judgement to determine pitch levels used by adults when speaking to adult and child listeners.

Blout and Padgug (1976) directed an investigation into parental speech in English and in Spanish. Listeners included nine children (five English children ranging from .9 to 1.6 years and four Spanish children ranging from .8 to 1.1 and from 1.6 to 1.10 years. Tape recorders were sent home with parents on a weekly basis. Parents were asked to record normal verbal interactions with their child during

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TABLE I

FORMS OF ACOUSTICAL ANALYSIS

Subjective Analysis	Non-Real Time Spectrum Analysis	Real-Time Spectrum Analysis
Blout & Padgug (1976)	Jacobsen et al. (1983)	Bernstein Ratner & Pye (1984)
Sachs et al. (1976)	Remick (1971)	Stern et al. (1983)
	Garnica (1974,1977)	Warren-Leubecker & Bohannon (1984)
		Fernald & Simon (1984)

regular times of day. Examination of the parent-child
utterances led to the identification of an inventory of 34
prosodic, paralinguistic, and interactional features. Once
this inventory was established, each parental utterance was
subjectively judged for the presence or absence of specific
child-directed features. Analysis of the English sample
revealed that exaggerated intonation and high pitch were
used most often by parents when speaking to their children
(no differentiation was made regarding specific features
used by mothers and/or fathers). Spanish parents used
repetition and exaggerated intonation most often when

speaking to their children, employing higher pitch to a lesser degree.

Sachs, Brown, and Salerno (1976) subjectively investigated the speech of five adults (three female, two male) who told a story first to a 22-month-old girl and then to a female adult. Comparison of adult-adult interaction and adult-child speech revealed subjective differences in the speaker's use of pitch. A rise in fundamental frequency as well as increases in pitch changes within a variety of utterances were noted during the adult-child interactions.

Non-Real-Time Spectrum Analyzer

Non-real-time or off-line spectrum analysis involves recording a segment of speech and playing it over again to perform an acoustical analysis. These types of wave analyzers are designed to analyze and display non-stationary signals. Often the analyzer is capable of printing an acoustical representation of the speech sample (Kay Elemetrics, 1986). A sound spectrograph is one example of an off-line spectrum analyzer.

Jacobsen, Boersma, Fields, and Olson (1983) reported the use of a sound spectrograph when analyzing adult speech to children. They investigated the use of pitch in parents and non-parents addressing children between the ages of 4-8 months and 1.10-2.6 years. Sixteen male and 16 female adults, half of whom were married and had children, and half

of whom were single without children, participated in the study. Seven sentences were chosen for analysis from each of the sessions. The selected samples were processed through a Kay Elemetrics Spectrum Analyzer model no. 6061B. Fundamental frequency was measured by hand from the spectrograms using dial calipers and a 1/2 mm rule. Fundamental frequency and variability of fundamental frequency were measured for each data sample. Analysis of the data revealed, in terms of sex differences and types of variations used in speech, females increased both their mean fundamental frequency and average variability across the four stimulus conditions significantly more than males. In terms of experience with children, nonparents increased their average fundamental frequency and average variability as much as parents with extensive child rearing experience. Thus, degrees of experience and "comfort" level with children does not seem to affect the modifications of fundamental frequency in speech to children. Baseline adult-adult values were found to be: males = 123 Hz, females = 209 Hz. Fundamental frequency values increased significantly when adults were asked to imagine speaking to an infant or child (males = 133 Hz, females = 223 Hz). When an actual youngster was present, males spoke to the infant with an average of 146 Hz, and to the child with an average of 143 Hz. Females spoke to the infant with an average of

255 Hz, and used an average of 245 Hz when addressing the child. This was the first study designed to document empirically that adults, regardless of sex or parental status, increase mean and variability of their fundamental frequency when speaking to an infant or small child.

Additionally, Remick (1971) calculated median fundamental frequency of mother's speech to children by way of spectrographic analysis. Remick studied speech of ten mothers speaking to their children (ages 1.4 to 2.5 years). She calculated both median fundamental frequency and frequency range from narrow band spectrograms for a subsample of sentences for each subject. Actual fundamental frequency, frequency range, and their standard deviations were not given in the study but were expressed rather by the difference between the quartile values. Utterances were analyzed while mothers addressed: (1) an adult, and (2) their child. Her findings revealed that only the mothers of the youngest children used a higher median fundamental frequency and a greater frequency range when addressing the child. The speech of mothers whose children had already begun to acquire language tended to show a restriction in both median and fundamental frequency range more similar to that seen in adult-adult interactions.

Measurements of fundamental frequency in Garnica's studies (1974, 1977) were calculated using a non-real-time

analysis system. She directed two studies involving
children who were producing language. Her 1977 study
involved a comparison of adult (mother)-adult interaction
and the interaction of an adult (mother)-child (her own two-
or five-year-old child). Twenty-four (12 women with a child
in the 1.0 to 2.6 range and 12 women with a child in the
5.1-5.7 range) participated in the study. Analysis of data
revealed that in comparison with the speech to the adult,
speech to the two year old was characterized by a higher
average fundamental frequency, a greater frequency range,
longer duration of content words, and rising pitch terminals
within certain types of sentences. The mean fundamental
frequency when speaking to the child listener was elevated
to 267.3 Hz, as compared to the mean fundamental frequency
of 197.6 Hz used when addressing the adult listener. The
frequency range, especially at the high end was greatly
expanded, with many frequencies in the 400-600 Hz range.
Speech to five years olds was characterized by a greater
frequency range and longer duration of some content words.
Garnica's 1974 study also investigated speech to two- and
five-year-old children. In this study Garnica noted that
pitch changes at the ends of utterances were more pronounced
in speech to two year olds than to five year olds. She also
found a greater tonal range (two octaves) when mothers
addressed the two year olds, as compared to the one and one-

half octaves used when talking to an adult. The pitch of the mother subjects was found to be at a higher level than during adult-adult interactions. A fundamental frequency of 267.3 Hz was found to be used with the two year olds, while a pitch of 200 Hz was found to be used when talking to the five year olds and the adult.

Real-Time Spectrum Analyzer

Real-time analysis of speech provides the user with an on-line, almost instantaneous spectrum analysis of a speech sample. Thus, it converts a time waveform to the frequency domain (Stemple, 1984). Several prior investigations of fundamental frequency used in maternal speech have employed real time spectrum analyzers in the analysis of speech.

Bernstein Ratner and Pye (1984) analyzed fundamental frequency data through the use of a Voice Identification Inc., PM 100 microprocessor-controlled device. This instrument was designed to display intensity and pitch curves on a split-screen display. The microprocessor capacity enables the PM 100 to sum each plotted fundamental frequency value and average the values across each utterance (Bernstein Ratner and Pye, 1984; Stemple, 1984). Bernstein Ratner and Pye noted that mothers who speak the Quiche Mayan language did not use a higher pitch when speaking to their children. Quiche is a Mayan language spoken in the western highland region of Guatemala. Data for this study were

originally gathered for syntactic and morphological analysis over a nine month period in 1977. Data from three Quiche mothers were compared with data from two English speaking mothers when speaking to their children. Quiche infant listeners ranged from 1.10 to 2.6 years and English infant listeners ranged from 1.8 to 1.9 years. Results of this longitudinal study revealed that the three Quiche mothers used a lower pitch or made no pitch distinction when addressing their children as compared to adult-adult interactions. In contrast, both English mothers increased their pitch by 35-70 Hz when speaking to their children as compared with the pitch they normally used when speaking to an adult. A PM 100 frequency-intensity analyzer was used to analyze data. However, the tape recordings of the Quiche mothers used in this study were originally gathered for syntactic and morphological analysis, not for acoustic analysis. Furthermore, the naturally noisy recording conditions encountered during taping in a rural village environment (chickens, threshing machines, etc.) limited the experimenters to a smaller body of "cleaner" and clearer tapes made during the original study.

