COMPARISON OF THE DIFFERENCES IN TONE SANDHI AMONG SLOW SPEECH, NORMAL SPEECH AND FAST SPEECH IN MANDARIN CHINESE

A Thesis

presented in partial fulfillment of the requirements
for the degree of
Master of Art

BY

Hwei-Bing Lin, B.A.
The Ohio State University
1982

Approved by

Reading Committee:
Rob A. Fox
Brian Joseph
Mike Geis

Advisor
Department of Linguistics

I hereby declare that I am the sole author of this thesis.

I authorize the Ohio State University to lend this thesis to other institutions or individuals for the purpose of scholarly research.

Hwei-Bing Lin

I further authorize the Ohio State University to reproduce this thesis by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

Hwei-Bing Lin

The Ohio State University requires the signatures of all persons using or photocopying this thesis. Please sign below, and give address and date.

Patrick Lucas, University of Oregon, 5-24-95

[illegible], Ohio U. 5/20/98

ABSTRACT

Experimental investigations of tone 3 sandhi in Mandarin Chinese have failed to find well-defined connections between sandhi and speech rates. In this study, empirical evidence is provided that indicates that the traditional claims of tone 3 sandhi are too arbitrary. Tone 3 does not necessarily change into tone 2 by all means. Furthermore, empirical, historical and theorectical arguments are raised concerning the validity of the duration of tone 3 in sandhi situation. Spectrograms and graphs are used to study durations and fundamental frequency of tone 3 in tone sandhi at slow, normal and fast speech by three females and three males. The degree to which the values of tone 3 are influenced appears to depend on various speech speeds. In addition, it is possible that greater variance in tone 3 duration and fundamental frequency is concomitant with the variance of speech speeds. The present study may be viewed as raising some interesting questions and careful cautions in future research on tone 3 sandhi.

ACKNOWLEDGEMENTS

Never am I able to express sufficiently my gratitude and appreciation to all the scholars for their encouragement throughout my graduate studies in the Department of Linguistics at Ohio State University. I would, especially, like to thank Dr. Rob A. Fox for his valuable guidance and helpful advice. Many thanks are due to Dr. Brian Joseph, Dr. David Stampe, Dr. Arnold Zwicky, and Dr. Ilse Lehiste for their suggestions on my work. Most of all, I would like to thank Jim Unkefer, my classmate, for his assistance.

Finally, I must thank all those subjects. Without their collaboration, this work can not be done.

CONTENTS

LIST OF TABLES

Table

LIST OF FIGURES

Figure

Chapter I

INTRODUCTION

Numerous works with respect to the role of speed have in speech have been extensively done within the past twenty years (see;Pike, 1952; Goldman-Eisler, 1956, 1958, 1961; Port 1979; Diehl, Souther and Convis, 1980). Investigations of fundamental frequency, voice onset time, and environmentally-conditioned vowel duration have indicated that these phonetic factors are rather sensitive to the speed of articulation regardless of sexual difference. Diehl, Souther, and Convis (1980) demonstrated that female talkers and male talkers both share the consistency and substantiality of a reduction of VOT at faster rates. But, in spite of the numerous phonetic studies in regard to the rate of speech, little attention has been paid to what influence speech rate might have on tone languages per se. If there is any study on the influence of speech rate on tone, Zee (1980) perhaps is the first person that adopted instrumental techniques to examine the phonemena of fast speech in tone languages. Most of the experiment in his paper focused on the studies of tone sandhi with respect to normal speech, instead of fast speech. The scarcity of subjects, only two female native speakers participated in the experiment, and the inconsistency of the results lessened the reliability of his findings. Except for Zee's studies in 1980, none of the reports so far with respect to instrumental investigations have been concerned with the effect of varying speech rates on phenomena such as tone sandhi in Mandarin Chinese. In order to extend our knowledge of the effects of utterance rate on various aspects of language, this paper shall examine the influence of speed on tone sandhi of a tone language.

The main body of the study is composed of six chapters. First, a general survey of the available scientific literatures on the influence of the speed on speech is made. Additional information about tone system and tone sandhi phenomena in Mandarin Chinese is introduced. On the basis of those findings together with the observations of the phenomena of tone sandhi in Mandarin Chinese, some hypotheses of the result of tone sandhi under the influence of the speech rate will be made. An experiment with regard to the different speeds of speech is described in the third chapter. Details of the process are included where appropriate. The fourth chapter will present the experimental results, and in the ensuing chapter subsequent statistical analyses will be given.

In the final chapter, the relationship between the speech speed and tone sandhi effect is further discussed, and a final conclusion is made.

Chapter II

SURVEY OF THE LITERATURE

This chapter will summarize the references of the findings of previous studies on speech style regarding speech rates as well as those on tone sandhi in Mandarin Chinese. Before further investigations of rate's influence on tone sandhi are conducted, the range of the terms with respect to slow, normal and fast speech should be defined first.

II.1. Speech style- an unsettled term

As early as the beginning of the nineteenth century, diverse domains have been assigned to 'speech styles'.

From the descriptive viewpoint, speech styles can be classified as follows: diction, instruction, deliberate speech, natural speech, rapid, fluent, and casual speech. However, Arnold M. Zwicky (1972) claimed that it was difficult to distinguish casual speech from careful speech. As he suggested, casual speech, generally speaking, was fast and stylistically marked as intimate and informal. But, he later argued that casual speech need not be fast. Thus, the term 'casual speech' instead of 'fast speech' was used in his paper. However, this type of division seems rather subjective and vague.

From the phonetic viewpoint, the definition of speech style may be more objectively acceptable. In 1937, Hudgins and Stetson proposed that a measure of the number of syllables per second should be the main factor in determining the speech style. In actual speech the speed of each of these articulations was modified by the accompanying jaw movement which is slower than the tip of tongue and faster than the lips. Therefore, they claimed that in rapid utterance the laryngeal movements ceased entirely at a rate of five or six syllables per second which was at least one syllable per second slower than the maximum rate of lip movements.

Goldman-Eisler (1956), on the other hand, assumed that pauses, instead of syllable-counting, should be the factor of speech variation. Slow speech was regarded as the flow of speech that was halted by frequent pauses because of hesitation. Fast speech, then, should be defined as a flow of speech without being much interrupted by pauses. In 1961, he provided evidence in support of this assumption.

Black(1961) further broadened Goldman-Eisler's pause-centered definition. Slow speech, as he defined it, required little effort in the articulating movement, and was obviously low in the fundamental frequency of voice. Thus, these implied that fast speech was a flow of speech that required greater vocal effort and consequently the fundamental frequency would be higher. He found that as vocal effort was increased, the fundamental frequency of a voice typically rose, and the rate of talking altered. A slow rate characterized soft speech.

Stevens and House (1963) explained that in sound production, the rapidity with which the articulators could move from one position to another was determined in part by the sluggishness of the articulatory gestures. The temporal characteristics of the articulatory gestures were presumably in part the result of the timing of the instructions to the muscles. Consequently, fast speech was rather sloppy in comparison with normal or natural speech in terms of the movement of articulation.

Due to the speech rate variation from speaker to speaker, all the above-mentioned phonetic findings with respect to speech style lack of objective differentiation. That is why Summerfield (1975) claimed that the listener appeared to 'normalize' temporal cues according to utterance rate if a phoneme distinction was signaled by a temporal cue, i.e. voice onset time, and faster utterance rates tended to shift the phoneme boundary toward smaller values of that cue. If the above-mentioned process that the listener automatically applies is doubtless, then speech style in regard to speed is simply a matter of subjective standard.

In spite of the variations of definitions that make us unable to standarize the definition of speech styles, the findings ot the phonetic experiments concerning speed of speech still have their significance, because they provide sound evidence for the topic to be discussed. Again in 1952, Pike demonstrated that with increasing tempo, vowel quality, pitch level, fundamental frequency and vowel duration were reduced. Thus, Stevens and House (1963) explained that due to the inertia and delay of the articulatory mechanisms, i.e. a lag between neural signals instructing the muscles to move and the actual movements of the muscle masses due to inertia, vowel formants deviated from target values.

In 1964, Sharf provided evidence that vowel duration varied with the dynamic properties of the speech mechanism. He compared the vowel duration between whispered speech and normal (natural) speech. He found that vowels in normal speech and in whispered speech were subject to the same durational influences. And the manner and the place of articulation of the following consonant appears to have sound influence. However, his experiment was done at a single speech rate. Thus, the influence of speech rate on vowel durations per se was not examined.

Wang (1967) mentioned that the phonetic differences among tones, in terms of pitch level, slope of contour, duration, etc., were characteristically more pronounced in deliberate speech and were reduced with regard to the change of speech rate, the phonetic variation of tone was similar to that of vowel articulation. Since both voice pitch and vowels varied along physical dimensions which were continuous, as against certain dimensions of consonant articulations which were discrete.

Ohala (1973) further mentioned that the production of tone involved larynx movement, and that a raised larynx shortened the length of a speaker's vocal tract from the glottis to the lips. A tone of higher fundamental frquency required a higher larynx position.

Even though the available scientific literature has been sparse in instrumental examination of the variation of Mandarin Chinese tones, we are still able to see into the working of them by inference. But before discussing any further studies on them , the questions of how many tones Mandarin Chinese has and what kinds of study on its tones have been already made need to be addressed first. In the following section, the outline of the research which has been done on Mandarin Chinese tones will be presented.

II.2. Tone language

The study of tone languages has been done to a fairly great extent in some areas within the twentieth century. Pike (1949) subdivided tone languages in the world into three groups: tone-register languages, tone-contour languages, and tone contour-register languages. Tone-register languages are the languages in Africa, i.e. Bini, Egede, Hausa, Igbo, Yoruba and Zulu, whose syllables tend to have level pitches; whereas, languages like Thai, Mandarin Chinese, and other languages in Asiatic Mainland are tone-contour languages which have gliding pitches on each syllable. Some dialects in China are tone contour-register ones which combine level and gliding on the syllables.

Mandarin Chinese, spoken by more than 900 million people in Mainland China and on the island of Taiwan, serves as a lingua-franca among the Chinese people. Originally, it was a dialect spoken in Peiping and it is the dialect which will be used in the following experiment. The studies of the tonal system can be traced at least back to the 5th Century A.D., when Chou Yang wrote a book entitled Szsheng Chyeyun', which is about the pronunciation of 4 tones. At the contemporary time, a supplementary copy of 'Szsheng Pu' (Treatise on 4 tones) written by Chou Yung provides further comment on Chinese tone system.

According to Chou Yang and Chou Yung, these 4 tones are ping, shang, shyu, and ru (even, low, going, and entering). Later on, due to sound change, they became the present 4 tones in Mandarin Chinese. Being represented by a citation syllables and indicated in the Pinyin romanizaion, they are as follows:

Tone is subject to change in actual speech. Chao (1948) regarded tone change as the change in the actual value of tones when syllables are spoken in succession. In Mandarin Chinese, as syllables are juxtaposed, tones change their shapes due to the effect of neighboring tones upon one another. In some cases they undergo a process of perseverative

TABLE I

Tonal System of Mandarin Chinese

Tone number	Description	Pitch	Tone letter	Example	Gloss
1	high-level	55	˥	da^1	ride
2	rising	35	˧˥	da^2	reach
3	fall-rising	214	˨˩˦	da^3	beat
4	high-falling	51	˥˩	da^4	big

assimilation; whereas, in others, they undergo dissimilation.

Tones subtly change their contours when paired with each other. The changes are described as follows (see Chao, 1948):

A. In a disyllabic compound, tone 3 /214/ changes to 2 [35] when followed by another tone 3 /214/.

/214/ ---> [35] / _____ [214]

B. In a disyllabic compound, tone 3 /214/ changes to [211] half tone 3 when followed by any tone except tone 3 /214/.

$$/214/ \text{ -----> } [211] \; / \_\_\_\_ \left\{ \begin{array}{c} [55] \\ \\ [35] \\ \\ [51] \end{array} \right\}$$

C. In a trisyllabic compound, tone 3 /214/ changes to [211], when followed by two tone 3 syllables. The second tone 3 changes to [35]. c.1 takes precedence over c.2.

c.1 /214/ ----> [211] / ____ [214] + [214]

c.2 /214/ ----> [35] / [211] + ____ + [214]

D. In rapid speech (see: Cheng, 1968), if the tones on all syllables are tone 3 /214/ in a sentence. i.e. /lau li ma ciau pi/(Old Li bought a small pen.), then, (a) tone 3 on the first syllable changes to tone 2, (b) tone 3 on the second, third and fourth syllables change to tone 1, and (c) tone 3 on the last syllable remains unchanged, that is,

/214 + 214 + 214 + .../ > [35 + 55 + 55 + ...+ 214].

But in 1980, Zee showed that the above-mentioned tone sandhi rules are invalid by providing a spectrographic analysis. He demonstrated that the only time rule A takes place is when the vowel in the first syllable is preceded by aspiration. Rule A should be revised as follows:

/35/ > [215] / C [-asp]_____/214/

/214/ > [34] / C [+asp]_____/214/

In rapid speech, he found that in most cases the tones /214/ on the second, third and fourth syllables do not change to high-level [55], although the tone on the first syllable in the sentence did change to a rising tone in all cases.

Chapter III

HYPOTHESIS

Based on the review of the literatures in the previous chapter, hypotheses concerning the correlation between tone sandhi and speech rates will be made in this chapter.

Since the phonetic variation of tones is essentially similar to that of vowel articulation in some way,[1] several hypotheses can be made as follows:

Hypothesis 1:

The duration of the nuclear vowel of tone 3 should be in inverse proportion to t speech rate. The slower the speech rate is, the longer the duration of is. Thus, in allegro, the duration should be the shortest.

Hypothesis 2:

The duration of the nuclear vowel of tone 3 varies with the speech rate. However degree of variation among the speech rate is impossible to predict, based on the reason that the speech style varies from speaker to speaker.

---

[1] See Pike (1952), Journal of the Acoustical Society of America 24, 618-24.

