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Acoustic Analysis of the Tones in the Shantou Dialect

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ACOUSTIC ANALYSIS OF THE TONES IN THE SHANTOU DIALECT

A Thesis Presented

by

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DEDICATION

I would like to dedicate my thesis and give thanks to my family especially my brother, who have always support and encourage me whenever it is needed. I also want to give thanks to my friends, who have helped me with the data collection in parts of this work.

Without the support of my family and friends, this work would not have made possible. Many thanks, to my family and friends.

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ABSTRACT

ACOUSTIC ANALYSIS OF THE TONES IN THE SHANTOU DIALECT

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This paper mainly analyzes the different tones in the Shantou dialect. The Shantou dialect is known as one of the branches of the Chaoshan dialect which is a sub-group of the southern Min. Compared to other sub-group southern Min dialects, one of the distinguishing tonal characteristics of the Shantou dialect is that it has eight tones while the others have seven. Common views have explained that the eight tones in the Shantou dialect are the result of the four Middle Chinese tones further splitting into the upper register and the lower register. Thus, the Shantou dialect has its unique position in the study of the tonal development of Chinese.

In order to better understand this unique tonal phenomenon, with references to the four Middle Chinese tonal categories, the tonal system in the Shantou dialect is acoustically examined. With an acoustic tonal experiment, this study aims to discuss three questions. First, what are the Shantou dialect's tonal values? Second, what is the relation between its tones and the four Middle Chinese tones? Third, what is the tonal value difference between auditory perception and objective analysis?

Based on the measurement of fundamental frequency of speeches from the selected native Shantou dialect speakers by Praat, objectively analyzed tonal values are provided. In comparison with an auditory perception of tonal value in previous studies, differences between the current study and previous research will be discussed. Moreover, I point out that the tonal system in the Shantou dialect is not spoken with as much symmetrical alignment as compared to the four Middle Chinese tones divided into the upper register and the lower register.

This paper contains five main parts. The first chapter gives a detailed introduction of the Shantou dialect. Second, the methodology that is used in this study is illustrated. Specifically, it includes how the data was collected and processed using a software program called Praat. Next, the third chapter gives an analysis on each tone's value, including illustration on its fundamental frequency and tonal contour. Fourth, previous studies and current study on the tonal system in the Shantou dialect are further discussed. Last, a brief conclusion is listed.

Keywords: the Shantou dialect, eight tonal values, four Middle Chinese tones

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CHAPTER 1

INTRODUCTION

Shantou is a harbor city and one of the special economic zones, located on the northeastern coast of Canton province in southeastern China with a population of about six million. It used to be known as Shantou Port in the Qing Dynasty and later established as Shantou City in 1912.

Shantou is surrounded by the cities of Chaozhou and Jieyang. Together they form the region known as the Chaoshan area with approximately fifteen million people. In the Chaoshan area, the Chaoshan dialect which includes the Shantou dialect, Chaozhou dialect and Jieyang dialect is commonly spoken in daily communication.

The Shantou dialect, as a subgroup of the southern Min, is spoken by about six million people in Shantou and by about four million people in some other places in South Asia, such as Singapore, Malaysia, Thailand and Vietnam.

The fame of the Shantou dialect is due to its preservation of many phonological characteristics from an earlier period of Chinese. It has been considered as one of the most special and the oldest Chinese dialects by one of the greatest linguists - Bernhard Karlgren. Due to this, the Shantou dialect has its unique position in the studies of Chinese phonology.

One distinctive phonological feature in the Shantou dialect is its tonal system. It is commonly acknowledged that the Shantou dialect preserves the four Middle Chinese tones: *Ping, Shang, Qu, Ru* and further splitting into the upper register (*Yin*) and the lower register (*Yang*). Thus, the Shantou dialect can have as many as eight tones.

One main difference between the Shantou dialect and other Min dialects is that the Shantou dialect has eight tones while the others have seven, which lack of *Yangqu* tone compared to the Shantou dialect. A smaller number of the tonal categories in other southern Min dialects are generally considered a consequence of subsequent merger.

In this paper, monosyllables from each of the four Middle Chinese tonal categories with *Yin* and *Yang* category differences are selected to be examined in the pronunciation of the Shantou dialect, in order to further study their relation. Meanwhile, new tonal values are provided to each tone in the Shantou dialect, based on the data collected and the analysis from the experiment.

Additionally, because of the mergence with other cities and counties, Shantou nowadays includes six districts and one county (shown in Figure 1[1]), which are Jinping, Longhu, Chaoyang, Chaonan, Chenghai, Haojiang districts and Nan'ao county.

Figure 1: The Map of Shantou

[1]This Figure is copied from the Wikipedia website. The area of 1 and 3 refers to Jinping and Longhu district respectively. The area of 2 means Haojiang district, 4 means Chaoyang district, 5 means Chaonan district, 6 means Chenghai district and 7 refers to Nan'ao County.

The Shantou dialect spoken in each place except Jingping and Longhu are slightly different in the respect of intonation and vocabularies. The typical Shantou dialect usually refers to the one that is spoken by people from the Jinping and Longhu district. In this paper, the study of the Shantou dialect's tonal system aims to study the one that is spoken in the Jinping district.

Previously, there are a few studies on the tonal system of the Shantou dialect. The earlier record is the dictionary *A Pronouncing and Defining Dictionary of the Shantou Dialect, Arranged According to Syllables and Tones* by Adele M Fielde in 1883. In the front page of his book, he records:

> "In the Chau-chau-fu vernacular there are eight distinct tones, which can be acquired only from a living teacher. Many Chinese teachers know no names for the tones, and different teachers place them in different orders".