Stern, Spieker, Barnett, and MacKain (1983) reported processing maternal speech samples through the Princeton Applied Research, FFT Real-Time Spectrum Analyzer #4512. This spectrograph was equipped with a narrow band filter

which allowed for hard copy records of changes in
fundamental frequency (Stemple, 1984; Stern et al., 1983).
These authors analyzed age-related changes in the prosodic
features of speech to infants at newborn, four, 12, 25
months. Their longitudinal study investigated maternal
speech used with their own children and speech addressed to
an adult examiner. Infant listening data was taken at the
time the infant was: (1) two to six days old, (2) four
months old, (3) 12 months old, (4) 24 months old. Maternal
speech samples were transcribed and processed through a
sound spectrograph. While average fundamental frequency was
not investigated, four different pitch events were recorded:
Terminal pitch change, transitional pitch change, range, and
absolute high. A comparison between infant-directed and
adult-directed speech revealed that mothers showed more
pitch contouring with her infant than she did with an adult.
Maternal speech to infants showed a significantly greater
degree of pitch change at the ends of utterances and
between utterances. Measures of both range and absolute
high indicated a greater degree of contouring in speech to
infants. Results reveal that maternal speech to four-month-
old infants shows a greater use of certain prosodic features
than maternal speech to neonates or to 12- or 24-month-old
infants. Specifically, all measures of pitch and sound
repetition showed more extensive/exaggerated use at the four

month level. Thus, these authors concluded that motherese has been shown to be especially responsive to changes in infant maturation during the first year of life.

In addition to these two studies, Warren-Leubecker and Bohannon (1984) identified fundamental frequency and frequency range using a Unigon Model 4512 real-time spectrum analyzer. These authors attempted to identify and quantify important prosodic features of male and female speech addressing two- and five-year-old children. The speech of 16 mothers and 16 fathers (one-half of the subjects were parents of two year olds, and one-half of the subjects were parents of five year olds). Data was collected on fundamental frequency and frequency range using a Unigon Model 4512 Real time Spectrum Analyzer which was displayed on an oscilloscope. Results of the analysis revealed that when addressing two year olds, mothers as well as fathers significantly increased their modal fundamental frequency; however, fathers increased their modal voice frequency when addressing the younger listener even more than mothers did (mean increase for fathers = 45 Hz; mean increase for mothers = 26 Hz). In terms of pitch used, fathers did not differentiate between the five-year-old children and adult listeners. That is, fathers used the same pitch levels when addressing both five-year-old children and adults. Mothers, on the other hand, still showed a significant increase in

modal frequency (16.3 Hz) when speaking to the five year olds. Furthermore, mothers used a greater frequency range than fathers when speaking to adult or to the older children. In summary, this study illustrated that fathers, as well as mothers, use exaggerated intonation when speaking to two-year-old children. Mothers continue to use some exaggerated intonation for five year olds, but fathers did not use this prosodic feature.

Fernald and Simon (1984) also used a real-time analyzer in their study of maternal speech. A PDP computer coupled with a pitch extraction program was designed for their study. They examined the speech of 24 German mothers (12 with a first born child, and 12 who had another child), in three interactional situations. Interaction was recorded in conversational speech between: (1) the mother and the experimenter, (2) the mother and her three- to five-day-old infant (which she held in her arms), and (3) the mother alone during a simulated infant-directed interaction in which the mother was instructed to pretend to talk with her baby (infant absent). Tape recordings of each interactional situation were analyzed on a PDP 11/45 computer using a Pitch-Extractor program designed for this particular study. Results revealed that both the experienced and non-experienced mothers radically modify the normal tonal and temporal patterns of their speech when addressing their

three- to five-day-old baby. Findings were significant when comparing mother-child speech (mean = 227 Hz) and mother-adult speech (mean = 203 Hz). Mean fundamental frequency was found to be higher (by 55 Hz), pitch excursions were greater, utterances shorter, and pauses were longer. In the simulated mother-child interaction, mothers significantly altered the investigated prosodic features, with the exception of fundamental frequency (mean = 201 Hz). Analysis of intonational contours revealed that mothers used primarily "expanded" pitch contours when speaking to their newborn infants. That is, mothers use long, smooth, continuous pitch glides with fundamental frequency excursions averaging 13 semitones and sometimes exceeding two octaves in range. This study suggests that extensive previous experience with infants may not be a prerequisite for the occurrence of these prosodic maternal behaviors.

One real-time spectrum analyzer that does not appear to have been used in previous studies is the Kay Elemetrics Visi-Pitch which extracts and measures fundamental frequency (50-1600 Hz) in real time. Speech signals may be analyzed by the instrument which extracts cycle-to-cycle changes in frequency. The speech signal is processed through four circuits and low-pass selected filters. The Visi-Pitch has the capacity to average the number of pitch periods for the previous second of voiced speech and displayed on a LED

counter (Kay Elemetrics, 1986; Stemple, 1984). This instrument, alone or coupled with a microprocessing computer, does not appear to have been used in prior investigations of pitch shifting in maternal speech. The Visi-Pitch is a real-time spectrum analyzer that is less expensive and more accessible than other real-time analyzers.

SUMMARY

In summary, research has shown the remarkable ways adults modify various prosodic and paralinguistic features when addressing children. It has been noted that both fundamental frequency and frequency range have been consistently modified by adults when addressing infants and children (Table II).

Measurement of these prosodic variations have occurred through a variety of methods and instrumentation. Subjective analysis, non-real time, and real-time methods of data collection have been utilized in acoustical research. The Visi-Pitch is a real-time analysis instrument that has not been used previously in these studies.

TABLE II

OVERVIEW OF MOTHERESE LITERATURE

Study	Speaker	Listeners	Tested F_0 Range	Tested Frequency
Garnica (1974,1977)	Mothers	Adults 2 year olds 5 year olds	Yes	Yes
Bernstein Ratner & Pye (1984)	English & Quiche speaking Mothers	Adults 20-33 months old	Yes	No
Remick (1971)	Mothers	Adults 1.4-2.5 year olds	Yes	No
Warren-Leubeker & Bohannon	Mothers Fathers	Adults 2 year olds 5 year olds	Yes	Yes
Fernald & Simon (1984)	German speaking Mothers	Mothers 3- 5 day olds	Yes	Yes
Sachs et al. (1976)	Non-Parents	Adults 22 month olds	Yes	No
Stern et al. (1983)	Mothers	Adults 2-6 day olds 4 month olds 12 month olds 24 month olds	No	Yes
Jacobsen et al. (1983)	Mothers Non-Mothers Fathers Non-Fathers	Adults 4-8 month olds 22-30 month olds	Yes	No
Blout & Padgug (1976)	English & Spanish speaking Mothers	.9-1.1 year olds	Yes	Yes