Hypothesis 3:

The value of the fundamental frequency of tones is in direct proportion to the speech rate. The faster the speed of the speech is, the higher the fundamental frequency is.

Hypothesis 4:

In careful pronunciation, the first tone 3 when paired with another tones 3 /214/ still maintain its value of contour. But in fast speech, the contour of its fundamental frequency changes into rising contour [35], and the following tones 3 change into level contour [55].

Chapter IV

EXPERIMENT

In this experiment, the durations and the values of fundamental frequency of 12 monosyllables in a text-reading paradigm were measured to determined whether differences of tone sandhi existed among the respective reading speeds and to what degree.

IV.1. Method :

IV.1.1. SUBJECTS:

6 Chinese graduate students studying at Ohio State University, 3 females and 3 males, served as volunteers in the experiment. All subjects were native speakers of Mandarin Chinese with no history of speech or hearing impairment. The linguistic backgrounds of the six informants are exhibited in Table II.

A TEXT-READING PARADIGM:

TABLE IIA

Linguistic Backgrounds of the subjects

Informant	1	2	3
Name	Tsai S-M	Liu S-M	Lee Y-M
Sex	Female	Female	Female
Age	24	28	28
Dialect	Mandarin Chinese	Mandarin Chinese	Mandarin Chinese
Place of Birth	Taipei Taiwan	Taipei Taiwan	Taipei Taiwan
Elementary School	Taipei Taiwan	Taipei Taiwan	Taipei Taiwan
High School	Taipei Taiwan	Taipei Taiwan	Taipei Taiwan
College	Taipei Taiwan	Taipei Taiwan	Taipei Taiwan
Parents' Dialect	Mandarin Chinese Je-Jyang	Mandarin Chinese	Mandarin Chinese Je-Jyang
Dialect spoken at home	Mandarin Chinese	Mandarin Chinese	Mandarin Chinese
Other dialects	Taiwanese	Taiwanese	Taiwanese
Other languages	English	English Spanish	English Japanese

According to Kolker (1975), in order to study a speaker's

TABLE IIB

Linguistic Backgrounds of the Subjects

Informant	4	5	6
Name	Ma S-F	Gu J-J	Ou H-Y
Sex	Male	Male	Male
Age	27	28	27
Dialect	Mandarin Chinese	Mandarin Chinese	Mandarin Chinese
Place of Birth	Taipei Taiwan	Taipei Taiwan	Taipei Taiwan
Elementary School	Taipei Taiwan	Taipei Taiwan	Taipei Taiwan
High School	Taipei Taiwan	Taipei Taiwan	Taipei Taiwan
College	Taipei Taiwan	Taipei Taiwan	Taipei Taiwan
Dialect spoken by parents	Mandarin Chinese Je-Jyang	Mandarin Chinese	Mandarin Chinese Jyang-Syi
Dialect spoken at home	Mandarin Chinese	Mandarin Chinese	Mandarin Chinese
Other dialects	#	#	Taiwanese
Proficiency in other languages	English	English	English

computational processes during speech production, a study a corpus of spontaneous speech would be most desirable. In addition to this study, the need for a controlled experimental setting is indispensible as well. Thus, setting up a story reading paradigm becomes necessary in order to examine certain effects of speech rates on tone sandhi in Mandarin Chinese. However, since the interplay of other influences on syllable timing, (e.g. The change of speaking rate and the pause in the middle of a constituent) would mask any systematic effects of the reading, some small magnitude of the complement effects would presumably be impossible to ascertain from a corpus of spontaneous speech. Therefore, a preliminary test was carried out. One subject was asked to test the rate of three various speeds under the requirement that in fast speech she is supposed to read as fast as possible without any difficulty. The time for the fast speech is one minute faster than that of normal speech, and as for normal speech, it is one minute and twenty seconds faster than slow speech. As a result, before the experiment started, any possibly awkward words or pronunciations were deleted from the paradigm.

Accordingly, a narrative reading procedure was adopted in this study in which the phonetic form of the utterance was tightly controlled. 110 pairs of disyllablic utterances or test items, were collected. They were evenly scattered within 33 sentences (Appendix I&II). Each sentence in the story contained one or more key phrases (compounds), placed at the locations of putative syntactic boundaries. Each one of them also had the same approximate sentence intonation contour. The reading list was prepared in Chinese characters. Each pair consists of one member with the sequence of lexical tones 3-3 and 3-3-3. For examples; 'Syau Jye' (Miss), 'Jeng li Hau' (all set) etc. are such pairs. (see Table III)

IV.2. Equipment:

All the instruments described are located in the linguistics lab at Ohio State University.

1. Microphone:

An Electro-Voice model RE 11 microphone was used for the voice recordings of the six Mandarin Chinese speakers. The recordings were made in a sound-treated booth.

2. Casette-Tape Recorder:

The voice recordings of the Mandarin speakers were made with a high-quality model T2M cassette Tape recorder.

3. Reel-to-reel Tape Recorder:

The recordings of the casette tapes were selectively dubbed with the appropriate preamplifier model TEAC 40-4 4 channel recorder/reproducer.

TABLE III

Test Tokens of Tone 3 for Analysis

Token-Tone 3+3	Pinying	Meaning
小雅	Syau Ya	Girl's name
已久	yi jyou	for a long time
柳小姐	Liou syau jye	Miss Liou
有點	you dyan	somewhat
處理好	chu li hau	all set
好幾百	hau ji bai	hundreds of
掩口	yan kou	close one's mouth
整理好	jeng li hau	all set
李小姐	Lee syau jye	Miss Lee
耿主筆	Gen ju bi	Editor Gen
勉強	myan chyan	force
淺水府	Chyan Shwei fu	building's name

4. Sound Sonagraph:

A Voice Print 700 series spectrograph was used to analyze the informant's speech to obtain measurements of formant frequencies (vowel quality), fundamental frequency (voice pitch). The recordings on the reel -to-reel tapes were played into the spectrograph. Frequency, from 0 to 2000 Hz, is shown along the vertical axis in Hz. The relative intensity of each component frequency is shown by the darkness of the mark. The formants show up as dark horizontal bars.

5. Sound-Proof Booth ---IAC Anechic Chamber

IV.3. Procedure:

Each speaker was recorded individually in a sound-insulated chamber for 3 minutes to 5 minutes per session. During the time, the speaker was typically asked to produce the desirable reading speed. He was asked to read the article three times by using three kinds of utterance speed.

At the beginning of an experiment, the speaker was told that the general purpose of the experiments was to study the timing control of tone sandhi. The speaker was then told that he would be given practice in reading a short paragraph in order to train him/her to utter each sentence as a unitary whole, as if it were spoken spontaneously, rather than word-by-word reading. Following the practice reading, the speaker was asked to utter the beginning sentence aloud once, providing the experimenter with a final opportunity to check recording levels. The speaker was asked to say each token of the sentence at the same overall rate and with the same rhythm. In the first session, he/she was told to speak as carefully as possible. Furthermore, he/she was urged to speak as naturally as he/she could. In the final session, he/she was instructed to speak as fast as he/she could but without blurring the intention of communication. Between reading, the speaker was provided a short rest period, and encouraged to take a drink of water, and then asked to begin the practice procedure with a new speed.

In case of mispronunciations during the test, the speaker was told to disregard them. As for any changes of the speed rate, the speaker was told to pause, and then read the article all over again.

While reading, the speaker maintained a constant position to the microphone.He/She was instructed to register -3 db on the sound level meter. The levels were selected after trying out two speakers to find feasible limits and after alternative instructions that were worded in terms of degrees of vocal effort. The intensity levels were equalized. And then, the casette-tape recordings were selectively copied to a TEAC 40-4 4 channel recorder/reproducer. The final step is to make spectrograms.

Chapter V

EXPERIMENTAL RESULTS

Time is a very critical factor in this experiment. Table III shows the time that each subject took in recording the reading at slow, normal and fast speeds.

TABLE IV

Time Table of Six Subjects

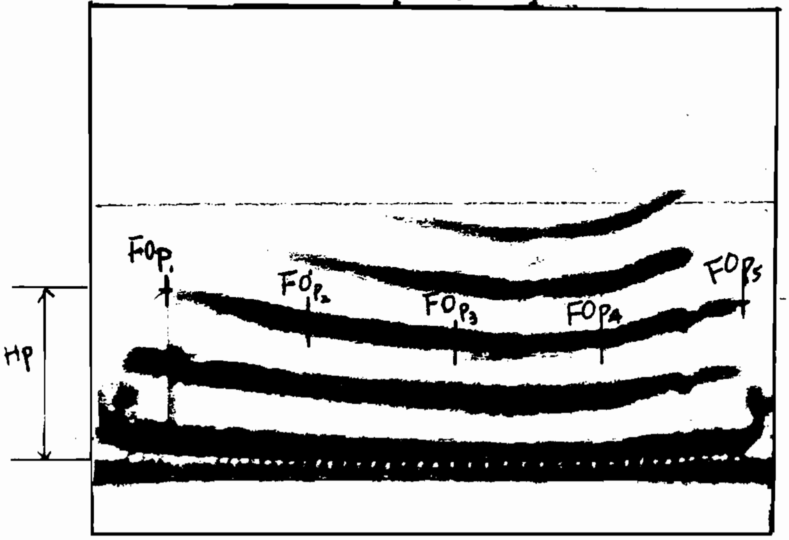
Subj/Sp	1	2	3	4	5	6
Name	Tsai S-M	Liu S-M	Lee Y-M	Ma S-F	Gu J-J	Ou H-Y
Slow Sp	04:42	04:38	05:21	05:53	04:29	07:27
Norm Sp	03:47	03:11	03:32	03:58	03:34	04:36
Fast Sp	02:63	02:28	02:34	02:33	02:17	01:59

Subject one, four and six did not show much variation of increasing speech speed between different reading speeds. The ratio for increasing speech rate is approximately equal between slow-normal, and normal -fast speed. The timing results of subject 2 and suject 3 show that the increasing rate between slow and normal speed is almost over twice as much as that between normal and fast speed. This might imply that even in ordinary (natural) speed, subject 2 speaks much faster than the other subjects. As for subject 5, the timing ratio for speeding-up between slow-normal speech and normal-fast speech is 1:2. We are, therefore, able to infer from this result that there is a lot more variation between slow-normal speech than between normal-fast speech. Of all the subjects, subject 6 spent the longest time in reading the article for the slow-speech recording, and also was the fastest of all in reading the text for the fast-speech recording.

In all, 728 narrow-band and wide-band spectrograms were made to trace the course of the fundamental frequency in determing the tonal contours and durations. The fundamental frequency was measured by dividing the chosen harmonic, which is supposed to be the most obvious one within a formant frequency, into 5 points. Each point and duration were measured according to the formulas shown in Figure 1A and Table V.

Figure 1A
the Calculations of
Fundamental Frequency and Duration

For example: 'Nyan'



		FOdur=(90mm/318mm)x2.4 sec
Harmp=3;	Hp1=25mm;	FOp1=(25mm/400mm)x1000Hzx(1/3)
	Hp2=21mm;	FOp2=(21mm/400mm)x1000Hzx(1/3)
Fdur=90mm	Hp3=19mm;	FOp3=(19mm/400mm)x1000Hzx(1/3)
	Hp4=18mm;	FOp4=(18mm/400mm)x1000Hzx(1/3)
	Hp5=23mm;	FOp5=(23mm/400mm)x1000Hzx(1/3)

Formulas of
the Calculations of FO and Duration

FOp=(Hp/400mm) x 1000 Hz x (1/Harmp)

FOdur= (Fdur/318mm) x 2.4 sec

FOp=the measurement point of the fundamental frequency

Hp=Height between the point and baseline of the formant frequency

FOdur=Duration of the measurement formant frequency

Harmp=the harmonic which the measurement point is located

All the calculations were done by computer. Finally, only 79 spectrograms of the twelve tokens at careful, normal and fast speeds were selected for analysis. These tokens were all located in the middle of the sentence. Choice of these token was based on the method used by Lehiste(1982),[2] Lindblom and Rapp (1973). In 1973, Lindblom and Rapp found that there were some influences of differences in subglottal pressure on segmental timing. In order to neutralize any possibility of the above-mentioned influences, it would be extremely necessary to choose the test tokens in the middle of the sentence.

As a result, one monosyllabic word 'Myan' pronounced by six subjects respectively at 3 kinds of speeds was cited as an example to demonstrate the possible variations within one subject. Figures 2, 3, 4, 5, 6 and 7, belonging to subject 1, 2, 3, 4, 5 and 6 respectively, are the narrow-band spectrograms of 'Myan' within 1000 Hz. Figure 1B shows the citation forms of tone 3 'Myan' and the case of being pronounced as tone 2 recorded by the author.

---

[2] Professor Lehiste suggested the author to choose the test tokens in the middle of a sentence.