A.M. Fielde describes the most usual order of the eight tones are:

Upper even	Lower even
Upper high	Lower high
Upper going	Lower going
Upper entering	Lower entering

Table 1: Fielde's Description on the Eight Tones

He also explains that the entering tones always end with *h, k, p* or *t*, and the tones may be presented schematically as shown below:

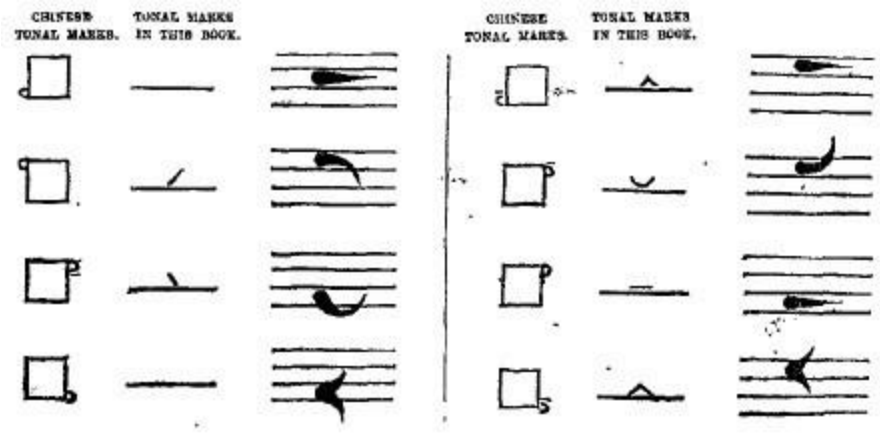

Figure 2: Fielde's Description on the Eight Tonal Contours

Later studies have affirmed that there are eight tones in the Shantou dialect. In 1995, Lin has marked its eight tonal values on a Five Degree Scale (Y.R Chao 1930). Lin points out that one striking feature of the Shantou dialect is that it still remains in the format of the Middle Chinese tonal system and further divides into the *Yin* and the *Yang.* According to his study, the tonal system of the Shantou dialect is marked as:

	I(*Ping*)	II(*Shang*)	III(*Qu*)	IV(*Ru*)
Yin	33	53	213	2
Yang	55	35	11	5

Table 2: Lin's Description on the Shantou Dialect's Tonal System

For the past several decades, this tonal value system has remained unchanged and been frequently quoted. However, the eight tonal values of the Shantou dialect in Lin's study shows deficiency in the description of informants or recorded data and it is great possible that his result is based on personal auditory estimation. There are few studies on this topic since Lin's research.

Languages, including dialects are changing diachronically. The deficiency of previous studies and the question of whether there is possible tonal change or not makes further study in this topic necessary.

With these questions and doubts, I conduct an acoustic experimental study in the tones of the Shantou dialect. Its tonal system has a unique position in the studies of Chinese Phonology. Hopefully, this acoustic analysis will shed light on further tonal studies in particular and other related linguistic studies in general.

1.1 The Four Middle Chinese Tones

The eight tones in the Shantou dialect are commonly viewed as a result of the interaction between the four Middle Chinese tones and the two types of registers. Before we move on to the further analysis in the following chapter, it is important to have some understanding and review on the four Middle Chinese tones and types of registers.

According to *Qieyun*, a Chinese rhythm book from Song Dynasty, there was four tones in the period of Middle Chinese. These four tones are called the level tone (*Ping*), the rising tone (*Shang*), the departing tone (*Qu*) and the entering tone (*Ru*). Further, the eight tones in the Shantou dialect are considered a result of the interaction between the four tones and the types of register (*Yin* and *Yang*). Thus, the eight tones in the Shantou dialect are often categorized and referred to as *Yinping, Yangping, Yinshang, Yangshang, Yinqu, Yangqu, Yinru* and *Yangru.*

Generally speaking, syllables with voiceless consonants or zero initials belong to the upper register tone (*Yin sheng diao*) while syllables with voiced or nasal consonants have a lower register tone (*Yang sheng diao*).

Based on the studies on *Qieyun,* many scholars detect and reach the conclusion of 36 initials in the Middle Chinese phonological system with no doubt. Refer to the former studies on Chinese phonology, the initial system in the Middle Chinese is shown below:

	Voiceless unaspirated	Voiceless aspirated
Yin	[p] [pf] [t] [ʈ] [k] [ts] [s] [tʃ] [ʃ] [ʔ]	[p^h] [pf^h] [t^h] [$ʈ^h$] [k^h] [ts^h] [$tʃ^h$] [h]
	Voiced	Nasal
Yang	[b] [bv] [d] [ɖ] [g] [dz] [dʒ] [ɦ]	[m] [ɱ] [n] [ɳ] [ŋ] [z] [ʒ] [l] [ɲ] [j]

Table 3: The Initials System in the Middle Chinese

For the present acoustic experimental study, the examined monosyllabic words are chosen with reference to a word list from *Fangyan Diaocha Zibiao.* The word list contains about 144 monosyllables which are categorized according to the four Middle Chinese tonal categories—*Ping, Shang, Qu,* and *Ru* into *Yin* and *Yang*. The word list is attached in Appendix A.

One reason to use this word list is to testify whether the eight tones in the Shantou dialect are systematically aligned with *Ping, Shang, Qu, Ru* into *Yin* and *Yang* as said in the previous studies.

One thing should be noticed is that the Shantou dialect does not have the same 36 initials system. During the examination of the monosyllables in the word list, a few

syllables carry voiced consonants which are considered as *Yang sheng* and are found to be pronounced with voiceless consonants in the Shantou dialect.