CHAPTER III

METHODS

SUBJECTS

Subjects included ten mothers, each with a child between ages of 4.0 and 8.0 months, ten infants, and ten adult females who do not have children of their own (non-mothers) (Table III). The subjects were all from the Greater Portland Area who were recruited through ads placed in various areas (Appendix A). The names of mothers were also obtained from interested graduate students and friends. In order to participate in this study, each of the adult subjects (mothers and non-mothers) read a cover letter (Appendix B) and met the following criteria:

1. All adult subjects passed a hearing screening test for the frequencies of 1000, 2000, and 4000 Hz.

2. All adult subjects passed standard English in the home and were judged to have sex-appropriate voices.

3. All adult subjects were between the ages of 20-40 years.

TABLE III

ADULT SUBJECT INFORMATION

Subject #	Age	Parental Status	Infant Age
1	27	Non-Mother	–
2	30	Mother	4 months
3	27	Mother	4 months
4	29	Non-Mother	–
5	29	Non-Mother	–
6	32	Mother	6 months
7	40	Mother	7 months
8	40	Non-Mother	–
9	32	Mother	6 months
10	29	Non-Mother	–
11	28	Mother	5 months
12	25	Non-Mother	–
13	33	Non-Mother	–
14	35	Mother	6 months
15	29	Non-Mother	–
16	27	Mother	8 months
17	26	Mother	8 months
18	27	Non-Mother	–
19	35	Non-Mother	–
20	35	Mother	6 months

4.   All adult subjects with or without a child signed
     a permission slip (Appendix C) allowing them and
     (if appropriate) their child to participate in
     the study.

5.   All mother subjects had a child between 4.0 and
     8.0 months of age and were willing to have the
     child participate in the study.

INSTRUMENTATION

Tape recordings were made of the ten mothers and the ten non-mothers as they spoke to the examiner and then to the infant. The electronic equipment (Appendix D) was in a suitably quiet, carpeted room. The clinic room was located in the speech and hearing clinic at Portland State University. Apparatus included the Ar-tik' Model 414 tape recorder and the corresponding Ar-tik' brand microphone. The Ar-tik' tape recorder is a specially designed high fidelity reel to reel recorder that operates at a speed of 7 1/2 ips. The tape recorder was placed in a microphone stand approximately six inches from the speaker's mouth. For the interactional setting of the adult-adult session, the subject sat in a chair across from the examiner. For the adult-child interaction, the infant was placed in a stroller, while the adult subject sat facing the child.

Once the data collection had been completed, the recorded information was transferred to a Tandberg (model 9200XD) reel to reel tape recorder, as the Ar-Tik' playback was noted to have a slow "rise time" unsuitable for Visi-Pitch analysis. The Tandberg interfaced easily with the Kay Elemetrics Visi-Pitch 6087DS that was used in this study. The Visi-Pitch is an electronic instrument which measures the fundamental frequency of an input signal (e.g., the subject's voice) on a cycle-to-cycle basis. The frequency

readout displays the average fundamental frequency over the last full second of voicing. The integral display screen provides for oscillographic tracing which can be used to track frequency, amplitude, or the two together (Stemple, 1984). For the purposes of this study, the following settings were used: TRIGGER CONTROL/"Normal"; RANGE/"C"; POSITION/"Full"; FUNCTION/ "Fundamental Frequency"; TIME/"2 second." It was necessary to use a two second time frame and the "C" range in order to appropriately interface with the computer. This time frame and frequency range allows the computer to analyze a body of data greater than nine seconds. This study sampled 60 seconds of speech; however, actual data analysis occurred with the middle 40 seconds of the speech sample. Data analysis was achieved by first clearing both the Visi-Pitch and computer CRT screens of previous information. Ten seconds of taped speech were allowed to run without performing any analysis. It was necessary to monitor the last utterance of the first ten seconds of speech in order to anticipate the initiation of the middle 40 seconds of speech. The initiation of data analysis was achieved by simply depressing the Visi-Pitch microphone's on/off switch for the desired 40 seconds.

Once the selected data had been introduced into the Visi-Pitch, the IBM PC computer Interface (VP + I) model 6098 and an IBM compatible computer were used to perform

extensive acoustic analysis of the speech samples (Appendix E and F). A Leading Edge Model D, 20-megabyte hard disk computer (IBM compatible) was used in this study. The computer and the accompanying interface contained a program which had the capacity to calculate average intensity, pitch perturbation, pitch range, and other useful parameters. Three parameters, extended average fundamental frequency, maximum fundamental frequency, and minimum fundamental frequency were extracted from the statistical analysis of the speech sample. The extended average fundamental frequency and frequency range for each of the forty speech samples were displayed on the computer screen and logged. All numerical data were rounded to the nearest whole in order to simplify further statistical analysis (e.g., 212.8 Hz rounded to 213 Hz).

For the purpose of this study, the IBM compatible computer was programmed with the following settings: TIME SELECTION/"9 Seconds"; FORMAT SELECTION/"Pitch and Intensity, Stationary Display"; FREQUENCY SELECTION/ "0-400 Hz." The nine second program was selected to obtain an extended average fundamental frequency and frequency range over the forty second duration of the samples. Initiation of analysis was accomplished by depressing the Visi-Pitch microphone's on/off switch for the amount of time desired

for data analysis (40 seconds) after elapsed time of ten seconds.

PROCEDURES

All adult subjects took part in two interactional sessions. Tape recordings were made of the adults as they spoke to the adult interviewer and the infant. The adult interviewer in all cases was the investigator. All subjects spoke first to the investigator then to the child. Both testing sessions took place in a Portland State University clinic room. During the adult-adult session, only the mother (or non-mother) and the experimenter were present in the testing room. For the adult-child session, the mother (or non-mother), the child and the experimenter were present in the testing clinic room. During the few minutes the mother or non-mother were in the first testing room with the examiner, the child remained in the second room with a graduate student or another mother who attended to the child.

Verbal Task

Subjects were told that the purpose of the study was "to look at the ways adults interact with infants." All subjects were told that they will be asked to talk briefly with the investigator and then to a child. During the adult-adult interaction, subjects were told: "I would like

you to talk for about one minute about this plastic ball.
You can tell me anything about the color, the shape, the
size, or any other thing it brings to mind. Please continue
describing the object until I tell you to stop" (Appendix
G). Immediately following the adult-adult session, the
subjects were asked to perform the same task (i.e.,
describing the object) while addressing the child.

Speech Sample

A one minute sample of each subject's spontaneous
speech was recorded and collected for data analysis. For
data analysis of the adult-adult and adult-child speech
samples, the first and last ten seconds of the 60 second
speech sample were omitted, based upon the assumption that
the middle portion would be the more representative. This
left the middle 40 seconds to be extracted for further
acoustical data analysis.

RELIABILITY AND VALIDITY

Reliability

In order to assess interjudge reliability, 16 of the
40 speech samples were randomly selected for replication.
Eight samples were taken randomly from the mother's speech
samples (four samples taken from mother-child interactions
and four samples taken from mother-adult interactions). In
addition, eight samples were taken randomly from the non-

mother speech samples (four samples taken from mother-child interactions and four samples taken from non-mother-adult interactions). Technician's run-rerun reliability was accomplished by a graduate student who was unfamiliar with earlier recordings. Instructions were given on entering the 16 speech samples into the Visi-Pitch/computer via tape recorder. Specifically, the graduate student was instructed on how to start the Visi-Pitch for the selected 40 seconds of speech data. It was necessary for the technician to begin and end each speech sample at a previously chosen point, so as to eliminate the first and last ten seconds of recorded speech.