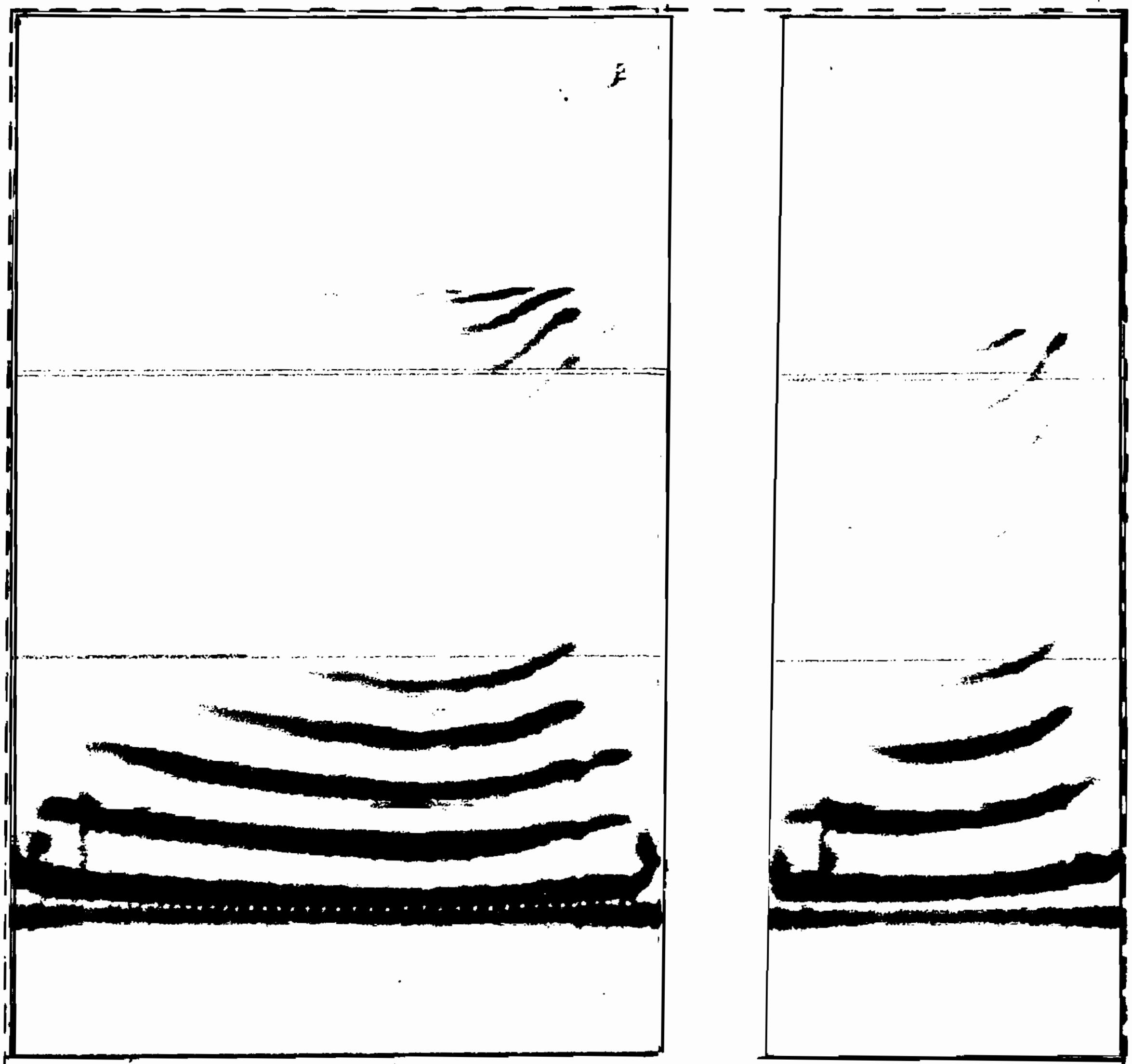
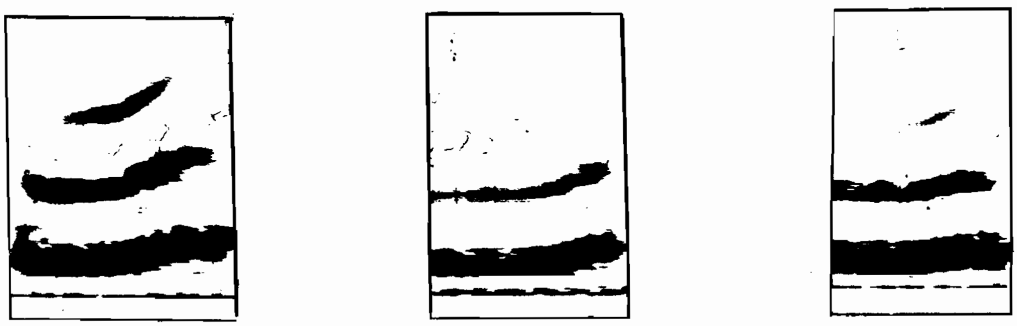


Figure 1B
the Citation Forms of :

Tone 3 'Myan' Tone 2 'Myan'

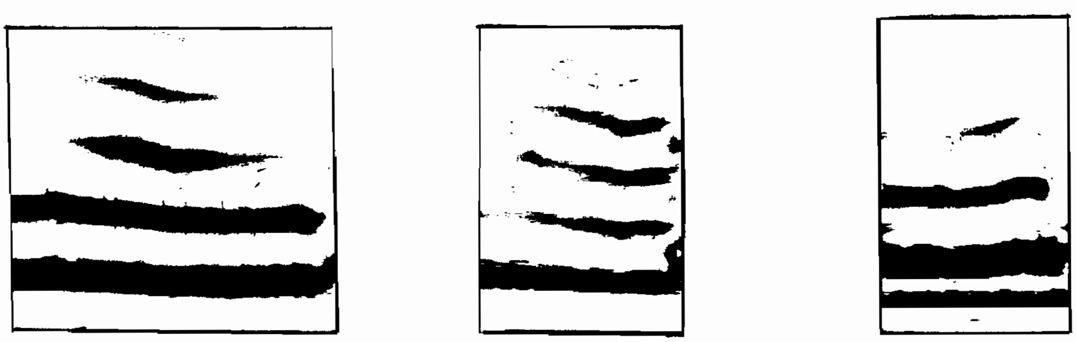
Spectrograms of Myan'

at Slow, Normal and Fast Speech



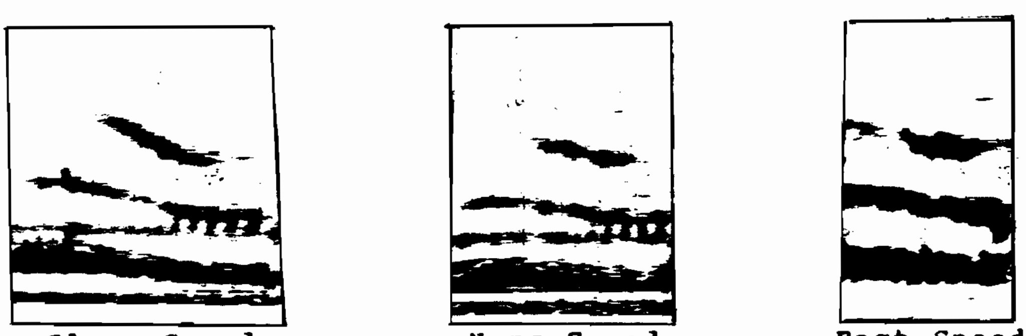
Slow Speed Norm Speed Fast Speed

Figure 2: Subject 1



Slow Speed Norm Speed Fast Speed

Figure 3: Subject 2

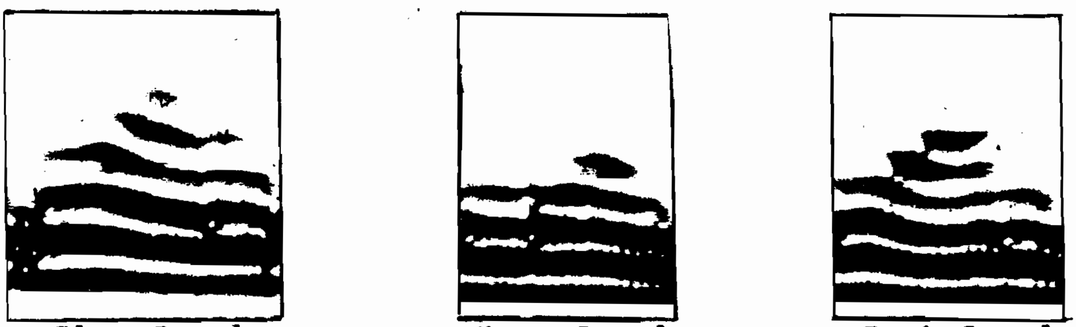


Slow Speed Norm Speed Fast Speed

Figure 4: Subject 3

Slow Speed Norm Speed Fast Speed

Figure 5: Subject 4



Slow Speed Norm Speed Fast Speed

Figure 6: Subject 5

Slow Speed Norm Speed Fast Speed

Figure 7: Subject 6

These spectrograms are narrow-band of expend -5 within 1000 Hz. Subject 4 shows an obviously different output which is hard to measure.

According to Figure 2 to Figure 7, some following observations can be made:

*. An obvious vowel-like nasal bar preceding each formant frequency can be easily seen. This is due to the fact that the word Myan' begins with a nasal consonant.

*. In careful speech, variations of the contours of tone 3 within six subjects exist. For subject 1 and 6, the contours of the tone tend to be rising-like. As for subject 2, 3 and 5, the contours of the tone are flatter in comparison with those of subject 1 and 6. The vague contour in Figure 5 might be the result of misarticulation of tokens by speaker 4.

*. As speech speeds up, the contour of tone 3 becomes increasingly level. At the stage of fast speech, the degree of evenness reaches its highest degree. For subject 4, the tone contour of the fundamental frequency at fast speed still has fall-rising shape. In addition to this, unnecessary friction took place during the pronunciation.

*. From the viewpoint of duration, each subject except subject 6 shows much more consistent results with respect to slow, normal and fast speech. To sum up, the duration is longest at slow speed and shortest at fast speed. Nevertheless, subject 6 has variant results for the duration at normal speed.

In each graph, the triangles represent the fundamental frequency values of tone 3 in slow speech, the plus '+' signs stand for those in normal speech. And the fundamental frequency values of tone 3 in fast speech is represented by the sign of 'x'. Each triangle, '+' and 'x' are the results of the calculations done by computer. The duration within each one of the figures had been normalized already. Likewise, by observing Figure 2.1, 3.1, 4.1, 5.1, 6.1 and 7.1, some remarks can be made in the following:

FIGURE 2.1
SUBJ 1:
F0 OF TONE 3
WORD 71: MYAN

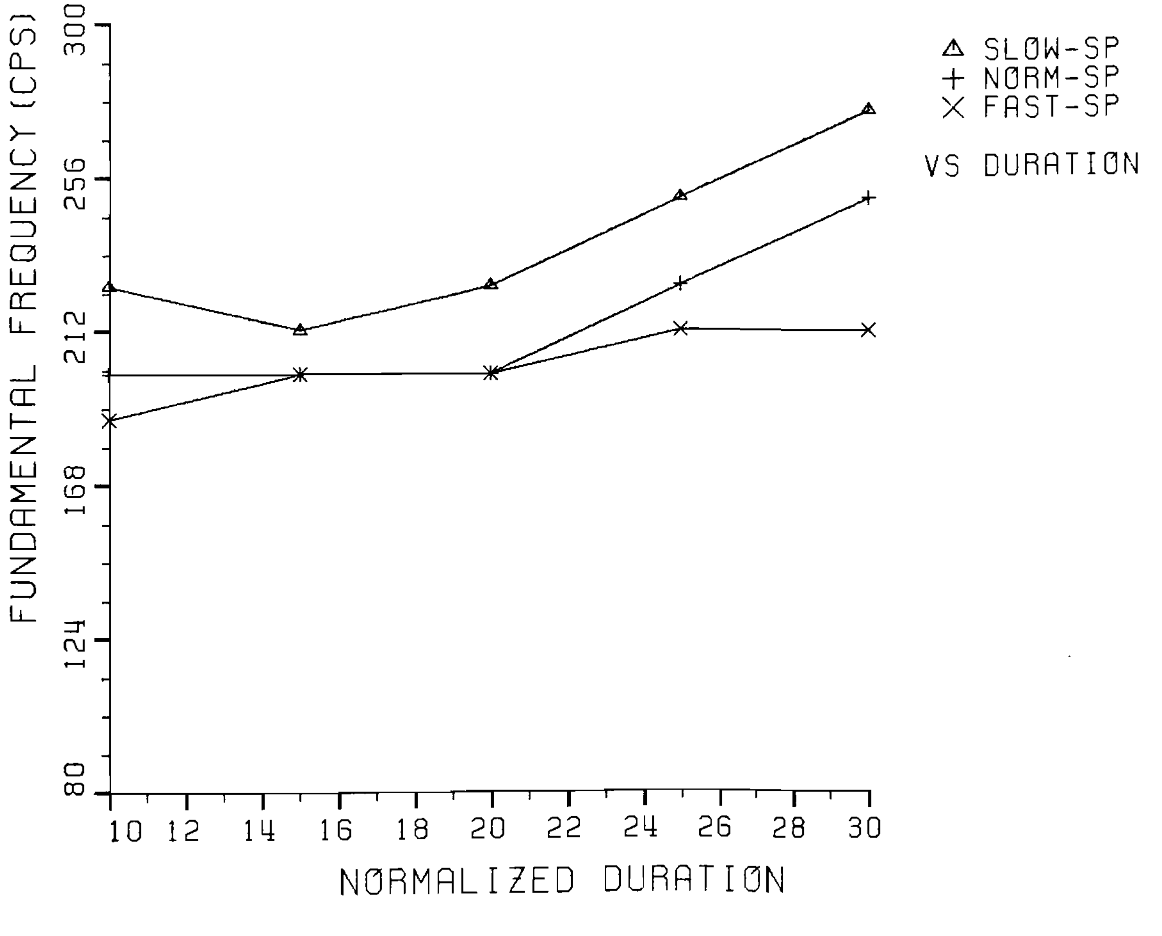


FIGURE 3.1
SUBJ 2:
FØ ØF TØNE 3
WØRD 71: MYAN

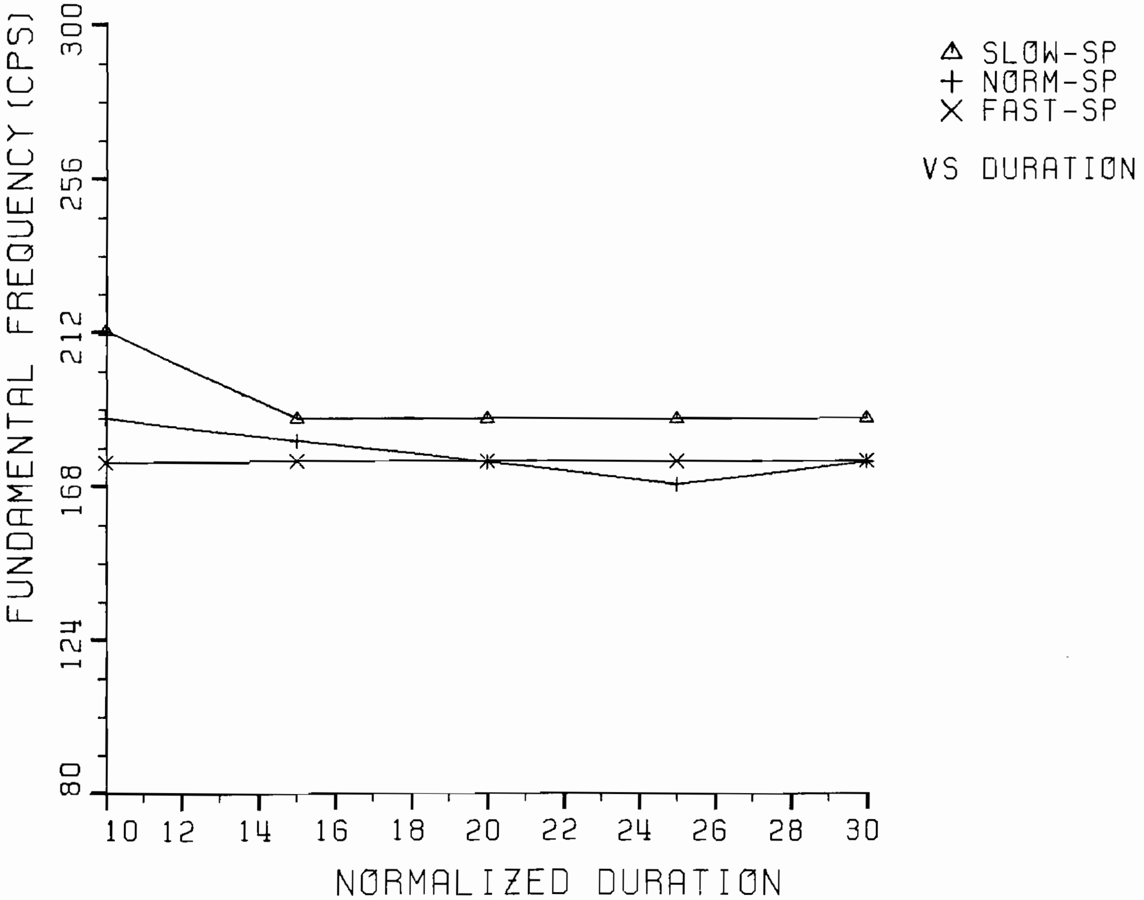


FIGURE 4.1
SUBJ 3:
FØ ØF TØNE 3
WØRD 71: MYAN

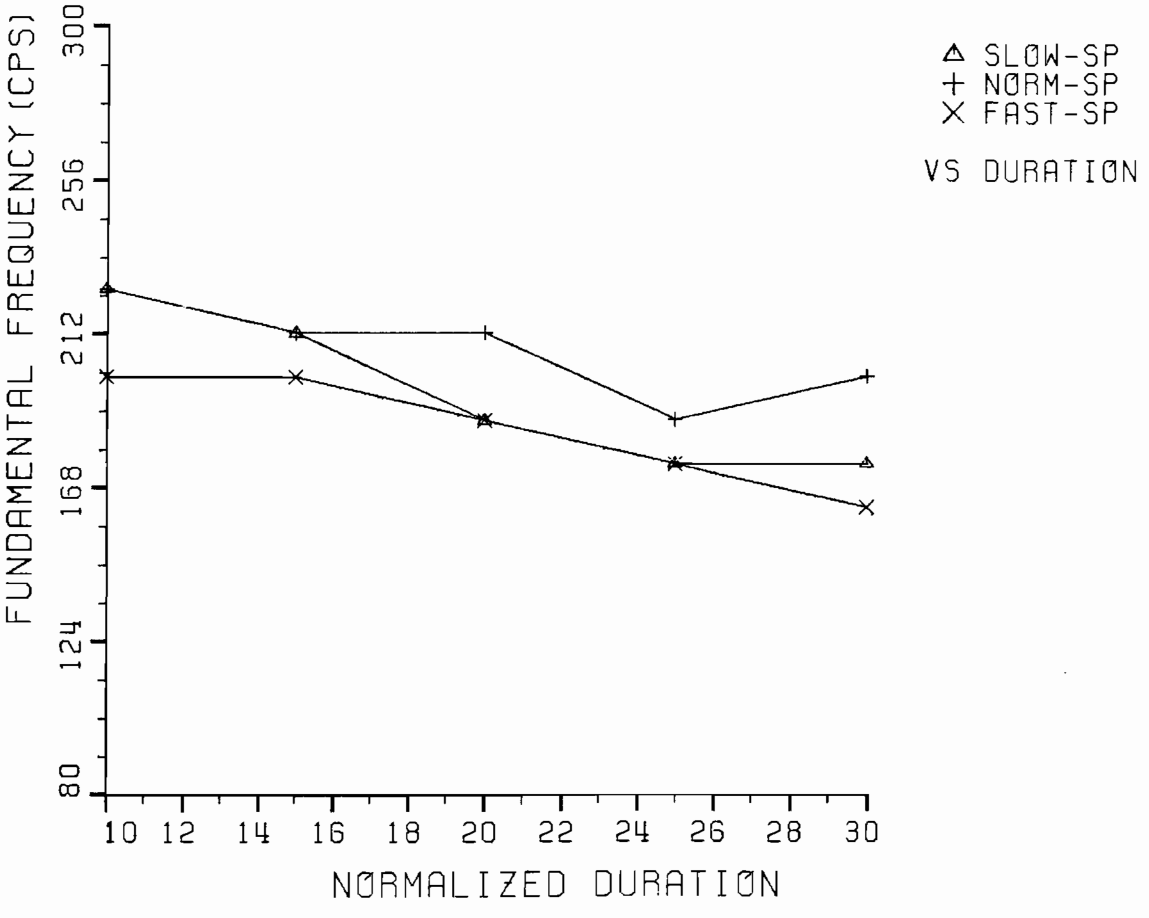


FIGURE 5.1
SUBJ 4:
F0 OF TONE 3
WORD 71: MYAN

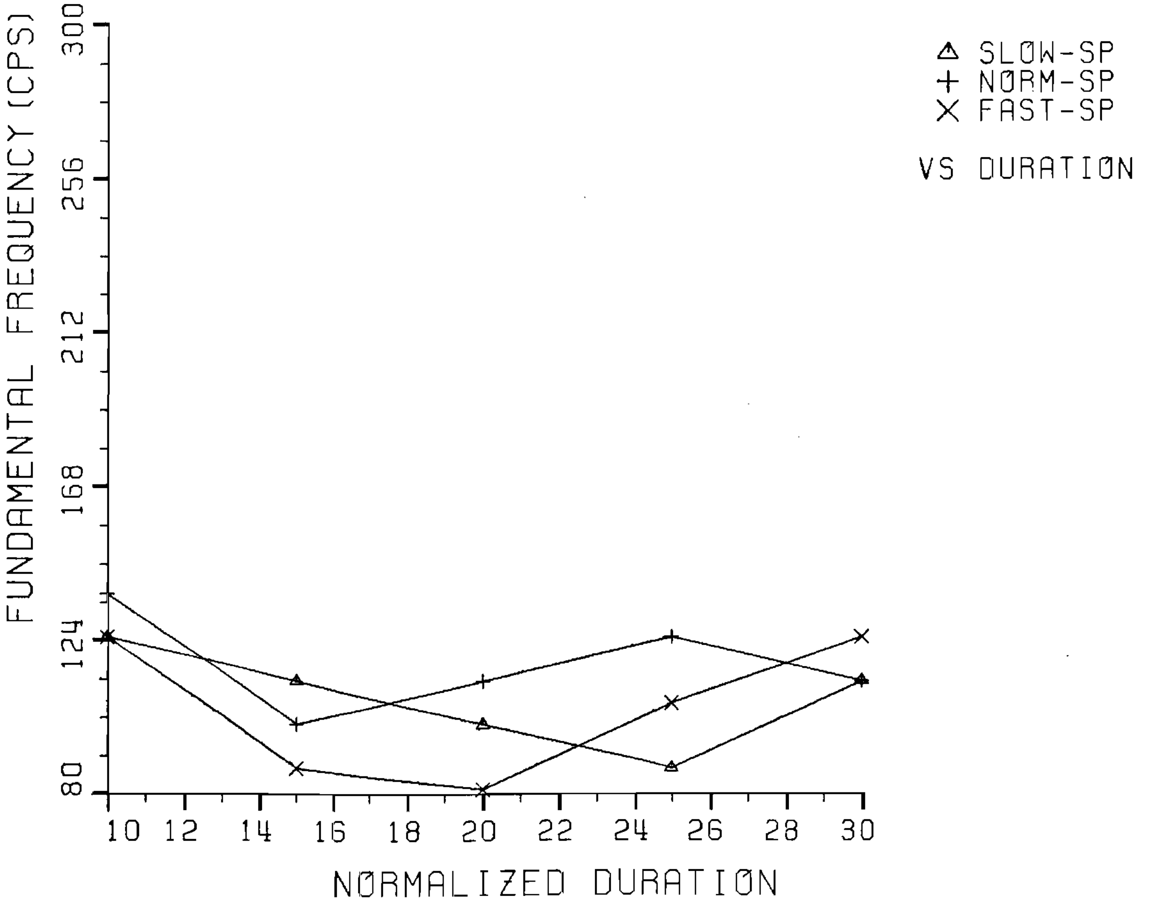


FIGURE 6.1
SUBJ 5:
F0 OF TONE 3
WORD 71: MYAN

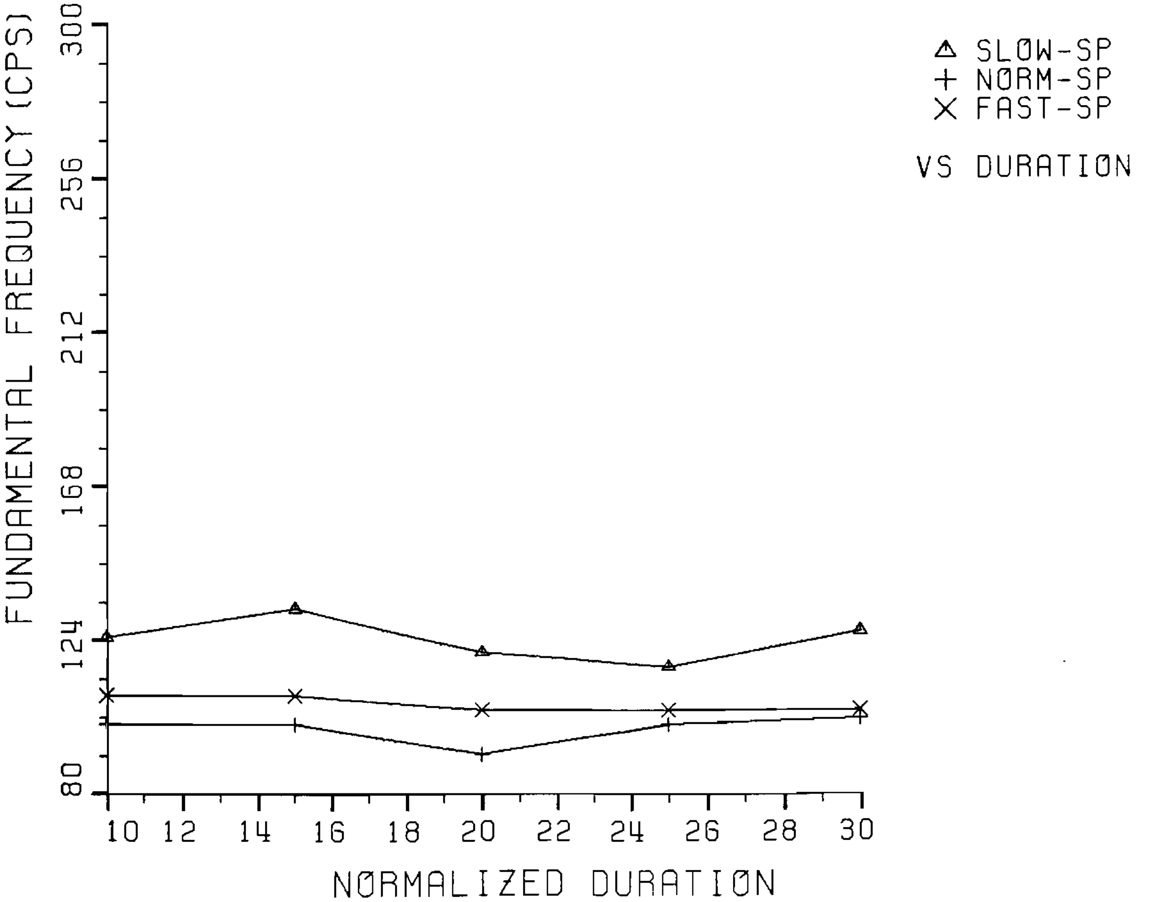
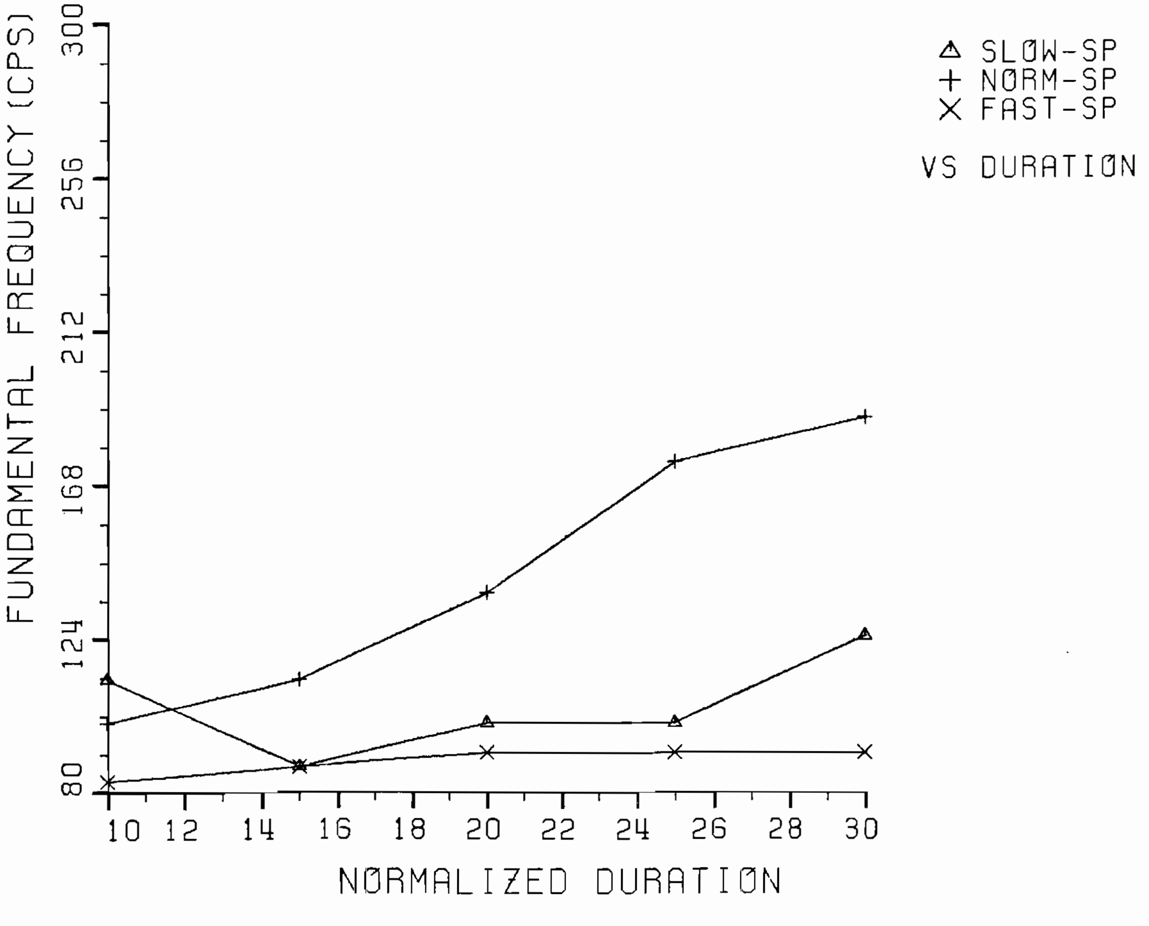