1.2 Phonological System of the Shantou Dialect

Before moving on to the acoustical experiment and analysis of the tonal relation between the Middle Chinese and the Shantou dialect, it is necessary to have some understanding of the initial system in the Shantou dialect as well.

In the following, its consonant system is presented. There are 18 initial consonants in the Shantou dialect, which are shown below:

	Voiceless	Vocied	
Plosive	[p] [p^h] [t] [t^h] [k] [k^h]	[b] [g]	
Affricative	[ts] [ts^h]	[dz]	
Fricative	[s]		
Approximant			[h] [l]
Nasal		[m] [n] [ŋ]	

Table 4: The Initials System in the Shantou Dialect

In the following acoustical experiment, the phenomenon that syllables within the *Yin* category are pronounced with voiced consonants as well as syllables within the *Yang* category are pronounced with voiceless consonant in the Shantou dialect will be noticed.

1.3 Additional Information

More evidences and analysis regarding the tonal system in the Shantou dialect will be presented in the following chapters.

For the convenience of discussion, several abbreviations of terms are applied in the latter sections:

- The roman number I, II, III and IV is used to represent the level tone *Ping*, the rising tone *Shang*, the departing tone *Qu* and the entering tone *Ru* in the Middle Chinese respectively;
- The letter “a” refers to the upper register *Yin* while “b” represents the lower register *Yang*. For example, Tone “Ia” will refer to the level tone in an upper register— *Yinping*; while Tone “IIb” will refer to the rising tone in the lower register— *Yangshang*.
- MC will stand for Middle Chinese.
- SD will stand for Shantou dialect.

CHAPTER 2

METHODOLOGY

2.1 Materials

For the acoustic analysis of monosyllabic tones in the SD, there are about ten words that are selected from each Middle Chinese tonal category from the words list contained in *Fangyan Diaocha Zibiao*.

Fangyan Diaocha Zibiao is designed by Y.R. Chao and published by the Chinese Academy of Social Sciences Language Institute. It collects more than three-thousand common used characters, which are arranged by their initials, finals and tones in the Middle Chinese according to the rhyme book *Qieyun. Fangyan Diaocha Zibiao* is considered a standard reference book for the studies of Chinese phonology and different dialectal studies. With the reference to *Fangyan Diaocha Zibiao* for dialectal studies, it is easy to distinguish the relation between the dialects and the Middle Chinese phonology as well as to figure out the dialectal phonological systems.

In the front pages of the reference book, there is a word list called the *Shengdiao,* which is a standard word list for the tonal studies in Chinese dialects. In the current acoustical study, this word list is used as a material for the study. The words from this list are sorted by their tonal categories of the Middle Chinese and their types of initials. The chart below shows the words that are selected from the list and used for analysis in this current study.

Tone Ia	诗 梯 衣 灯 方 天 初 昏 胸
Tone Ib	时 题 移 棉 房 田 锄 魂 雄
Tone IIa	使 体 椅 等 碗 委 隐 比 九
Tone IIb	是 弟 以 免 晚 尾 引 米 有
	远 妇 稻 似 市 柱 件 舅 旱
Tone IIIa	试 世 替 意 付 到 四 试 注 见 救 汉
Tone IIIb	事 第 异 面 附 盗 寺 示 住 健 旧 汗
Tone IVa	识 滴 一 得 八 发 督 桌 失 湿
Tone IVb	石 食 笛 逸 灭 拔 罚 毒 实 十

Table 5: Tested Monosyllabic Word List

Specifically, the list is sorted by the four Middle Chinese tonal categories----*Ping, Shang, Qu, Ru*, which are represented from Tone I to Tone IV. Furthermore, they are subdivided by their initial types in the Middle Chinese. For example, words in the “a” item mean that they have voiceless initials while “b” item indicates that they are with voiced initial.

2.2 Informants

In the present study, four informants are chosen to collect the data for the acoustic experiment. There are two considerations when choosing the informants. One is gender difference and the other is age gap. According to a large amount of studies and convincing data, it is commonly acknowledged that the fundamental frequency (pitch/tone) of females is generally and significantly higher than males. For example, in

one previous study done by G.E. Peterson and H.L. Barney (1951), they tested 76 speakers' fundamental frequencies on speaking different vowels and their result shows that female speaker have higher fundamental frequencies than male speakers. (The result from their studies is attached in Appendix B). As to the age gap, there may be possible tonal differences between the younger generation and the older generation due to the language/dialect tone changes.

Thus, in order to reduce the bias opinion caused by influences of different genders and ages, four informants with different ages including two female and two male informants were selected to collect the phonetic data.

The data are based on the recordings of four native SD speakers in December 2013. The detailed information of each informant is described below:

(1) Informant A is a twenty-five year old female. Born and raised in the *Jinping* district, she currently works as a high-school teacher in the *Chaoshan* area speaking the SD in daily communication. She spent most of her time in Shantou city except for four years when she went to college in *Guangzhou* where she spoke Modern Mandarin on a daily basis.

(2) Informant B is a thirty-three year old male. He was born and raised in the *Jinping* district as well. Informant B finished middle school and spent two years in technical training school in Shantou. He currently works and lives in the *Shenzhen* city, speaking in both SD and Modern Mandarin daily.

(3) Informant C is a forty-three year old female. She went to middle school in Shantou. Informant C has been living in Shantou since birth and speaks in SD every day.

(4) Informant D is a seventy year old male. He finished college and worked as a doctor in Shantou. Informant D has also been living in the *Jinpin* district since birth, only speaking SD in daily communication.