Analysis of interjudge reliability revealed that for three of the 16 speech samples chosen for reliability analysis, agreement of fundamental frequency values between technician and investigator was 100 percent. In the other 13 cases, agreement differed by 1-3 Hz (See Table IV).

A pilot study investigating interjudge reliability levels was performed earlier in the project, with extended average fundamental frequency found to differ by $\pm$ 5 Hz.

To determine intrajudge reliability, the examiner performed the same data analysis procedure on four of the 20 speech samples (two randomly selected samples from adult-adult interactions and two from the adult-child

TABLE IV

SCORESHEET FOR INVESTIGATOR AND TECHNICIAN
INTERJUDGE RELIABILITY

Listener	Subject #	Parental Status	Addressing Adult (Hz)	Addressing Infant (Hz)
Investigator	1	Non-Mother		227
Technician				224
Investigator	2	Mother		229
Technician				228
Investigator	3	Mother	175	
Technician			177	
Investigator	4	Non-Mother		207
Technician				204
Investigator	5	Non-Mother	247	
Technician			250	
Investigator	5	Non-Mother		256
Technician				253
Investigator	6	Mother	203	
Technician			200	
Investigator	7	Mother		262
Technician				264
Investigator	8	Non-Mother	181	
Technician			179	
Investigator	9	Mother		207
Technician				204
Investigator	10	Non-Mother		300
Technician				301
Investigator	11	Mother	310	
Technician			310	
Investigator	12	Non-Mother	224	
Technician			225	
Investigator	16	Mother	215	
Technician			215	
Investigator	18	Non-Mother	224	
Technician			225	

interactions). The investigator used the same procedures in entering recorded data into the Visi-Pitch as were used with interjudge measurements. Investigator intrajudge reliability revealed a 1-2 Hz difference between the two readings of the selected samples (See Table V). Technician intrajudge reliability revealed a 1-3 Hz difference between the two readings of the selected speech samples (See Table VI). A pilot study investigating intrajudge reliability levels was done early in the project, with extended average fundamental frequency found to differ by $\pm$ 3 Hz.

Validity

Since the study appears to be the first of its kind to use the real time analysis system of the computerized Visi-Pitch, a validity test on the instrument was performed, comparing the results with data obtained from a non-real time Kay Elemetrics Spectrum Analyzer (Digital Sona-Graph, 7800). To determine validity, the investigator extracted three randomly selected utterances within the large body of data. All the three selected utterances were between 3-5 seconds in length. The utterances were run first through the Visi-Pitch/computer system and then the Digital Sona-Graph. While the computerized Visi-Pitch allows for a real time analysis of speech, the Digital Sona-Graph utilizes the more traditional method of hand counting striations displayed on a sonagram. Striations are actually lines

TABLE V

SCORESHEET FOR INVESTIGATOR INTRAJUDGE RELIABILITY

Subject #	Subject Status	Addressing Adult (Hz)	Addressing Child (Hz)
1	Non-Mother		227 229
2	Mother		229 231
5	Non-Mother	247 245	
11	Mother	310 311	

TABLE VI

SCORESHEET FOR TECHNICIAN INTRAJUDGE RELIABILITY

Subject #	Subject Status	Addressing Adult (Hz)	Addressing Child (Hz)
1	Non-Mother		226 227
2	Mother		228 230
5	Non-Mother	250 247	
11	Mother	310 309	

resolved into their frequency components (Kay Elemetric, 1986). In order to obtain accurate fundamental frequency data on a speech sample, striations need to be clear and countable (with the aid of a magnifying glass). Upon completion of sonagrams, it was found that two of the three displays could not be hand counted. This was due to the poor clarity of the graphic display. Validity judges were unable to count the striations and perform necessary calculation. Therefore, they were unable to calculate a fundamental frequency for those utterances. Only one of the three proved clear enough to count striations. Using the Visi-Pitch, average fundamental frequency for the utterance was found to be 194 Hz. When using the Sona-Graph, the four validity judges hand counting striations and calculated fundamental frequency to be: 193 Hz, 195 Hz, 189 Hz and 186 Hz, respectively. Half of these sonagraphic results were found to be within 2 Hz of the Visi-Pitch results.

STATISTICAL ANALYSIS

Data analysis included a comparison between mothers and non-mothers use of average fundamental frequency and frequency range both when speaking to an adult and when speaking to an infant. To determine the significant difference between average fundamental frequency used by mothers when addressing the infant and when addressing the

adult, a one-tailed t-test was used for dependent measures. This same type of t-test was used to determine the significant difference between average fundamental frequency used by non-mothers when addressing the infant and the adult. A one-tailed t-test for independent measures was chosen: (a) to determine the significant difference between mothers fundamental frequency and non-mothers fundamental frequency when addressing an adult and (b) to determine the significant difference between mothers fundamental frequency and non-mothers fundamental frequency when addressing the infant.

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS

This study was conducted to determine the capability of a real time computerized Visi-Pitch to reflect elevation of fundamental frequency and expansion of frequency range by female adults when addressing infants.

The first question asked in this study was: Does the average fundamental frequency used by mothers when speaking to infants differ significantly from the average fundamental frequency used in adult-adult interactions? Results of this study revealed that average pitch for the ten mothers when addressing adults was 213.7 Hz. The average pitch used by the mothers when speaking to the infant was 228.7 Hz. Seventy percent of the mothers used a higher pitch when addressing the child as compared to when they spoke to the adult. It was predicted that mothers would use a higher pitch when addressing the child. This prediction was based on findings by Bernstein Ratner and Pye (1984); Garnica (1974 and 1977); Remick (1971); and Stern et al. (1983). In order to test this prediction, a one-tailed t-test was performed. A t-test for dependent measures showed that for

the average of the ten mother's fundamental frequency, pitch used when addressing the child was not significantly higher (t = .67, df = 9, (NS)) than pitch used to the adult. It must be noted that although this elevation in pitch did not reach conventional levels of significance, average pitch used when addressing infants was elevated by 15 Hz. The results are presented in Table VII and Figure 1.

The second question was: Does the average fundamental frequency used by non-mothers when speaking to infants differ significantly from the average fundamental frequency used in adult-adult interactions? A comparison was made between non-mothers speech to adults versus speech to infants, similar to the Jacobsen et al. (1983) study. The difference between pitch used in the two test situations was quite large (mean = 207 Hz when speaking to adults; mean = 243.8 Hz when speaking to infants). The difference in average pitch used during the two listener sessions (36.8 Hz) was found to be significant (t = 3.18, df = 9, p = ≤.01, one-tailed). The results are presented in Table VIII and Figure 2.