FIGURE 7.1
SUBJ 6:
FØ ØF TØNE 3
WØRD 71: MYAN



* In the result of our experiment, the fundamental frequency of the female voice is around 180-280 Hz, while that of the male voice is within 80-130 Hz. Subject 6, however, shows an extraordinarily large amount of variance during the normal speech. The fundamental frequency is up to 180 Hz at normal speed.

*. Subject 2 and subject 3 show variant tone contours at slow speed. Figure 3.1 and 4.1 indicate that the fundamental frequency at slow speed of 'Myan' for subject 2 and 3 tends to decrease.

*. As for normal speed, Figure 4.1 and 5.1 show the irregular contours at normal speech. For subject 2, the tone contour is flat as well.

*. Regarding fast speech, almost each tone contour of fundamental frequency is steady-state except for that of subject 3 and 4. Figure 4.1 shows a gradual downdrift, while for subject 4, the fundamental frequency of tone 3 still retains the slow-speed contour.

*. The fundamental frequency of slow speech in the figures displayed is higher than those of normal speech and fast speech Subject 5 shows the contrary result in

Figure 6.1. Figure 5.1 and Figure 7.1 show that the fundamental frequency of normal speech is much higher than that of slow speech.

After the investigations of the spectrograms previously mentioned as well as the graphs on Figure 5.1 , subject 4 was eliminated from any further analysis, because he showed the anomalous result of tone contour at fast speech contrary to the other subjects.

Figure 8 and Figure 9 show the results of mean normalized fundamental frequency of tone 3 by collapsing across twelve tokens and five subjects respectively.

FIGURE 8: NORM-F0 OF TONE 3
COLLAP ACROSS 12 WORDS

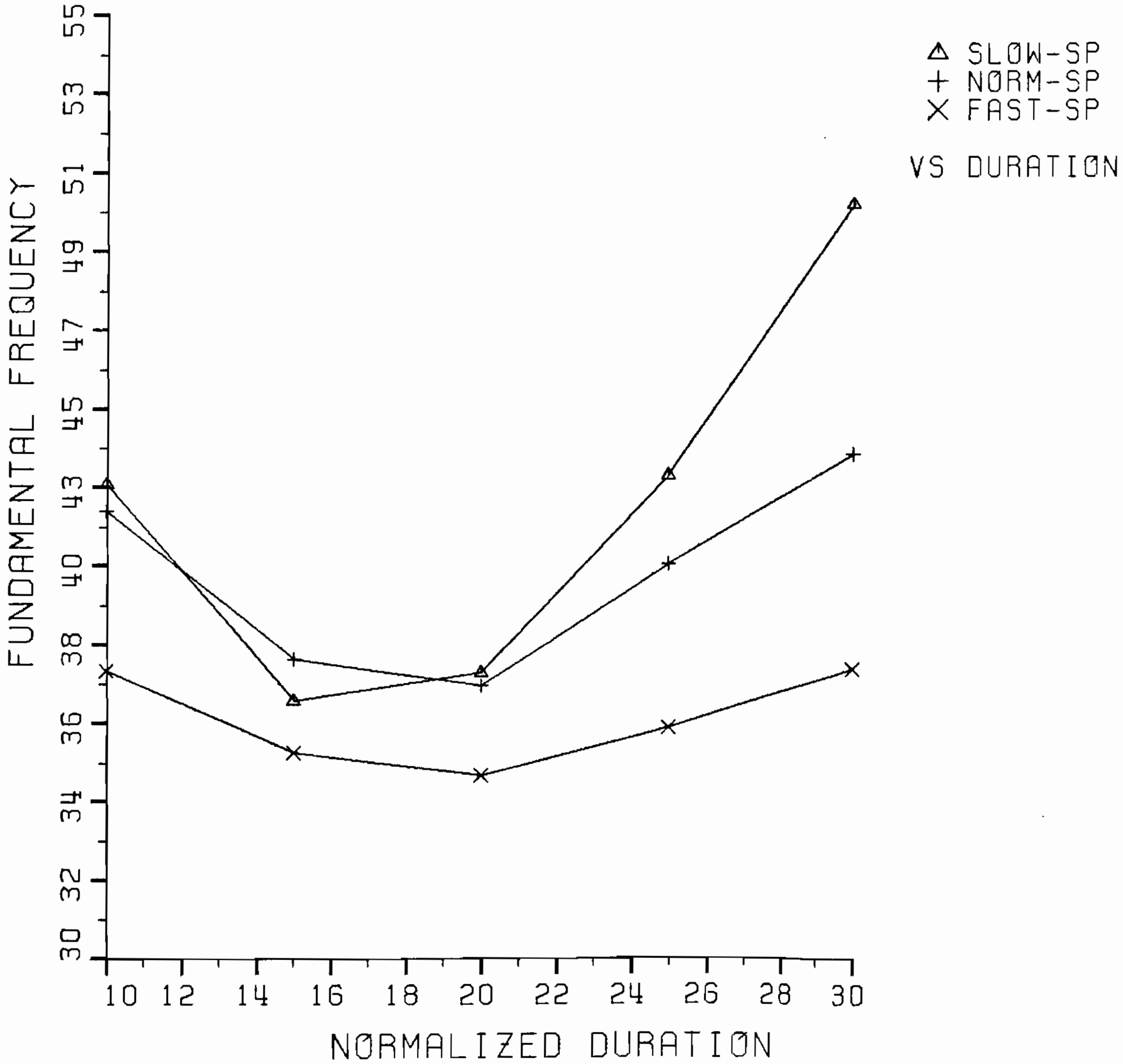
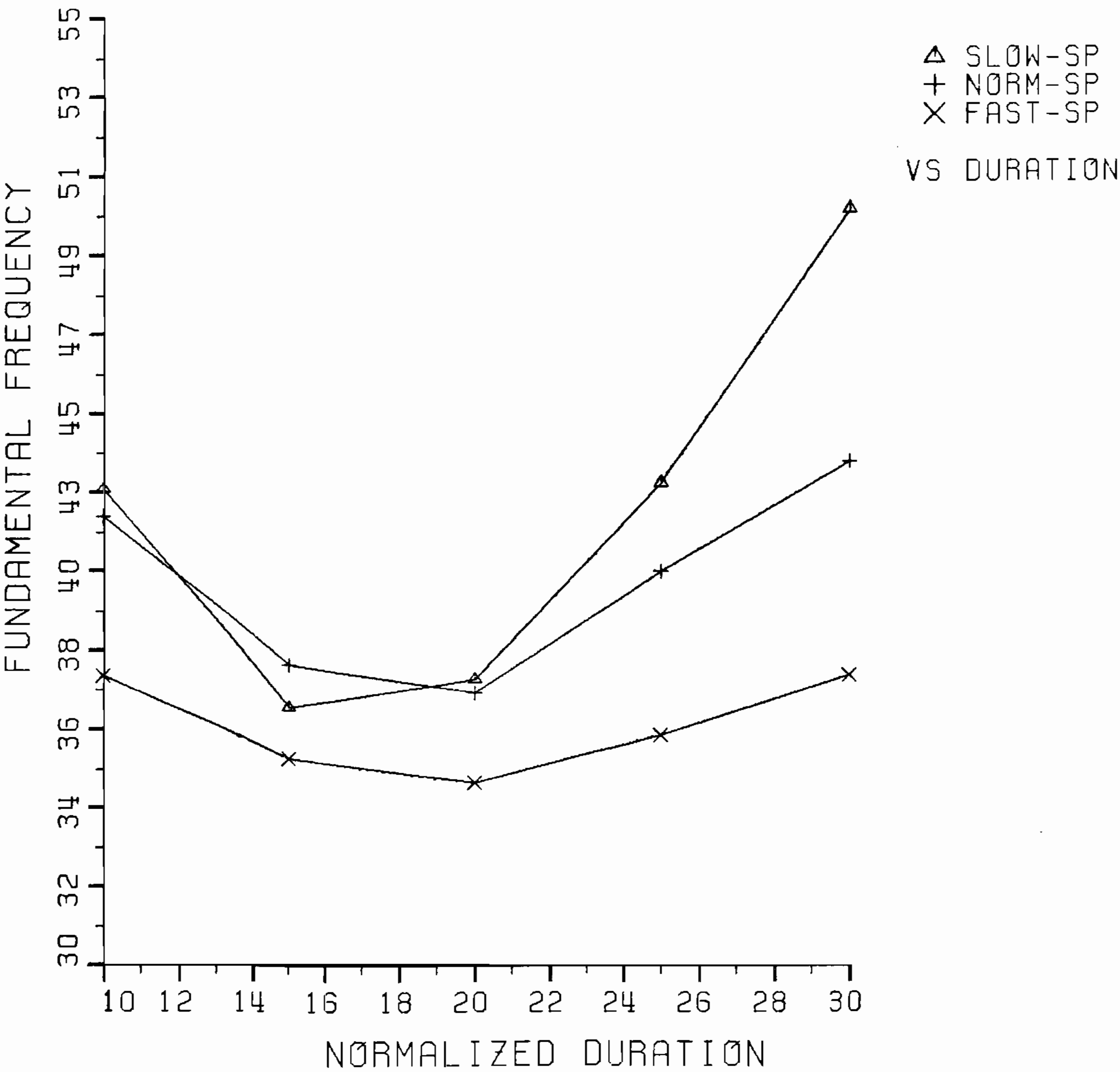


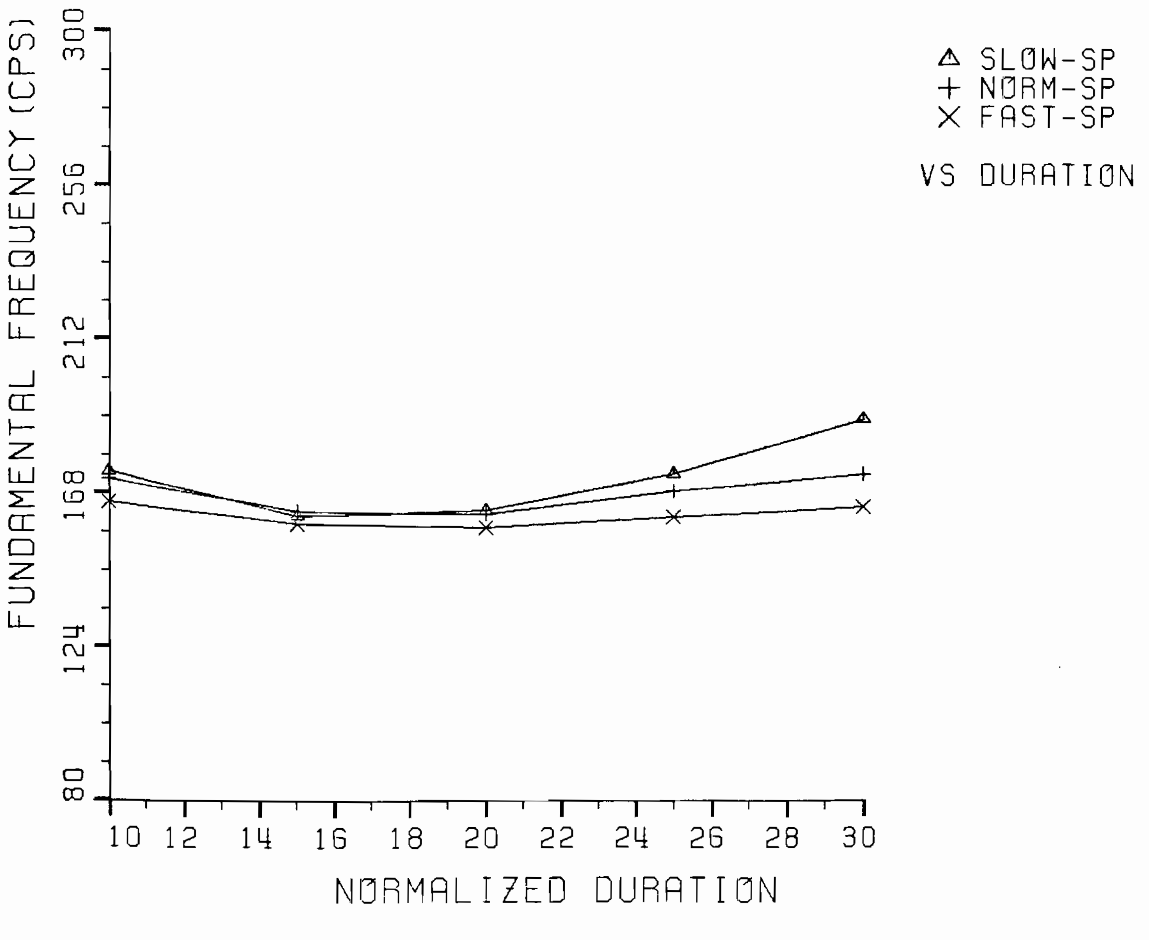
FIGURE 9: NØRM-FO ØF TØNE 3
CØLLAP ACRØSS 5 SUBJS



We are able to tell from the graphs that as speech speeds up, the tone contour of the fundamental frequency tends to be flatter and the degree of the slope decreases as well. In slow speech, the graph shows a perfect tone-3 contour with fall-rising shape. The fundamental frequency decreases as speech rate increases.