2.3 Method and Data

Each informant is invited to read the list of selected words (Table 3), which is categorized based on their MC tonal categories aligning with *Yin* and *Yang*.

The digital audio workstation Cool Edit Pro 2.1 is used to record each speech as a .wav sound file, with 16,000 rates and 16-bit resolution. The sound files are recorded in a completely silent environment in order to avoid any noise interference.

The procedure is that prior to the recording, each informant is asked to read the word list so as to get comfortable and familiar with each monosyllable. After that the informants start to read each monosyllable in a moderately loud and clear voice, with two to three second pauses between each monosyllable.

After the recording, each informant is asked to listen and ensure whether the pronunciation of each monosyllable is what he/she originally intended to articulate. A few of the informants came across the experience that he/she produced several syllables differently or inaccurately compared to what he/she originally intended to pronounce. In this case, recording of the target words were re-made again.

Each sound recording is saved as a .wav file and then analyzed by Praat. Praat is a computer software program for the analysis of speech in phonetics. It detects the spectrum, pitch, intensity, formant, etc. of speech. In this study, Praat is mainly used to

label vocalic segment duration of each monosyllabic word and detect its pitch/fundamental frequency in the pronunciation of the SD.

Specifically, each sound file is converted into a text grid file for the convenience of labeling the voiced segments for measurement of pitch contours and its duration. There are several aspects needed to be considered while marking the starting point and the ending point of pitch contours.

Ideally speaking, the starting point would refer to the beginning of the voicing segment. However, in the actual pitch graphic, it always has slightly unusual curves, either upwards or downwards at the beginning of the pitch (on glide) or in the end of the pitch (off glide). These relatively slight curves at the beginning are not taken and considered as the starting point of the pitch contour because it is universally acknowledged that pitch of a monosyllable in the first few milliseconds is influenced by the voicing characteristics of its consonant at some degree.

Previous studies such as Mohr's (1971) show that the fundamental frequency in the early part of a vowel is influenced by the voicing characteristics of the consonants. Moreover, according to Xu's study of Mandarin, she found that the pitch of a monosyllable that carries aspirated stops was lower than that following the un-aspirated stops; the same result was also found in Cantonese. There are quite a few acoustic studies on the tones. How to segment and measure the pitch during the whole voicing segment are questions concerned by many scholars. According to *A Perceptual Study on the Domain of Tones in Beijing Mandarin,* Lin (1995) segements the pitch during the whole voicing segment into three parts, which is the curve part (on-glide), the main part

(tone), and the dropping part (off-glide). He points out that the on-glide corresponds to the initial consonant while the tone and the off-glide are relevant to the vowel. The information of pitch is carried mainly by the main vowel and its juncture between consonant. Thus, the beginning of the pitch should segment at the juncture between consonant and vowel.

In Shi Feng's acoustic tonal studies on the *Changsha* and *Beijing* dialects, he raises a point that the pitch during the whole voicing segment can divide into two stages, one called the steady stage, and the other called the dynamic stage. Whether the stage is steady or dynamic is decided by the significance of T value (a tonal value on a Five Degree Scale) standard deviation. If the standard deviation is small then it refers to the steady stage and vice versa. Thus, he measures the "steady stage" as the pitch of the syllable.

In my current study, I refer to the previous studies by Lin (1995) and my experimental operation; I use the method of "taking off the on-glide," with the combination of distinguishing by both personal auditory perception and fundamental frequency spectrum as well as considering the influences that different types of consonants may have on the pitch.

Usually, the measurement of pitch begins where the wave form of the F_0 becomes periodically regular and ends where the wave form becomes irregular or stops vibrating. Any unusual "curves" such as "sharp rise and drop" at the beginning or ending of the pitch, are mainly caused by the inertia of the vibration from the vocal cord.

2.4 Normalization of Fundamental Frequency

In order to better compare and analyze the variant data from different informants, the fundamental frequencies are then converted from a hertz (Hz) scale into the YR Chao's Five Degree Scale logarithmically. The converting formula used is:

$$T = [\log (F_{0i}) - \log (F_{0min})] / [\log (F_{0max}) - \log (F_{0min})] * 4 + 1$$ [2]

- T value refers to a tonal value on the Five Degree Scale;
- F_{0i} means each fundamental frequency of the selected point;
- F_{0min} means the lowest F_0 among all the selected points; (the F_{0min} of each informant is various)
- F_{0max} refers to the highest F_0 among all the selected points. (the F_{0max} of each informant is as well different)

The Chao's (1930) is commonly considered as the most standard way to transcribe tones in tonal languages. For example, in Modern Mandarin the four tones are marked as 55, 35, 214, and 51 respectively. The tone of 55 indicates a level tone, so does the tone of 11, 33 or 44 in other languages or dialects. The difference between the tone of 55 and 11 is that 55 is considered a high level tone while the tone of 11 refers to a low level tone. The tone of 33 means a mid-level tone while the tone of 44 is a mid-high level tone. The tone of 35 or 24 refers to a rising tone, and the tone of 51 or 42 refers to a dropping tone. The tone of 214 means that the tone has a curve contour, the pitch rises before it drops to a certain point.

[2]This logarithmical formula is referred from Shen's (1995) *The Tones in the Wujiang Dialect.*

In this study, a Praat script is used to section the selected pitch segments every ten percent of the whole time duration. Thus, there are eleven points taken on each pitch contour. Each point's fundamental frequency is converted from a Hz scale into the T value on a Five Degree Scale graph.