The third question asked was: Does the average fundamental frequency used by mothers when speaking to adults differ significantly from the average fundamental frequency used by non-mothers when speaking to adults? A t-test for independent measures revealed no statistically

TABLE VII

COMPARISON OF MOTHERS FUNDAMENTAL FREQUENCY
WHEN ADDRESSING ADULTS VERSUS CHILDREN

	Mean (Hz)	S.D.	Differences of Means (Hz)	t	p
Adult	213.7	37.33			
			15	0.67	0.60
Infant	228.7	40.56			

TABLE VIII

COMPARISON OF NON-MOTHERS FUNDAMENTAL FREQUENCY
WHEN ADDRESSING ADULTS VERSUS CHILDREN

	Mean (Hz)	S.D.	Differences of Means (Hz)	t	p
Adult	207	22.90			
			36.8	3.18	.01
Infant	243.8	26.89			

325 300 275 250 225 200 175 150

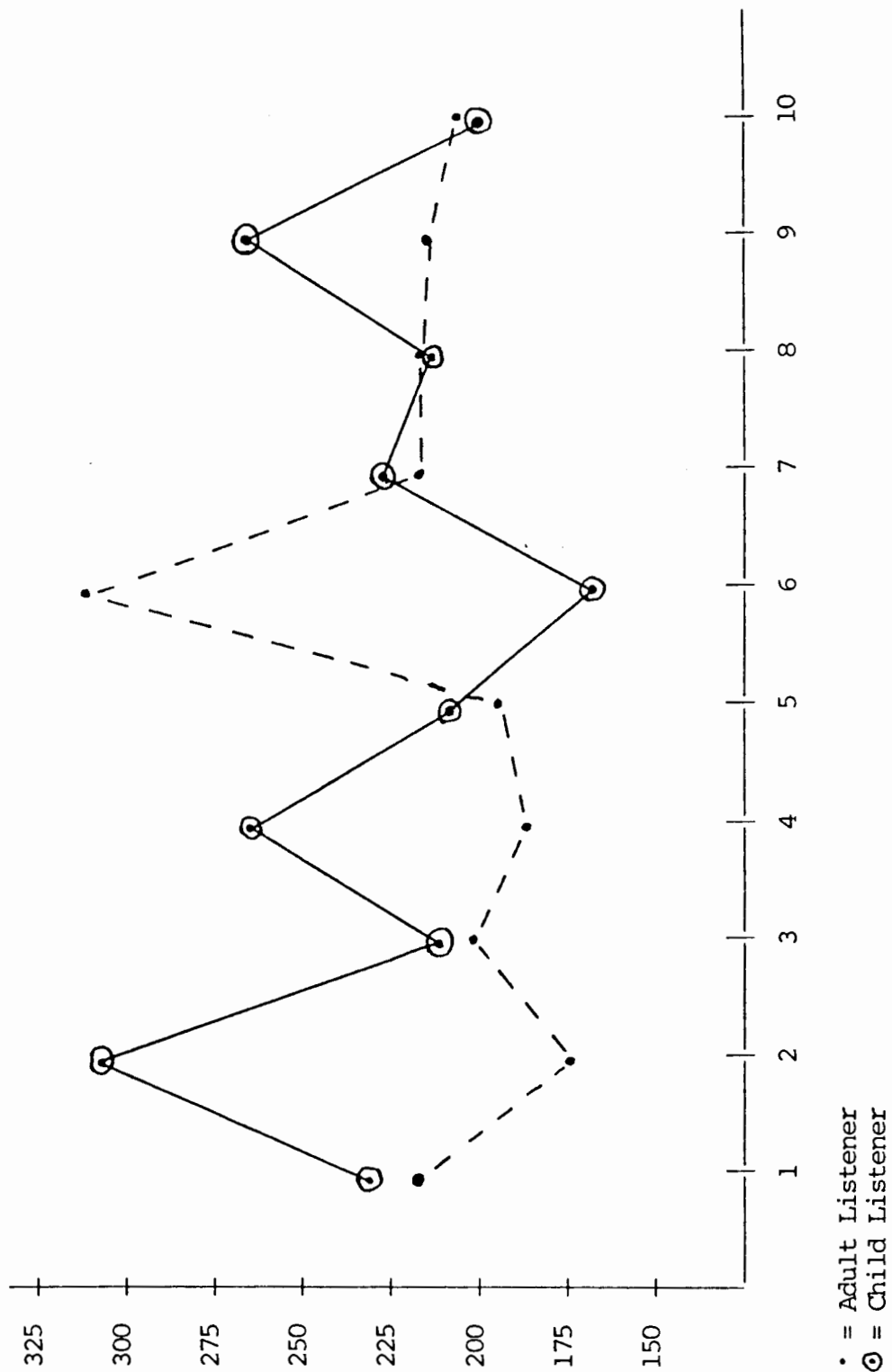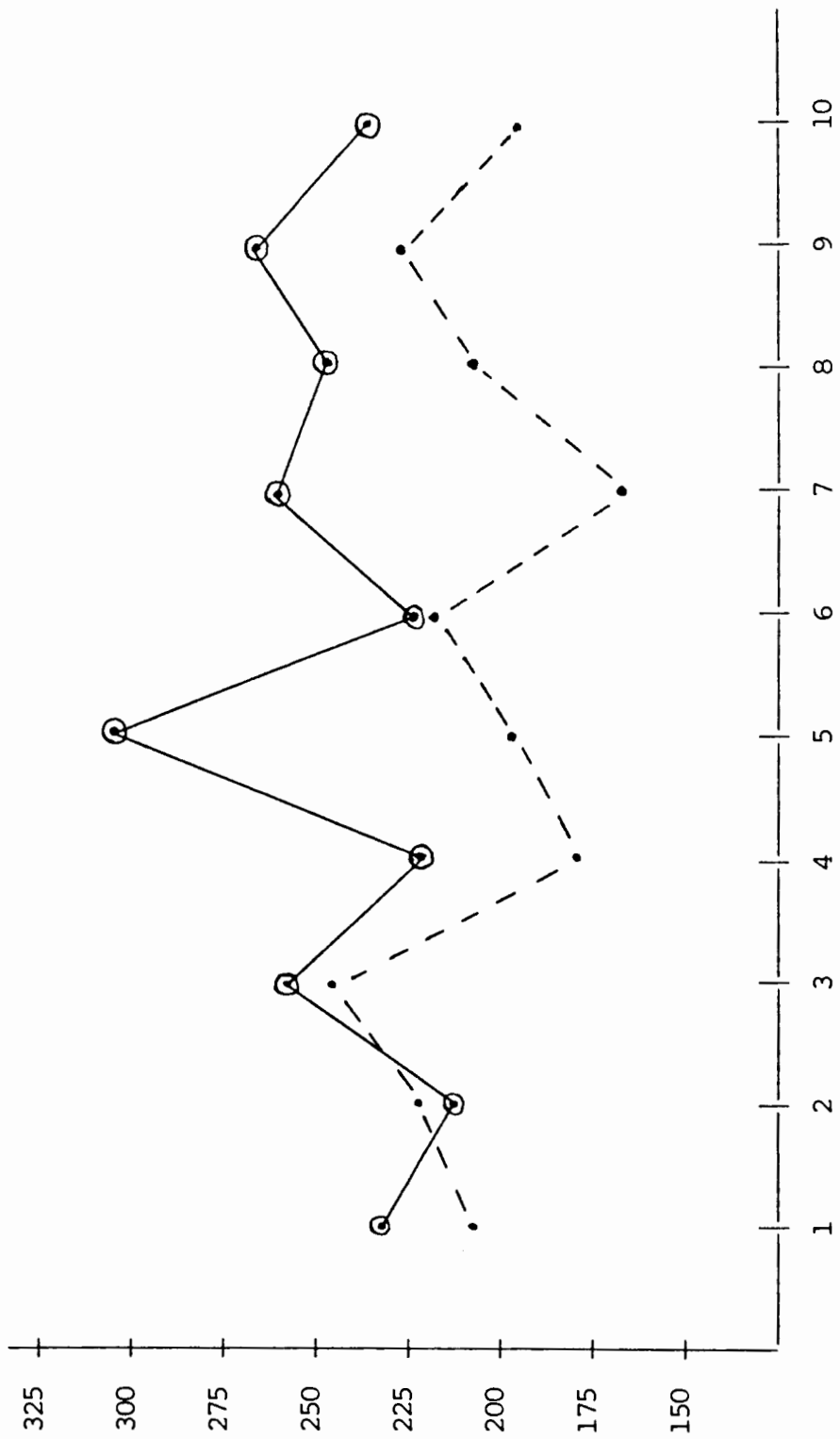• = Adult Listener
⊙ = Child Listener

Figure 1. Mean fundamental frequency for mothers addressing two listener types.