Figure 10 demonstrates the result of non-normalized fundamental frequency of tone 3 collapsed across twelve tokens.

FIGURE 10: F0 OF TONE 3
COLLAP ACROSS 12 WORDS



Compared with that of Figure 8, the contour of the fundamental frequency of tone 3 at slow speed is not so obvious as that of normalized one. Nevertheless, the slight difference among the three kinds of speed is still detectable. The contour of tone 3 at fast speed is the most impressive one. It is characterized by the evenness of the tone contour of the fundamental frequency as indicated by the above-mentioned figures.

Figure 11 to Figure 15 belong to subject 1, 2, 3, 5 and 6 respectively. They show the values of the fundamental frequency of tone 3 by collapsing across twelve tokens.

FIGURE 11
SUBJ 1:
FØ ØF TØNE 3 ACRØSS WØRDS

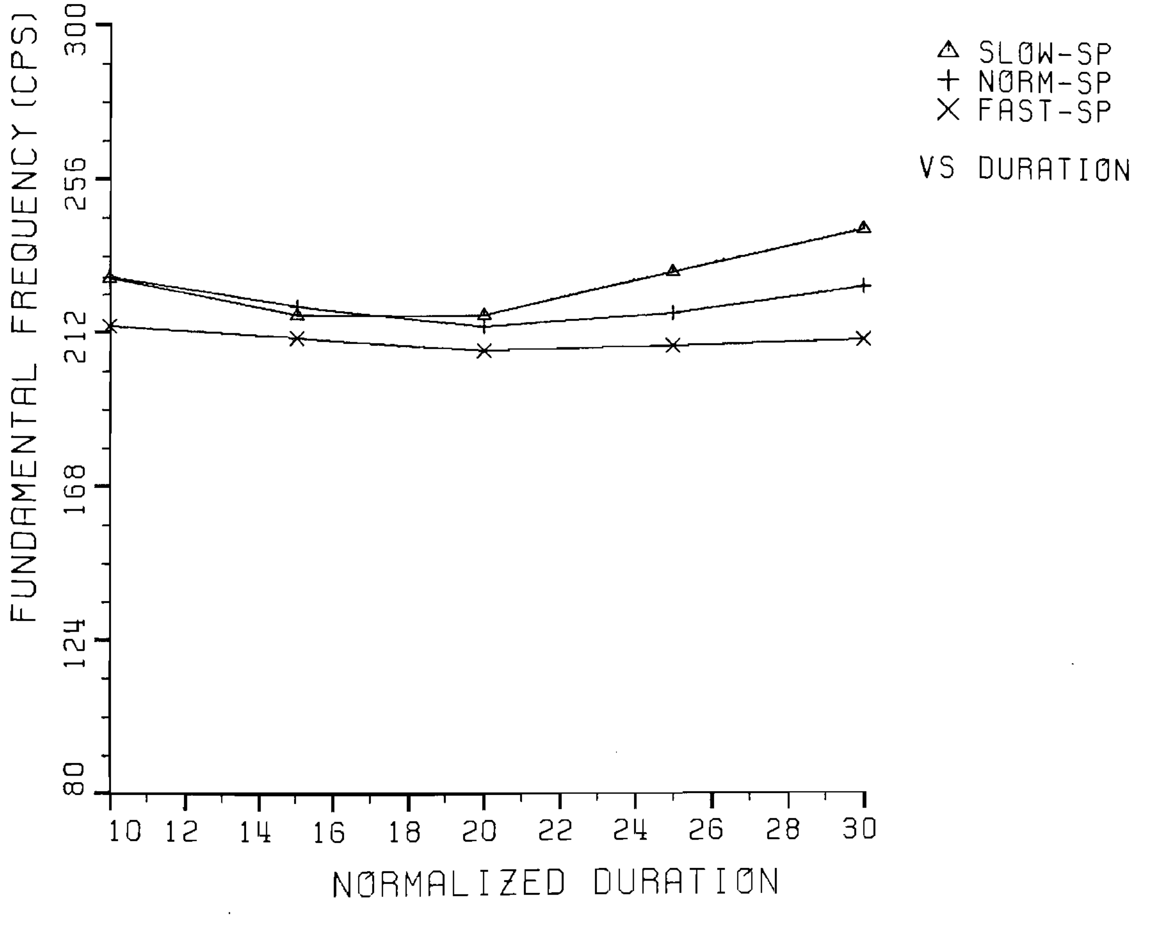


FIGURE 12
SUBJ 2:
F0 OF TONE 3 ACROSS WORDS

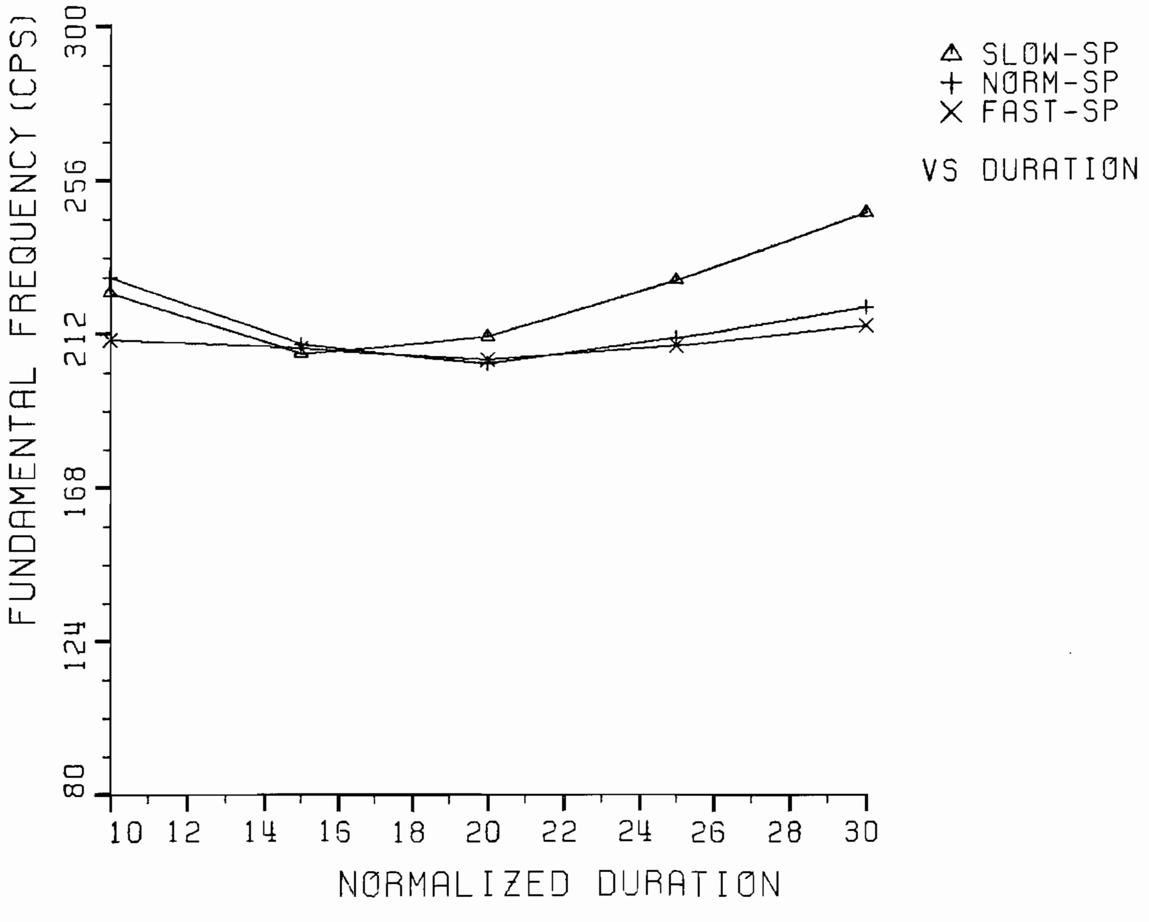


FIGURE 13
SUBJ 3:
FØ ØF TØNE 3 ACRØSS WØRDS

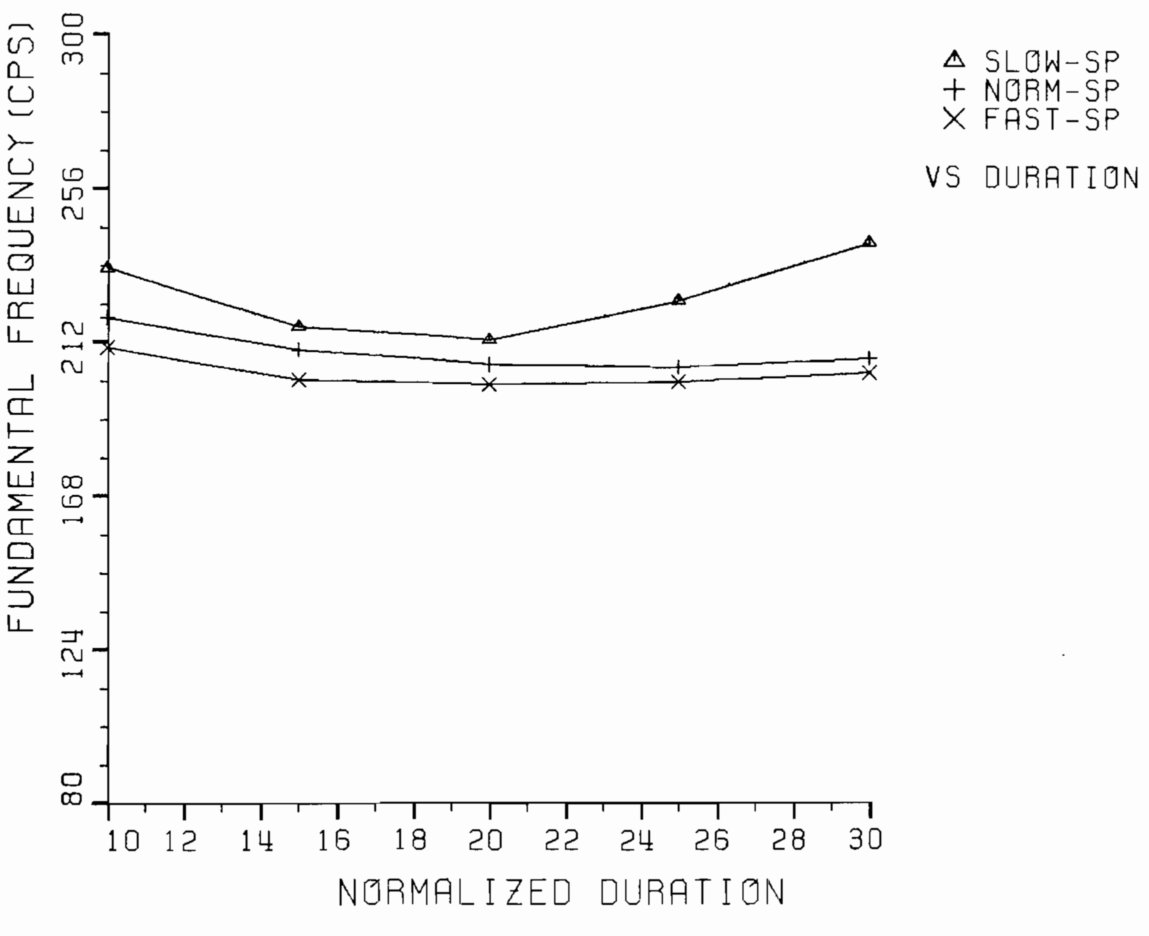


FIGURE 14
SUBJ 5:
FØ ØF TØNE 3 ACRØSS WØRDS

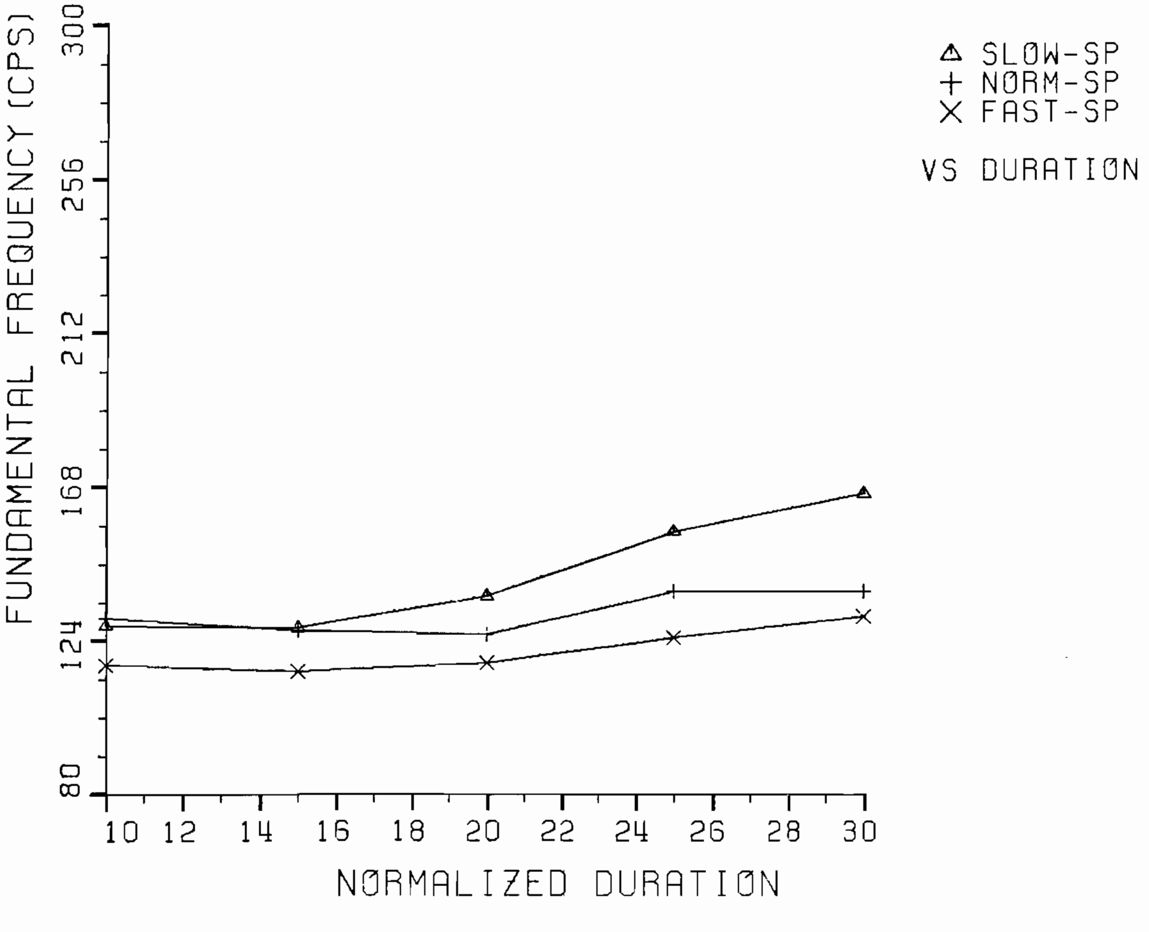
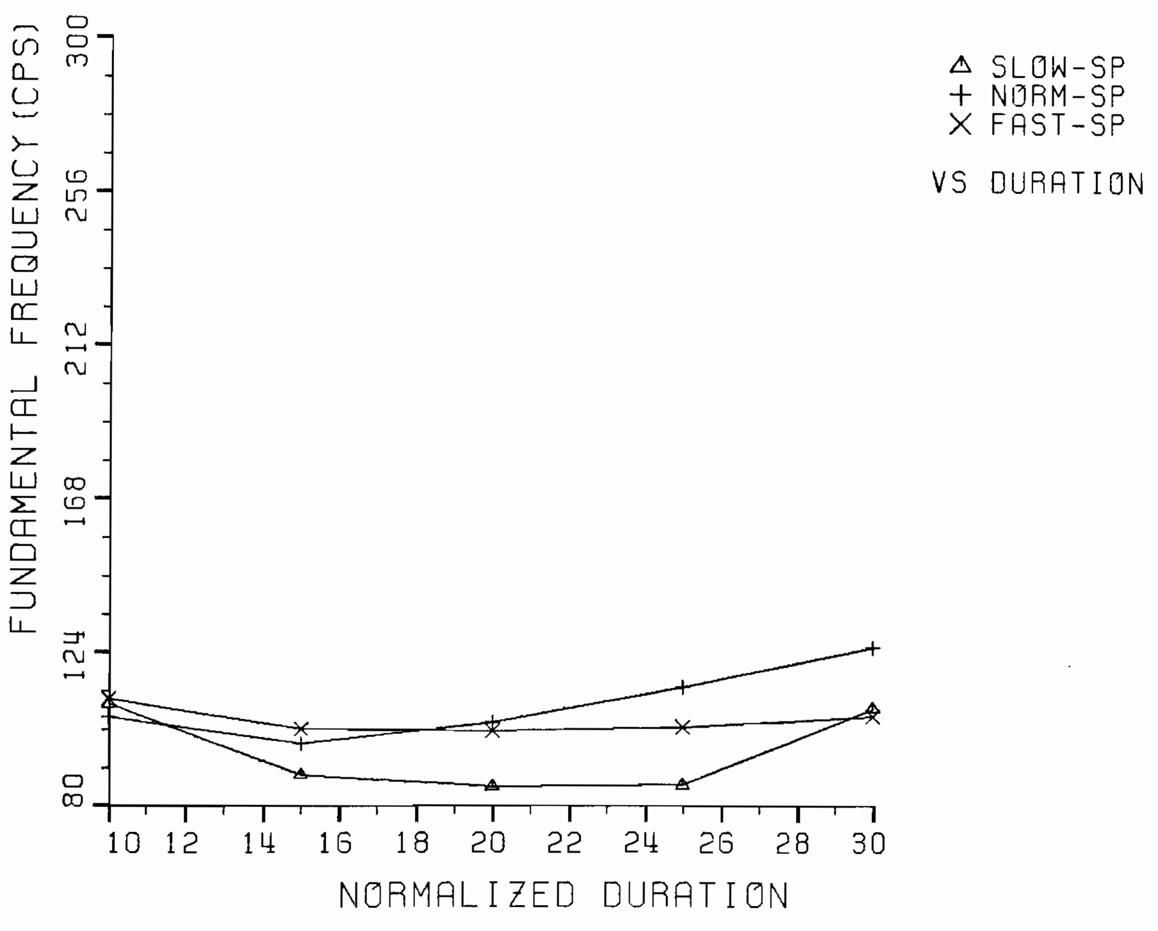


FIGURE 15
SUBJ 6:
F0 OF TONE 3 ACROSS WORDS



The following results again confirm the observations made with regard to a single token 'Myan':

*. The fundamental frequency of female voice is higher than that of male's. For subject 6, the distribution of the fundamental frequency concerning various speeds is much more steady.

*. At fast speed, the tone contour of fundamental frequency once more confirmed the previous findings, that is, a tendency towards flatness.

*. The faster the speed is, the higher the fundamental frequency is. Figure 11, 12, 13 and 15 provide sufficient evidence for this finding. On the other hand, subject 6 shows a different result. At slow speech, the fundamental frequencies of tone 3 at normal speech and fast speech almost combine together regardless of the beginning point. Like subject 6, the lowest fundamental frequency is the one at slow speed.

From the tone contour point of view, the faster the speed is, the flater the contour will be. Most of the tone contours at fast speed were found to be level as claimed by Zee(1980).

Chapter VI

ANALYSIS

The validity of any experimental results is unreliable until they are confirmed by further scientific tests. Therefore, some statistical tests in this chapter will be demonstrated in order to support the experimental findings.

In examining the spectrograms, we assumed that time had a close relation with the duration of a formant frequency. This assumption was confirmed. Table V shows the individual mean of the durations of twelve tokens. Subject 6 shows the longest
as well as the shortest durations, that is, 324.5 msec and 80.5 msec respectively, of all the subjects. And, he shows a significant variance of durations between speeds. The mean duration of slow speech is twice as long as that of normal speech, and the ratio of duration between normal and fast speech is 1:2 as well. For subject one, the durations between normal and fast speech do not have much difference as compared with the others. The mean of durations for fast speech is only 25.7 msec shorter than that of normal speech. This result is mainly due to the nonsignificance of increas-

TABLE V

Mean Duration of Each Subject (in msec)

Sp/Subj	1	2	3	5	6
Name	Tsai S-M	Liu S-M	Lee Y-M	GU J-J	Ou H-S
slow sp	212.5	272.9	244	214.4	324.5
norm sp	137.1	166	153.4	155.9	162.8
fast sp	111.3	123.2	118.8	112.5	80.5

ing speed that subject one applied in the experiment. The difference between speeds of the other subjects is rather consistent. For both subject 2 and subject 5, the difference of duration between normal and fast speeds is around 43 msec. As for the speeds between slow and normal speech, subject 2 and subject 3 have the similar variance: around 90-100 msec. For subject 5, the difference is only 58.3 msec. This is attributed to the fact that the timing difference for subject 5 at slow and normal speeds is only 55 seconds. Consequently, the smaller the difference between the time of two speeches, the smaller the difference between the durations will be. The close correlation between the time and duration, thus, is shown without doubt.

In order to analyze the difference within two groups, i.e. slow and normal, normal and fast speeds, a t-test was adopted. The t-value for analyzing slow and normal speeds is 6.922. And from the T table we obtain a critical value that is 2.074. Thus, the null hypothesis rejected and a comment was made as follows: The groups from two populations do not have the equal mean , in other words, different speeds influence the duration of the fundamental frequency. And the t-value for analyzing normal and fast speeds is 3.8548, which is greater than the critical value from T table. Thus, a significant difference exists between normal and fast speeds. By comparing these two t-values, we can see that the degree of significance of variance between slow and normal speeds is obviously larger than that between normal and fast speeds. Therefore, one remark can be made regarding these results: The change of duration between slow speech and normal speech is much greater than between normal and fast speech. Furthermore, the variance of the mean of duration between slow and normal speeds is 98.6 msec, whereas, it is 45.7 msec between normal and fast speeds.