The lowest T value is 1 while the highest value is 5. A rounding off method is applied when the data ranges between 1 and 5. For example, numbers from 1 to 1.49 is marked as 1; numbers from 1.5 to 1.99 is labeled as 2, and so on. A final tone value given at the end is based on the total average in the same tonal category collected from the informants included within this study.

CHAPTER 3

ANALYSES OF TONAL VALUES

3.1 Tone Ia

Tone Ia refers to *Yinping* tone, which is a level tone (*Pingsheng*) with an upper register (*Yin*) in the MC. Based on the measurement of the mean fundamental frequency of selected monosyllabic words from the Tone Ia category, its pitch contour in the pronunciation of the SD from each informant is shown below. In Figure 3, the horizontal axis refers to the percents of the time duration and the vertical axis indicates the range of fundamental frequency. Among all the collected data, the fundamental frequencies of informants range from 60 Hz to 300 Hz. Thus, on the vertical axis, the lowest number is set at 50 Hz while the highest one is set at 300 Hz.

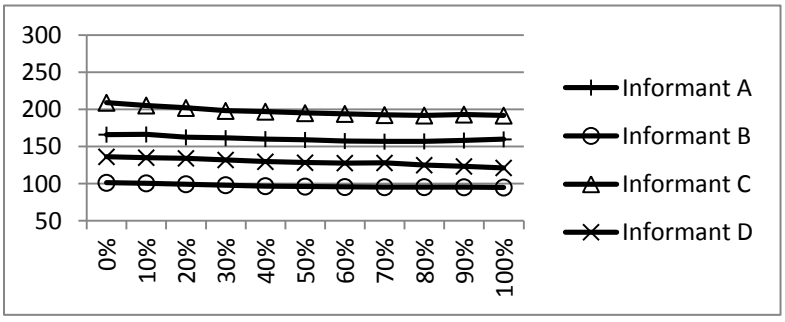

Figure 3: Tone 1 Pitch Contour in Hertz

Tone Ia is pronounced as a level tone in the SD as shown. Furthermore, several linguistic phenomenons regarding fundamental frequency/pitch are also indicated.

First, among the tested informants, the mean fundamental frequency of female informants including Informant A and Informant C is generally higher than that of the

male informants (Informant B and Informant D). Within the female informants, their pitch of the Tone Ia ranges between 150 Hz to 200 Hz. Moreover, Informant C has a higher pitch than Informant A.

In contrast, the male informants including Informant B and Informant D have a relatively lower pitch compared to the female informants. Their mean fundamental frequency of Tone Ia ranges between 100 Hz to 150 Hz. Further, Informant D has a relatively high pitch in comparison to Informant B. Among the four informants, Informant B is observed to have the lowest pitch.

Although there are pitches ranging differently between each informant, the differences are not being considered in this present study. It is commonly known that female informants have a relatively higher pitch than male informants, which is supported by many previous acoustical studies. Barney and Harold (1951) once tested 76 speakers' fundamental frequencies on their vowels and the results well illustrated that the female speakers generally have a higher pitch than male speakers. (The result are shown in Appendix B).

As to the fundamental frequency differences between each informant within the same gender group, it is because that every person carries a different voice, and a different pitch. The difference of pitch is due to personal articulation. Thus, the differences also will not be discussed and considered in the study.

For the purpose of better describing of the tonal contour of the Tone Ia in the SD, YR Chao's Five Degree Scale (1930) is used to picture the tonal contour.

In order to picture the fundamental frequency/pitch of Tone Ia on the Five Degree Scale, a logarithmic formula is used to normalize the data of the pitch. Thus, the measurement of the pitch in hertz is converted into a T value, which ranges from number 1 to 5. After the data processing, Tone Ia on a Five Degree Scale from each informant is given below:

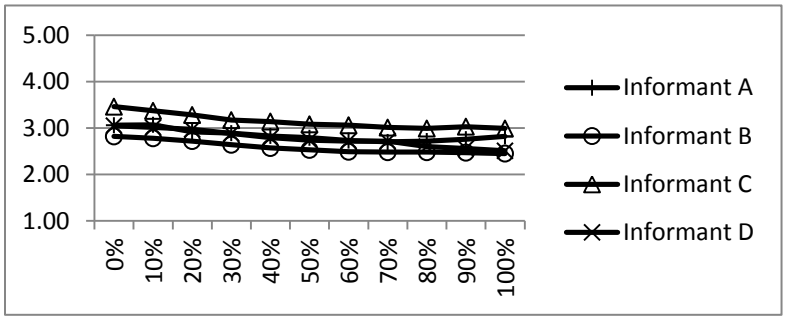

Figure 4: Tone 1 Tonal Contour on a Five Degree Scale

From Figure 4 above, we can see that: after the normalization of the fundamental frequencies, the tonal contour of each informant becomes relatively similar and overlaps. In Table 6[3], more details about the data in Figure 3 and 4 are described:

[3] $F_{Staring}$ refers to the mean fundamental frequency of the selected beginning point, while F_{Ending} indicates the mean fundamental frequency of the ending point within the selected voiced segments. The T next to them shows the corresponding T value on the Five Degree Scale of each point's fundamental frequency.

Informant	$F_{Starting}$	T	F_{Ending}	T
A	166.1	3.06	159.7	2.82
B	101.3	2.82	95.0	2.45
C	209.0	3.46	191.7	2.99
D	136.2	3.05	121.3	2.51
Avg.	153.2	3.10	141.9	2.69

Table 6: Data on the Tone 1 Contour

As Table 6 shows above, the average of the T value of the beginning point and ending point is 3.17 and 2.77 respectively. Using the rounding off method, they can be summarized as 3 and 3. Therefore, Tone Ia in the SD can be graphed as a mid-level tone with value 33.