• = Adult Listener
⊙ = Child Listener

Figure 2. Mean fundamental frequency for non-mothers addressing two listener types.

significant difference between mothers and non-mothers addressing the adult listener (t = .48, df = 18, NS). It appeared that mothers (213.7 Hz) used a non-significantly higher mean fundamental frequency than non-mothers (207 Hz), when addressing the adult, reflecting a 6.7 Hz difference (refer to Table IX).

The fourth question asked was: Does the average fundamental frequency used by mothers when speaking to children differ significantly from the average fundamental frequency used by non-mothers when speaking to children? A comparison was made of average pitch mothers use when speaking to the infant (mean pitch = 228.7 Hz) and non-mothers use when addressing the infant (mean pitch = 243.8 Hz). A t-test for independent measures revealed that this 15 Hz difference was not statistically significant (t = .98, df = 18, NS) (see Table X).

The above four questions dealt with fundamental frequency. The four questions pertaining to frequency range were not subjected to statistical analysis due to the fact that spurious data points indicating frequencies exceeding the known possible range of adult female voices. This was verified by independent analysis of frequency range raw data by the product specialist for Kay Elemetrics.

TABLE IX

COMPARISON OF MOTHER AND NON-MOTHERS FUNDAMENTAL
FREQUENCY WHEN ADDRESSING ADULTS

	Mean (Hz)	S.D.	Differences of Means (Hz)	t	p
Mother	213.7	37.33	6.7	.48	.70
Non-Mother	207	22.90			

TABLE X

COMPARISON OF MOTHERS AND NON-MOTHERS FUNDAMENTAL
FREQUENCY WHEN ADDRESSING CHILDREN

	Mean (Hz)	S.D.	Differences of Means (Hz)	t	p
Mother	228.7	40.56	15 Hz	.98	.40
Non-Mother	243.8	26.89			

DISCUSSION

The present study was designed to investigate empirically the capability of the computerized Visi-Pitch to reflect elevation in fundamental frequency and expansion in frequency range in adult females. It was hypothesized that, when investigating these two acoustical features of motherese, a real time computerized Visi-Pitch would yield results similar to those studies utilizing subjective judgement, non-real time, and other real time forms of analysis. Results of this study did not support the hypothesis.

Questions raised earlier in this project regarding mothers and non-mothers use of frequency range could not be statistically answered due to questionable face validity for this acoustic parameter. Frequency range values computered by the Visi-Pitch appeared to be in question when analyzing low frequency points in the speech samples. This author began to question data obtained for the low points of the frequency range data points as early as the pilot study. Numerous inquires were made to the Visi-Pitch manufacturer regarding frequency range data. Despite continued communication and assurance from the product specialist, problems persisted with regard to outcomes for the low end of the frequency range. Finally, after the study's data were gathered, the product specialist for Kay Elemetrics

substantiated these data by agreeing that all ten samples submitted for analysis contained spurious or questionably spurious low frequency points and were noted to be "too low for a female" (Paul Arcell, personal letter, May 10, 1988). In addition, the product specialist performed an analysis of female speech and reported similar "garbage data" (Paul Arcell, personal letter, May 10, 1988). By approved procedures, he obtained frequency range data outside the female range. He further pointed out that obtaining accurate frequency range values can be tricky as "...even one low pulse will contaminate the data" (Paul Arcell, personal letter, May 10, 1988). The solution offered for the dilemma was to manually scan the data and use the cursor to work around values or data points that were suspected of being incorrect. In effect, after the fact, he recommended that one subjectively determine when data points seemed to be outside the limits of a female's voice. Thus, he concluded, if one were to manually eliminate the spurious data points it would increase the reliability levels. In short, the equipment does not do what its manufacturer purported that it would do. Thus, frequency range values could not be compared to other acoustical research studies.

When examining fundamental frequency data analyzed by the computerized Visi-Pitch, it was found that pitch shifting by mothers and non-mothers did occur in the same

direction as in other studies (Fernald and Simon, 1984; Garnica, 1974 and 1977; Jacobsen et al., 1983; and Warren-Leubecker and Bohannon, 1984) but was not as pronounced (see Table 11). The average pitch used by all mother subjects when addressing the child was raised by an average of 15 Hz as compared to the adult-adult interaction. Non-mothers were found to raise their pitch when speaking to the child by an average of 36.8 Hz. This study illustrated that the Visi-Pitch provided pitch data that reflected pitch shifting in the same direction as in other motherese studies; however, these findings should be interpreted conservatively. Possible design flaws may have influenced this investigator's results.

One design flaw may have been the inclusion of a mother whose voice, under testing situations, was not representative of the larger population of mothers. Analysis of this subject's voice revealed a pitch of 165 Hz used when addressing the child. A fundamental frequency this low could not be considered sex-appropriate (a criterion for inclusion in the study). Additionally, this subject used a rather pronounced increase in pitch (311 Hz) during the adult-adult interaction (see Table XI, Subject #11). It appeared that this woman's voice represented more than just pitch shifting. Contamination of the data could have occurred due to the presence of ambient noise (e.g.,

TABLE XI

FUNDAMENTAL FREQUENCY USED BY ADULT FEMALES IN TWO LISTENER SITUATIONS

Subject #	Parental Status	F_0 Used by Subjects When Speaking to Adult (Hz)	F_0 Used by Subjects When Speaking to Child (Hz)
1	Non-Mother	205	229
2	Mother	220	232
3	Mother	175	307
4	Non-Mother	223	210
5	Non-Mother	246	253
6	Mother	201	209
7	Mother	186	263
8	Non-Mother	179	222
9	Mother	191	206
10	Non-Mother	199	301
11	Mother	311	165
12	Non-Mother	221	222
13	Non-Mother	169	260
14	Mother	217	226
15	Non-Mother	204	246
16	Mother	216	215
17	Mother	215	266
18	Non-Mother	226	264
19	Non-Mother	198	231
20	Mother	205	198

subject laughter). The subject used frequent high pitched giggling when she spoke to the investigator. Since the Visi-Pitch averages out all voiced stimuli between 50 and 1600 Hz for each second of voicing, it appeared these vocal insertions were also averaged, thus yielding pitch outcomes that represented more than maternal pitch shifting. In

light of these finding it can be argued that a 40 second
speech sample allows for greater possibility of
contamination of the actual speech data. It appeared that
the computerized Visi-Pitch was often unable to distinguish
speech from other noises (e.g. laughter, coughing,
whispers, etc.), thus, inappropriately extending pitch
levels. By using a 40 second sample, this investigator was
unable to provide for a greater control over the data used
in the acoustical data analysis.