With respect to the tone contour of fundamental frequency among three groups of dependent variables, i.e. slow, normal and fast speeds, a two-way analysis of variance was used to analyze groups of data in order to provide the evidence that the fundamental frequency of tone 3 is definitely influenced by speech speed. The results of analysis for subject 1, 2, 3, 5 and 6 are shown in Table X to Table XIV respectively. The ANOVA summary table for normalized fundamental frequencies collapsed across the twelve tokens is shown in Table VII. Table VIII shows the result of F-test by collapsing across all five subjects. And the result of F-test for non-normalized fundamental frequencies by collapsing across twelve tokens with respect to slow, normal and fast speeds is displayed in Table IX.

Based on Table VII to IX, some observations in terms of the

TABLE VII

ANOVA Summary Table for Norm-FO Across Words

Source	SS	DF	MS	F
pos	1268.5	4	317.1	4.25
sp	982.3	2	491.1	6.593
posxsp	463.9	8	57.99	0.778
error	12292.3	165	74.49	

TABLE VIII

ANOVA Summary Table for Norm-FO Across Subjects

Source	SS	DF	MS	F
pos	528.63	4	132.1	2.6268
sp	409.33	2	204.66	4.7839
posxsp	1193.3	8	149.16	2.965
error	3018.39	60	50.3	

TABLE IX

ANOVA Summary Table for Non-Norm FO Across Words

Source	SS	DF	MS	F
pos	5525.8	4	1381.4	41.57
sp	3428.7	2	1714.35	51.59
posxsp	8930.6	8	1116.32	33.59
error	5483.3	165	33.23	

relationship between fundamental frequency of tone 3 and various speeds can be made as follows:

Most of the cases show that the F value in speed is much more significant than in position. Thus, the value in speed was chosen for discussion.

*. The critical value from the F table for two degrees of freedom in the numerator and 165 degrees of freedom in the denominator and =.05 is 3. Since the values of F for speed are 6.593 and 51.59 respectively in Table VII and IX which are greater than the critical value 3. Thus, the null hypothesis was rejected. The three groups of slow, normal and fast speeches do not come from the populations with equal mean, that is, different speeds of speech do have an effect on the value of the fundamental frequency of tone 3.

*. For the normalized fundamental frequency across five subjects, the values of F-test for speed is 4.7839 which is greater than the critical value from the F table for 60 degrees of freedom in the denominator and 2 degrees of freedom in the numerator. Thus, the significance of F value for speed further confirms that speed of speech does have influential effect on fundamental frequency of tone 3.

Table X to Table XIV show the result of individual analysis for subject 1, 2, 3, 5 and 6, by collapsing twelve tokens.

TABLE X

ANOVA Summary Table for Subject 1

Source	SS	DF	MS	F
pos	3738.8	4	945.97	2.827
sp	8584.8	2	4292.43	12.829
posxsp	2822.2	8	352.78	1.054
error	55205.9	165	334.58	

The values of F of five subjects are 12.829, 39.566, 8.9564, 3.917 and 25.563 respectively which are highly significant for speed. Consequently, the individual case further demonstrates that the speech speed does have influence on the fundamental frequency. Table XIII unlike the others shows that the value of F for speed is slightly greater than the critical F value. The degree of significance of its variance somewhat decreases compared with others.

TABLE XI

ANOVA Summary Table for Subject 2

Source	SS	DF	MS	F
pos	10881.07	4	2720.26	35.977
sp	5983.198	2	2991.59	39.566
posxsp	6336.659	8	792.08	10.475
error	12475.57	165	75.609	

TABLE XII

ANOVA Summary Table for Subject 3

Source	SS	DF	MS	F
pos	5465.85	4	1366.46	1.5594
sp	15696	2	7848.002	8.9564
posxsp	3399.05	8	424.881	0.4848
error	144579.6	165	876.24	

TABLE XIII

ANOVA Summary Table for Subject 5

Source	SS	DF	MS	F
pos	13596.91	4	3399.22	1.8914
sp	14080.69	2	7040.35	3.917
posxsp	4321.66	8	540.207	0.03
error	296535.79	165	1797.18	

TABLE XIV

ANOVA Summary Table for Subject 6

Source	SS	DF	MS	F
pos	7717.7	4	1929.425	16.65
sp	5923.5	2	2961.75	25.563
posxsp	5475.42	8	684.42	8.6312
error	86820.9	165	115.8583	

Chapter VII

DISCUSSION AND CONCLUSION

VII.1 Discussion:

This part of the chapter will be devoted to a discussion of the findings obtained from the experiment. It is divided into sections presented as follows:

VII.1.1. Duration:

The data presented in this study are in agreement with earlier results, reviewed in the literature survey, showing that at fast speech the duration of the nuclear vowel of tone 3 is much shorter than at slow speech or normal speech. The mean duration of five subjects at slow speech is 253.7 msec, at normal speech it is 155 msec, while at fast speech it is 109.3 msec. Thus, the faster the speed is, the shorter the duration is. Besides, the results of t-test indicate that the degree of significance between slow and normal speech is greater than that between normal and slow which is 3.8548. The difference between slow and normal speech is far greater than between normal and fast speech. And the mean duration between normal and fast speech is 45.7 msec. The difference between these two variances leads to the result that the duration does not change relatively among slow, normal and fast speech, confirming what we have presumed.