Notice that the level tone shows a very slight falling tendency overall among the tested samples. For example, the ending pitch or T value generally shows a little lower tendency than the beginning pitch or the T value. This phenomenon happened in 98% of the selected samples within this study. Also it can be observed in another level tone within this study among the informants. This feature will be further discussed later in another level tonal analysis.

Besides from the slight decline, some of the above level tones also show little “bumps”. This feature is as well commonly found in the articulation of a level tone. In fact, it is rare to find that informants are able to maintain a strict line pitch during the whole voicing segments. The same phenomenon can be seen in the other tonal studies as well.

In conclusion, the selected monosyllabic words from the category of Tone Ia of the MC, show a mid-level tonal contour in the SD. The measurement and calculation of

the data shows that the tonal value of Tone Ia in the pronunciation of SD can be summarized as 33, which is marked as Tone 1 in the SD. This result is the same to the previous study by Lin (1995). Thus, the tonal value of Tone 1 can be further confirmed as 33.

3.2 Tone Ib

Tone Ib refers to the level tone (*Pingsheng*) with a lower register (*Yang*) in the MC. In the pronunciation of the SD, the Tone Ib's pitch contour based on the average is listed below:

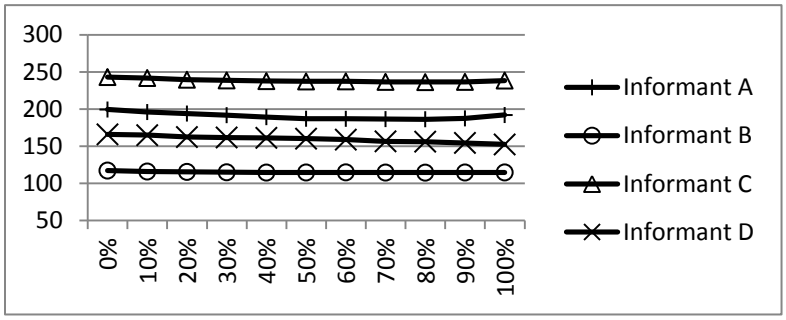

Figure 5: Tone 2's Pitch Contour in Hz

Similar to Tone Ia, it is noticeable that Tone Ib in the SD shows a level contour as well. However, different than Tone Ia, Tone Ib has a higher fundamental frequency overall. In general, for Tone Ib each informant has about 30 Hz higher than Tone Ia level tone in all. Individual informants may have either bigger or smaller differences.

Several features can again be seen in Tone Ib, which are found previously in Tone Ia. For example, first, female informants have a higher pitch than the male informants. Specifically, Informant A's pitch ranges around 200 Hz, and Informant C's ranges around

250 Hz. For the male informants, Informant B 's ranges a little above 100 Hz and Informant D's pitch contour ranges about 150 Hz. Overall, the female informants' pitch can be seen about 50 Hz to 150 Hz higher than the male informants'.

Second, among the female informants, Informant C is found to have a higher pitch than the Informant A; and among the male informants, Informant B has a lower pitch than Informant D. In all, Informant C has the highest pitch compared to the rest of the informants, while Informant B has the lowest pitch among the tested informants. These common features can be seen in the other tonal studies within this study. Thus, it will not be mentioned and discussed any more.

Based on the measurement and the normalization of the fundamental frequency, the pitch of the Tone Ib is shown on a Five Degree Scale below:

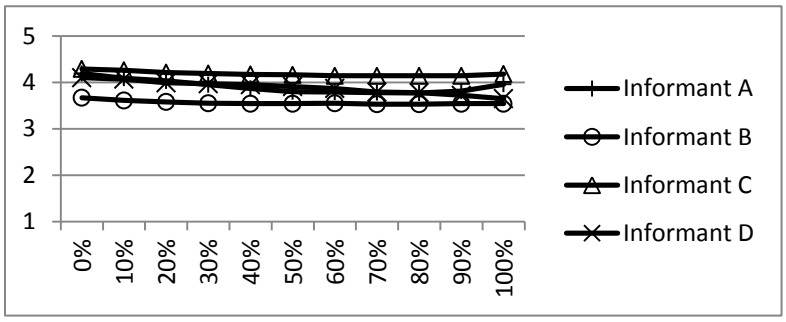

Figure 6: Tone 2 Tonal Contour on a Five Degree Scale

As the graph indicates, Tone Ib in the SD can be marked as tone of 44. Notice that there are some differences between each informant's averages of T value. For example, Informant B is found to have a relatively lower tonal value compared to the others. His Tone Ib pitch is located on around half of Degree 3 while the others' are shown on Degree 4 or above.

Notice that in the previous mid-level tonal category, Informant B also shows a relatively low pitch compared to the other informants. Compared the T values of the $F_{Starting}$ and the F_{Ending} in Tone 1 to those in Tone 2, Informant B shows approximately one degree differences like other informants.

Informant	$F_{Staring}$	T	F_{Ending}	T
A	199.4	4.19	192.0	3.96
B	118.3	3.67	114.6	3.54
C	243.1	4.28	238.6	4.18
D	166.0	4.10	152.4	3.65
Avg.	181.5	4.06	174.4	3.83

Table 7: Data on the Tone 2 Contour

Similar to level Tone Ia, their tonal contours also show a decline tendency. In other words, the ending point pitch is slightly lower than the beginning one. However, overall, their tonal contours indicate horizontal tendency. Therefore, they are considered to be the tone of 44.