In addition to the inappropriate mother subject, it
was noted that three additional subjects (one non-mother and
two mothers) used their habitual pitch or actually lowered
their pitch when addressing the child. It was apparent that
these subjects did not follow expected pitch shifting.
Findings similar to this investigation may have been found
in other motherese studies; however, due to small sample
size utilized in this study, outcomes were altered more.
Sample size, no doubt, significantly altered the outcome of
this study as reflected by a large standard deviation noted
in the mother subject group (Table VII, p. 36).

The findings that mothers and non-mothers pitch levels
did not differ significantly from one another while they
spoke to both listeners is consistent with the literature
(Jacobsen et al., 1983; Snow and Ferguson, 1977). If pitch
shifting is universal, pitch shifting should occur in the

same direction and with similar magnitude for both mother
and non-mother speakers, with allowances made for individual
vocal fold variation of mass, size, and elasticity (Borden
and Harris, 1980). While both mothers and non-mothers
exhibited pitch shifting in the same direction as in the
literature, it was surprising to find that non-mothers used
greater elevation in pitch than mothers when addressing the
child listener. It was found that four of the ten mothers
elevated their pitch with the magnitude as in other
motherese studies (Fernald and Simon, 1984); Garnica, 1974
and 1977; Warren-Leubecker and Bohannon, 1984). The
remaining four mothers that exhibited pitch shifting raised
their fundamental frequency by 8-15 Hz when addressing the
child. Several variables could be attributed to this lack
of significant elevation: use of a 40 second speech sample,
presence of ambient noise, questionable validity of the
apparatus, or the presence of vocal behavior in addition to
pitch elevation may have reduced the "strength" of the
outcomes.

Several of these variables could have been eliminated
by reducing length of speech samples while providing for
repeated measures of pitch using real words and phrases,
similar to the Garnica (1974) study. Even after controlling
for the above variables, the question still remains in
regard to letting the Visi-Pitch run for the full 40

seconds. This is noted, after the fact, to be a design flaw of the study.

Finally, from this study some serious questions were regarding the appropriateness of the computerized Visi-Pitch to extract frequency range data arose. As for fundamental frequency, the equipment does seem to have the capability to follow appropriate trends similar to existing research; however, due to possible design flaws, coupled with the small sample size, it was difficult to draw strong conclusions about the machine's ability to represent fundamental frequency in running speech.

CHAPTER V

SUMMARY AND IMPLICATIONS

SUMMARY

With commercial availability of non-real and real-time
spectrum analyzers, the speech-language pathologist has the
means to objectively extract and measure pitch taken from
speech samples. Though both types of spectrum analyzers
provide the clinician with viable methods of measuring
fundamental frequency and frequency range values, pitch
extraction using real time allows for greater efficiency in
acoustic measurements. The Kay Elemetrics Visi-Pitch is one
such real-time spectrum analyzer that is less expensive and
more accessible than other real time speech science
hardware. The purpose of this study was to investigate the
capability of a computerized Visi-Pitch to reflect elevation
of fundamental frequency and expansion of frequency range by
female adults.

Ten mothers and ten non-mothers, between the ages of
20 and 40, were used as subjects in the study. In addition
to this subject group, ten of the mother's infants between
the ages of 4.0 and 8.0 months of age were used as listeners
in the study. Sixty second speech samples were elicited

from the female adults while they spoke to: 1) the investigator, and 2) the infant. Forty seconds of these samples were analyzed through a computerized Visi-Pitch in order to determine average fundamental frequency (pitch) and frequency range in each speaking situation.

Analysis of fundamental frequency revealed that both adult subject groups (mothers and non-mothers) elevated their pitch when addressing the child, in comparison to the adult-adult interaction. A one-tailed t-test for dependent measures was used to determine the significant difference between average fundamental frequency used by mothers when addressing the infant and the adult. The same type of t-test was used to determine differences between average fundamental frequency used by non-mothers when addressing the child and the adult. Statistical analysis revealed that for the average of the ten mothers fundamental frequency, pitch used when addressing the child was not significantly higher than pitch used to the adult. The average pitch used by mother subjects when addressing the child was elevated by 15 Hz. In terms of fundamental frequency outcomes used by non-mothers addressing the two listeners, it was found that non-mothers elevated their pitch by an average of 36.8 Hz, a statistically significant difference.

A t-test for independent measures was used when comparing mothers and non-mothers fundamental frequency when

addressing the adult listener. Statistical analysis of the data revealed no significant difference between mothers and non-mothers use of pitch when speaking to the adult. Similarly, analysis of pitch levels used by mothers (228.7 Hz) and non-mothers (243.8 Hz) when addressing the infant listener was found not to be statistically significant.

While it appeared that the computerized Visi-Pitch allows for comparison and analysis of fundamental frequency data, the instrument provided questionable frequency range results. Low points of frequency range were not subjected to statistical analysis due to spurious data points at the low end of frequency range, which exceeded the known range of normal adult female voices.

Results of this study revealed that the real time computerized Visi-Pitch has the capability to demonstrate the use of adult female pitch shifting in the same direction as other motherese studies; however, it was found that this instrument is an inadequate tool for frequency range analysis.

It was concluded that more solid evidence on the validity of frequency range outcomes needs to be disseminated by the Visi-Pitch manufacturer before this instrument can be considered of value to the researcher.

IMPLICATIONS

Based on the outcomes of this study, the following suggestions are offered for future investigations: 1) establish validity for low point of frequency range values when using the Visi-Pitch to investigate frequency range; 2) reduce speech sample length; 3) increase the number of subjects per group; and 4) reduce subject awareness of the testing situation.

As questions were raised on the capability of the computerized Visi-Pitch to reflect frequency range, it is imperative that Kay Elemetrics re-evaluate the validity of the equipment to measure low points of frequency range data. If the manufacturer's assessment of the machine yields results consistent with this author's results, the question can be raised: Can the computerized Visi-Pitch be modified in order to more accurately analyze frequency range? Until this question can be fully addressed by the manufacturer, future acoustical researchers should seek other forms of real time spectrum analysis system or non-real time systems.

Reducing the length of the speech samples is suggested for future research in order to allow for greater control over input of data into the spectrum analyzer. Analyzing a smaller segment of speech (less than 40 seconds) may possibly reduce the chance of ambient noise contaminating

the data and thus, inappropriately extending pitch levels due to inappropriate data points.

In conjunction with reducing the number of seconds of speech used in the analysis, increasing the number of subjects used per group would provide for better design of future studies. Due to small sample size, the results of this study were often difficult to interpret and generalize to the adult female population. Future endeavors would find interpretation easier if a larger group of mothers and non-mothers were used as subjects.

Finally, subject awareness of the recording of speech may have affected some subject's ability to communicate naturally with both investigator and child. Future investigators may find that minimizing the presence of the investigator and the audio taping equipment while taping speech will reduce feelings of anxiety in subjects. Awareness of testing may be reduced by involving the subject in a task such as reading several sentences, similar to the Jacobsen et al. study (1983). Additionally, the use of a one-way mirror coupled with an inobtrusive microphone may create an environment conducive to more natural interaction.