VII.1.2. Fundamental Frequency of Tone 3-Is its height in a direct proportion to the speech rate?

Black (1961), from the physiological point of view, demonstrated the close affinity between the mechanism of aricu-lation and the value of fundamental frequency. Slow speech he mentioned was apparently low in fundamental frequency because of little effort of articulating movement involved. Fast speech, on the other hand, requires greater effort while articulating. Therefore, a much higher fundamental frequency would be the result as he defined. However, our finding is in contradiction to what Black (1961) had presented. We found that the fundamental frequency decreased as speed rates increased. By referring this to all the figures displayed (except Figure 1 to 7), the formant frequency of tone 3 is indeed not in a direct proportion to the speech rate. Roughly speaking, the lowest fundamental frequency belongs to the fast speech. And at slow speech, the value of the fundamental frequency of tone 3 normally is high. (Except for several few cases which present some abrupt change of the frequency with respect to speed,i.e.subject 6 is one of the cases.) Thus, this implies that physiologically, fast speech is supposed to require little effort instead of much articulation effort.

VII.1.3. The Reliability of Traditional Viewpoint of Tone 3 Sandhi Phenomena:

It has long been argued that due to the mechanism of articulations, tone 3 arbitrarily changes into tone 2. Hockett (1947) claimed that phonemically speaking, the changes of pitch were in fact substitutions of one toneme for another rather than nonphonemic modifications of tonemes. Nevertheless, our case does not yield any consistent results. From the tone contour point of view, Figure 2.1 to 16 illustrate that even in careful (slow) speech, tone 3 does not retain its original shape as compared with the one in Figure 1. The valley of tone 3 contour becomes less obvious, or in other words, it is flater. The variability of tone 3 sandhi in running speech in Mandarin Chinese is further confirmed. Therefore, it is impossible for tone 3 to retain its value of contour when followed by another tone 3 even in careful speech. In normal speech, tone 3 does not necessarily change into tone 2 as declared in numerous articles. Figure 2.1 to 7.1 support our findings. Almost each subject except for subject 6 exhibits a puzzling result opposed to what had been claimed. It shows that the falling portion of tone 3 in some case becomes flat [12]. And in the other cases some retain its fall-rising contour, some with the rising portion change into a low level [211]. In Figure 4.1, subject 3 even shows a zigzag shape of tone contour. As a result, provided that the claim made on tone sandhi had been precise, then the variability of tone 3 contour at normal speech should not have taken place except the rising contour of tone 2 [35]. Nevertheless, our finding leads us to raise an objection against the traditional viewpoint on tone 3 sandhi in Mandarin Chinese.

The hypothesis that in fast speech, the contour of tone 3 would change into rising contour [35], and the following tone 3's change into level contour [55] was proved to be invalid. Our result shows that tone 3 changes into neither rising [35] nor level [55], instead, it becomes low level contour [11] in most cases.

VII.2 Conclusion:

Although the present study examined only a small number of subjects and a small set of measurements, the interesting results of our experiment might be used for the base for the future research. It is no doubt fair to say based on our experiment that speech speeds strongly affect the duration and the fundamental frequency of tone 3. The problem of influence is simply a matter of degree. The faster the speed is, the deeper the influence would be. The conclusion can be drawn that as the speech rate increases, the lower the fundamental frequency of tone 3 becomes , and the flater the contour would be. Any phonological rule with respect to tone 3 sandhi should be set up with great care; otherwise, there is a good chance that the results will be invalid.

BIBLIOGRAPHY

Black, John W. (1961). 'Relationships among Fundamental Frequency, Vocal Sound Pressure, and Rate of Speaking,' Language and Speech. Vol. 4, pp. 196-199.

Brotzman, Robert, L. (1968). 'Progress Report on Mandarin Tone Study,' OSU POLA. 8

Brotzman, Robert, L. (1964). 'Recognition of Lexical Tone in Mandarin Chinese by Sampling of Fundamental Frequency,' Journal of Acoustic Society of America. 36, pp. 1048.

Chao, Y. R. (1920). 'A System of Tone Letters,' Le Maître Phonétique. 45, pp. 24-27.

Cheng, Chin-Chuan. (1972). 'A Statistical Approach to the Study of Chinese Tones,' Paper presented at the 5th International Conference on Sino-Tibetan Language and Linguistic Studies, Ann Arbor, Michigan.

Cheng, Chin-Chuan. (1973). A Synchronic Phonology of Mandarin Chinese. New York: Mouton & Co. The Hague.

Diehl, Randy L. Arthur F. Souther, and C. L. Convis. (1980). 'Conditions on Rate Normalization in Speech Perception,' Perception and Psychophysics. 27, pp. 435-443.

Dreher, John J., and Lee Pao-Chen. (1966). 'Instrumental Investigation of Single and Paired Mandarin Tonemes,' Huntington Beach, Calif.: Douglas Aircraft.

Fant, G. (1973). Speech Sound and Features.

Frieda Goldman-Eisler. (1961). 'The Significance of Changes in the Rate of Articulation,' Language and Speech, 4, pp. 171-174.

Fromkin, Victoria A, ed. (1978). Tone-A Linguistic Survey. New York: Academic Press.

Goldman-Eisler, Frieda. (1961). 'The Significance of Changes in the Rate of Articulation,' Language and Speech. Vol. 4.

Grandour, Jackson T. (1978). 'The Perception of Tone,' Tone-A Linguistic Survey. New York: Academic Press. pp. 46-71.

Henry, F.M. (1948). 'Discrimination of the Duration of a Sound,' Journal of Experimental Psychology. Vol.38, pp. 734-743.

Hockett, C.F. (1947). 'Peiping Phonology,' Journal of Acoustic Society of America. Vol. LXVII, pp. 256-257.

Herdan, G. (1956). Language as Choice and Chance.

Howie, John Marshall. (1976). Acoustical Studies of Mandarin Vowels and Tones.

Klein, Michael. (1976). PLOTALL. U. of Akron.

Kloker, D. (1975). 'Vowel and Sonorant Lengthening as Cues to Phonological Phrase Boundaries,' Paper presented at the 89th Meeting of the Acoustical Society of America.

Lehiste, Ilse. (1969). Suprasegmental. Massechusette: MIT Press.

Li Kung-Pu. (1963). 'Tone Perception Experiment,' OSU POLA 6r.

Lindblom, B. & Rapp, K. (1973). 'Some Temporal Regularities of Spoken Swedish,' Papers from the Institute of Linguistics, U. of Stockholm, Publication 21.

Lindblom, B.E.F. & Sundberg, J.E.F. (1971). 'Acoustical Consequences of Lip, Tongue, Jaw, and Larynx Movement,' Journal of the Acoustical Society of America. 50, pp. 1166-1179.

Maddieson, Ian. (1978). 'Tone Effects on Consonants,' Journal of Phonetics. 6, pp.327-344.

Meddis, Ray. (1975). Statistical Handbook for Non-Statisticians. Berkshire, England: McGraw-Hill Book Co. Ltd.

Ohala, J.J. (1973). 'The Physiology of Tone,' Southern California Occasional Papers in Linguistics. 1, pp. 1-14.

Osser, Harry, and Peng, Frederick. (1964). 'A Cross Cultural Study of Speech Rate,' Language and Speech. Vol.7, pp. 120-125.

Pike, Kenneth L. (1976). Tone Language.

Potter, Ralph K., Kopp, George A., and Green, Harriet C. (1974). Visible Speech.

SAS USER'S GUIDE. (1979). Cary, North Carolina: SAS Institute Statistical Analysis System.

Sharf, Donald J. (1964). 'Vowel Duration in Whispered and in Normal Speech,' Language and Speech. Vol.7, pp.89-97.

Subtelny, J.D., Woth, J.H. and Sakuda, M. (1966). 'Introral Pressure and Rate of Flow During Speech,' Journal of Speech and Hearing Research. Vol.9, pp. 498-518.

Tseng, Chiw-Yu. (1981). 'On the Interaction Between Tones and Intonation in Mandarin Chinese: An Acoustic Phonetic Study,' Program in Experimental Psychology. U. of California, Santa Cruz.

Wang, W. S-Y. (1967). 'Phonological Features of Tone,' International Journal of American Linguistics. Vol.2.

Wang, W. S-Y. and C.J. Fillmore. (1961). 'Intrinsic Cues and Consonant Perception,' Journal of Speech and Hearing Research. Vol.4, pp. 130-136.

Wang, W. S-Y. and Li Kung Pu. (1967). 'Tone 3 in Pekinese,' Journal of Speech and Hearing Research. Vol.10, pp. 629-636.

Welkowitz, Joan, R.B. Ewen, and Jacob Cohen. (1982). Introductory Statistics for the Behavioral Sciences. New York: Academic Press.

White, Carym M. (1981). 'Tonal Pronunciation Errors and Interference from English Intonation,' Journal of Chinese Language Teaching Association. Vol.XVI, No.2, pp. 27-56.

Wise, C.M. and Chong, Lily Pao-Hu. (1957). 'Intelligibility of Whispering in a Tone Language,' Journal of Speech and Hearing Disorders. Vol.22, No.3, pp. 335-338.

Woo, Nancy. (1972). 'Prosody and Phonology,' PH.D. Dissertation, MIT.

Zee, Eric. (1980). 'A Spectrographic Investigation of Mandarin Tone Sandhi,' UCLA Working Paper. pp. 98-116.

Zwicky, Arnold M. (1972). 'On Casual Speech,' CLS. 8.607-15.

Appendix I

A Text-Reading Paradigm

晌午，北卡的整個大表演廳內，擠滿了海外遊子。一聲鑼，好戲開始了。這是雲門舞集第五次的演出。小雅，舞者之一，率先在舞台上演出。「春」拉開了今天全部的序幕。土語唱出的民謠這時穿插在管絃樂中，使人感到份外親切。隨著曲子逐漸的消失，繼之而來的是近乎野蠻的鼓聲，由四方湧來。觀眾全沈醉在小雅忘我的一擧手，一投足中。她美麗的臉龐上塗滿了五彩。在期待已久的掌聲中，她結束了整整半個小時的獨舞，然後從柳小姐手裡接下了五朵粉紅的玫瑰。汗珠在她額頭上閃爍著。史綺美在旁低聲耳語：「事實上，她的舞步有點亂，她好像很緊張，但臉譜倒是很討好，因而掩蓋了其他的毛病。」回到後台，小雅趕緊洗掉所有的粉彩。看著鏡中的自己，一時竟陷入了往事的網中。「打起精神來，手擧高，對…」史師使出所有力氣喊著。暑氣不時從風縫中逼來。在這舞蹈室中，一天十六小時，苦練了整整五年多。為了這次巡迴演出，誰敢不努力。在那段日子裡，「休息」這個字眼是不屬於他們的。經紀人董老，積極地籌劃和找場地，等到他處理好所有的細節後，已是九月份的事情了。秋初，他們整團得以整裝待發。一路上馬不停蹄地在歐洲各地演出。美國北卡州是他們舞出的第一站。緊接著，她拿起話筒打給正在貴家的馬

小姐，請她早點寫好在翡翠府請客的請帖。所有在美親朋好友都將列席，起碼有好幾百人。想到這些，她禁不住滿足地掩口而笑。多年來的苦練，究竟沒有白費，想著，想著，門外一陣吵雜聲，把她拉回現實。撿起落在地上的錦巾，整理好舞衣，開門一看，原來守在門外的李總管帶著聯合報的耿主筆走進來。李總管在把其他記者勉強打發後，把門帶上，頓時，室內一陣悄然。耿主筆首先道出了開場白：「沈小姐的舞技，的確可以美媽海格蓝姆。對於今天的演出，您是否有些感觸呢？」望著淡水府送來的花，她低頭默默地說：「這一切的一切都要感謝老師。如果不是老師的指導和鼓勵，我決不會有今天的成就。」淚水在她的眼眶內打轉。「我想，努力再努力，一直到美滿的境界，該是我今後所要做到的目標。」

註：(1)本文純屬虛構，名稱若有雷同，亦為偶然。
(2)練習句：
語言大樓的前面草地上有很多松鼠。

Appendix II

Tokens of Tone Three Followed by Tone 1, 2, 3, 4 and 0

TABLE XVA

Test Tokens of Tone 3 Followed by Other Tones

Tone 3+1	Tone 3+2	Tone 3+3	Tone 3+4
gu sheng 鼓聲	ye man 野蠻	syau ya 小雅	wu tsz 五次
wu chu 舞出	fen hung 粉紅	ji jyou 已久	wu bu 舞步
jeng jwang 整裝	wu nyan 五年	jou dyan 有點	yan gai 掩蓋
you ye 有些	syau shr 小時	jan kou 掩口	ching ke 請客
lao shr 老師	man ju 滿足	myan chyan 勉強	shou dzai 守在

TABLE XVB

Test Tokens of Tone 3 Followed by Other Tones

Tone 3+0	Tone 3+3+3	Tone 3+3+3
jeng ge 整個	chu li hau 處理好	liou syau jye 柳小姐
chyu dz 曲子	jeng li hau 整理好	lee jung gwan 李總管
syang je 想著	chyan shwei fu 淺水府	gen ju bi 耿主筆
han je 喊著		hau ji bai 好幾百