In the comparison to the previous studies that have recorded Tone Ib in the SD as a tone of 55 which is a high level tone by auditory perception, I point out that this study's analysis has shown that Tone Ib in the pronunciation of the SD is a tone of 44 during the experiment.

In addition, during the study of Tone Ib, another interesting phenomenon is also found. As we know, in the *Yin* category, there are initials with voiceless consonants and the *Yang* category refers to initial with voiced or nasal consonants. However, in the selected monosyllabic words, which are categorized as the lower register with voiced consonants in the MC, are mostly pronounced as voiceless consonants. For example,

words like 时 题 房 田 锄 魂 雄. These words are considered to have voiced consonants in the MC, however, are pronounced as voiceless consonants [s], [t], [p], [ts'], and [h].

In summary, Tone Ib is pronounced with a tone value of 44 in the SD. It is marked as Tone 2 in the SD in this study.

3.3 Tone IIa

Tone IIa refers to the *Yinshang* tone in the MC, which is also used to represent the third tone in the SD. Previous studies have shown that Tone IIa in the pronunciation of the SD is a high dropping tone with a value of 53. In this experiment, results have affirmed that Tone IIa is pronounced as a dropping tone in the SD, with a value of 51 overall.

There are ten monosyllabic words selected from the Tone IIa category that are pronounced in the SD, and each of the collected informant's pitch is shown below:

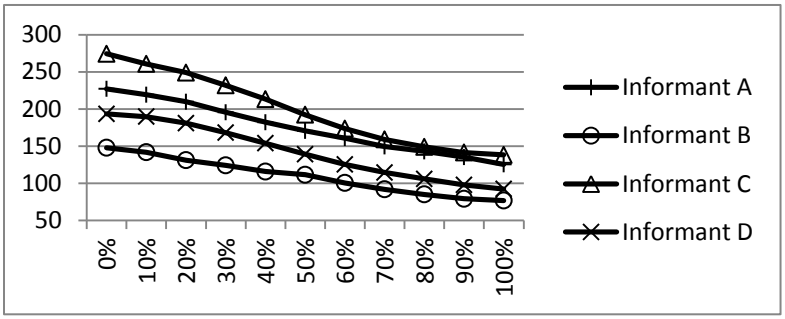

Figure 7: Tone 3 Pitch Contour in Hz

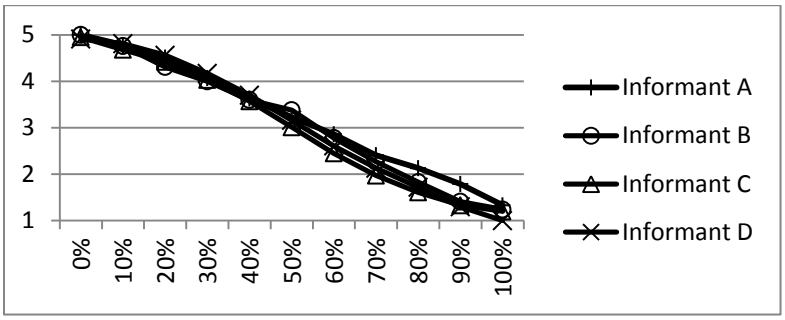

Figure 8: Tone 3 Contour on a Five Degree Scale

Specifically, based on the data collection from the tested informants, in the SD, Tone IIa is pronounced as a high falling tone. Although there are differences between each informant in the fundamental frequency, it shows very little distinctive features after the normalization. Each tonal contour collected from different informants' shows similarity and overlap. On the Five Degree Scale, their pitches fall from the scale 5 reach to about 1.

The chart following shows the fundamental frequency and T value of the beginning point and the ending point from each informant as well as the total average:

Informant	$F_{Starting}$	T	F_{Ending}	T
A	227.1	5.00	125.5	1.33
B	147.9	5.00	76.9	1.24
C	274.2	4.95	138.2	1.20
D	193.4	4.91	92.5	1.00
Avg.	210.7	4.97	108.3	1.19

Table 8: Data on the Tone 3 Contour

Using the rounding off method on the mean of the T value of the beginning point and the ending point from all the informants, the tonal value of Tone IIa can be summarized as 51, which is a high falling tone. However, among the tested monosyllabic characters, various results are collected from each informant. For example, Informant A

has one character pronounced with tone value of 42; Informant B and D have various tonal results such as 41, 51 and 52 collected from the tested characters.

	A	B	C	D
使	51	41	51	N/A
体	52	51	51	51
椅	52	51	51	51
等	41	52	51	51
碗	51	52	51	52
委	N/A	51	51	51
隐	51	51	51	51
比	N/A	51	51	51
九	51	51	51	51

Table 9: List of Contours in Tone 3

From Table 9, the T value of each monosyllable among the informants is quite random. However, they all indicate a falling tone. In order to understand if their differences between each other (such as 51, 52 and 41) are significantly different, a statistical method is applied. First we propose a null hypothesis that the differences between the tone of 51, 52 and 41 are not significantly different, and just a function behavior of the samples themselves. Next, we calculate the standard error of differences between each tonal value in fundamental frequency (The calculation formula are in Appendix D). Third, we proceed to divide the difference between the means by the standard error and get a *t* value. Last, we refer to a table list of the *t*-Distribution[4] value to interpret the meaning the *t* value and further determine whether we could reject the null hypothesis at what level of confidences. After calculation, we

[4] This list is the Table A-1. *t*-Distribution referred from the book of *Statistics in Dialectology* by Lawrence Davis. The list can be found in Appendix C.

got the *t* result of .24 for the beginning point and the result of 1.89 for the ending point. Neither of them is greater than 1.960 (p=.05) to be significantly different. Thus, we could not reject the null hypothesis at p>.05.