In conclusion, the questions raised as a result of this study create a need for Kay Elemetrics to re-evaluate the capabilities of the Visi-Pitch to accurately analyze frequency range data. Additionally, suggestions are offered

to future researchers in order to reduce design variables that may have influenced the results of this study.

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APPENDIX A

PUBLIC NOTICE

ATTENTION MOTHERS

I am seeking mothers (ages 20 to 40 years old) with an infant (four to eight months) who would be willing to contribute ten minutes of their time to advance science.

I am doing a study of how adults communicate with pre-language infants. You will be expected to talk to an investigator and then to your child for about one minute each. If interested please contact me at the speech and hearing clinic, PSU (464-3533) or home (224-9224).

Thank you,

Denise Clemens
Graduate Student

APPENDIX B

COVER LETTER

Dear Subjects:

I am a graduate student at Portland State University conducting a study investigating the ways adults interact with young children. I am investigating the ways mothers and non-mothers (ages 20 to 40 years) talk to infants in the 4.0 to 8.0 age range.

This study will be accomplished by a two minute audiotaped conversation talking to me and the to a/your child. The tape recording will be done at Portland State University at a time mutually convenient for you and the department. Names will not be used in reporting the results and the audiotapes will only be available to authorized University personnel. Any participant may be excused from participation from this study at any time without penalty. Prior to the tape recorded sessions, you will be given a brief hearing screening test.

I you experience problems that are the result of your participation or potential participation in this study, please contact Robert Tinnin, Office of Graduate Studies and Research, 105 Neuberger Hall, Portland State University, 464-3423.

Please complete the information on the attached sheet, indicating your approval and willingness for you or your family to participate in this study, and return this form to me immediately in the envelope provided. It is important that I schedule the taping session as soon as possible. Please call me at 224-9224 (home) or 464-3533 (PSU) if you have any questions. I appreciate your cooperation.

Sincerely,

Denise Clemens
Graduate Student

APPENDIX C

CONSENT LETTER

SUBJECT'S NAME:

BIRTHDATE: AGE:

ADDRESS:

TELEPHONE:

1.   Do you have any children between the ages of 4.0 and
     8.0 months? (If yes, complete question #2.)

2.   CHILD'S NAME:

     BIRTHDATE: AGE:

     I understand that this research project will
investigate the ways adults talk to young children. This
study will be conducted by Denise Clemens under the
supervision of Dr. Robert Casteel.

     I understand that the study involves me speaking to an
investigator and then to a/your child for about one minute
each. I understand that each conversation will be tape
recorded. My child will listen to me and listen to another
adult talk for the allotted time.

     It has been explained to me that the purpose of the
study is to learn more about how adults talk to children who
have not yet learned language.

     Ms. Denise Clemens and Dr. R. Casteel have offered to
answer any questions I may have about the study and what is
expected of me in the study. I have been assured that all
information I give will be kept confidential and that the
identity of all subjects will remain anonymous.

     I understand that I am free to withdraw from
participation in this study at any time without jeopardizing
my course grade or my relationship with Portland State
University.

     I have read and understand the foregoing information.
I hereby agree to serve as a subject and (if applicable)
give my permission for my child to participate in the study.

_____   _____
SIGNATURE   DATE

APPENDIX D

INSTRUMENTATION TECHNICAL DATA

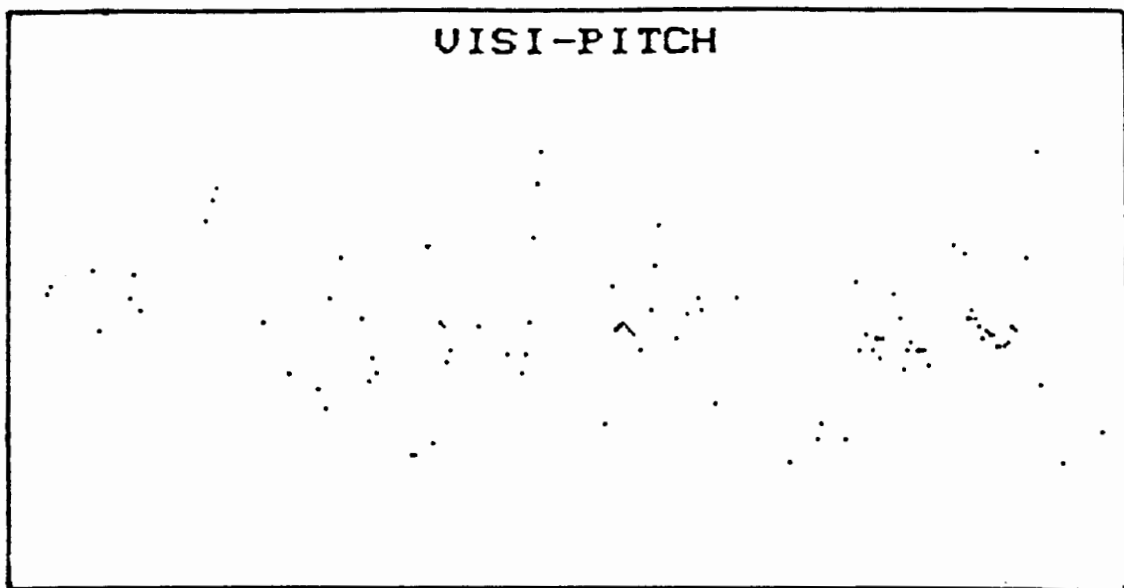TAPE RECORDERS: Ar-Tik' Model 414

                  Tandberg Series 9200XD

MICROPHONE: Ar-Tik' Brand Microphone

SPECTRUM ANALYZERS: Real Time
                  Kay-Elementrics Visi-Pitch Model 6087DS

                  Non-Real Time
                  Kay-Elementrics Digital Sona-Graph Model 7800

APPENDIX E

SAMPLE COMPUTERIZED VISI-PITCH DISPLAY

VISI-PITCH

TRIGGER Normal/Continuous
ERASE Normal/Overwrite
SCREEN Lower/Upper/FULL
CURSOR Left/Right/Horz

APPENDIX F

SAMPLE COMPUTERIZED VISI-PITCH READOUT

```
    STATISTICS.   COL 1 COL 2 CHANGE
----------------------------------------
Time Bet. Cursors  -----:-----:-----  S
                        :     :
Average FO        203.0:-----:-----  HZ
Extended Avg. FO  200.7:-----:-----  HZ
Std. Deviation FO  61.7:-----:-----  HZ
Average DB        -----:-----:-----  DB
Std. Deviation DB -----:-----:-----  DB
                        :     :
Perturbation      1.298:-----:-----  Z
                        :     :
Maximum FO        615.4:-----:-----  HZ
Minimum FO         88.0:-----:-----  HZ
FO Range          527.4:-----:-----  HZ
                        :     :
FO at Left Cursor  -----:-----:-----  HZ
FO at Right Crsr.  -----:-----:-----  HZ
DB at Left Cursor  -----:-----:-----  DB
DB at Right Crsr.  -----:-----:-----  DB
              Col 1 = Current
              Col 2 =
Next Set of Statistics will be in Col 1
(Spacebar) For Page 2        For Column
(P) To Print Screen <  For Main Options
```

APPENDIX G

VERBAL INSTRUCTIONS TO SUBJECTS

"I would like you to talk for one minute about this plastic ball. You can tell me anything about the color, the shape, the size, or any other thing that it brings to mind. Please continue describing the object until I tell you to stop."