Based on the average and the standard deviation of the tonal values, the graph shows the ranges of the value in Tone 3.

PTD	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
T avg.	4.97	4.76	4.45	4.07	3.63	3.20	2.68	2.20	1.82	1.46	1.19
Stdev.	.04	.06	.11	.07	.06	.15	.18	.19	.22	.23	.14

Table 10[5]: Standard Deviation of Tone 3

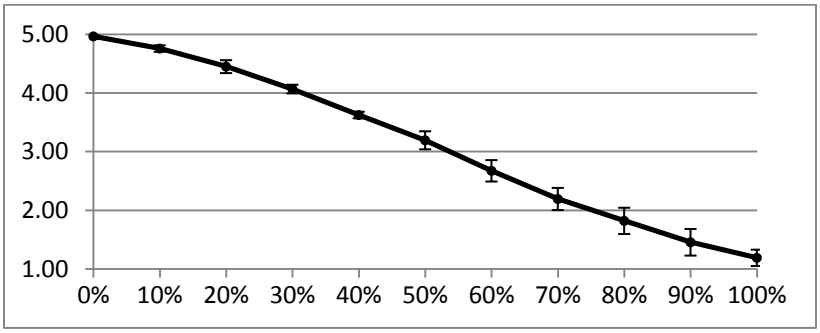

Figure 9: Tone 3 Standard Deviation on a Graph

In Figure 9, the line indicates the average tonal contour of Tone 3. In this graph, the bars above and below the line refer to the standard deviation, which means that some tonal values fall above or below the average. Based on the average, the tonal value of Tone 3 is confirmed as 51 in the SD.

[5]PTD means the percentage of the time duration;
T avg. refers to the mean of T value; and Stdev. is the abbreviation of the standard deviation.

3.4 Tone IIb

Tone IIb, is also called *Yangshang* tone. In previous studies, the *Yangshang* tone in the SD is marked as a rising tone with a value of 35.

However, among the tested monosyllabic words from the Tone IIb category, two distinctive pitch contours are found. The first one is a rising tone while the other one is a falling tone. Among the selected testing words, around two thirds of the words are pronounced with a rising pitch. The graphs of the rising pitch and the tonal contour are shown below:

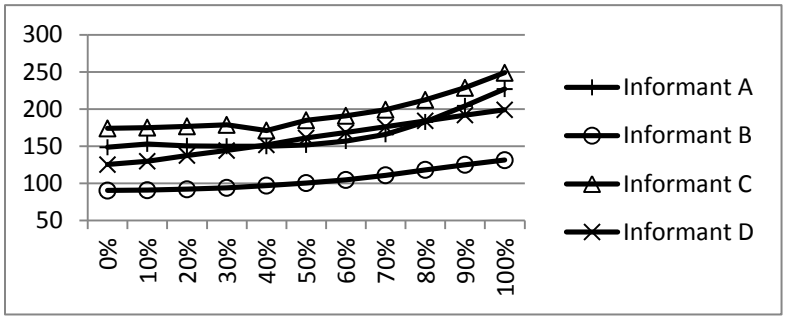

Figure 10: Tone 4 Pitch Contour in Hz

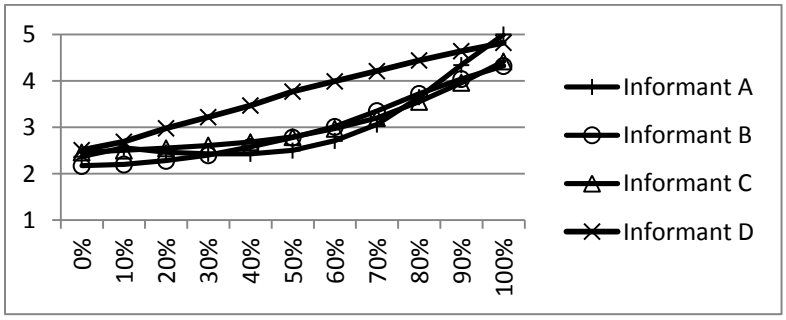

Figure 11: Tone 4 Contour on a Five Degree Scale

Informant	$F_{Starting}$	T	F_{Ending}	T
A	148.6	2.37	226.9	5.00
B	90.4	2.17	131.3	4.32
C	174.0	2.46	248.8	4.42
D	125.3	3.07	199.0	4.58
Avg.	134.6	2.38	201.5	4.64

Table 11: Data of Tone 4

The graphs and table reveal that the four informants all show a rising tonal contour. However, their tonal contour shows a different tendency of rising. For example, the tonal contour of Informant D shows a gradual rising curve continuously, while the other informants' tonal contours prolong and show a flat curve until the middle of the articulation before the line rises gently.

Also, among the informants, various results of the rising tonal values are found. Notice that for Informant B and Informant C, their T value of the beginning points and the ending points fall below 2.5 and 4.5 respectively. Thus, their tonal value of the rising tone is marked as 24. In contrast, Informant D's T value of the beginning point and the ending point both reach above 2.5 and 4.5 respectively. Thus, his tonal value of the rising tone is marked as 25. As to Informant A, her rising tonal value is marked as 25.

In the following table and figure, the total average and the standard deviation from each informant's T value are described.

PTD	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
T avg.	2.38	2.49	2.57	2.67	2.79	2.96	3.17	3.46	3.84	4.25	4.64
Stdev.	.15	.21	.30	.38	.46	.56	.56	.52	.41	.31	.32

Table 12: Standard Deviation on Tone 4

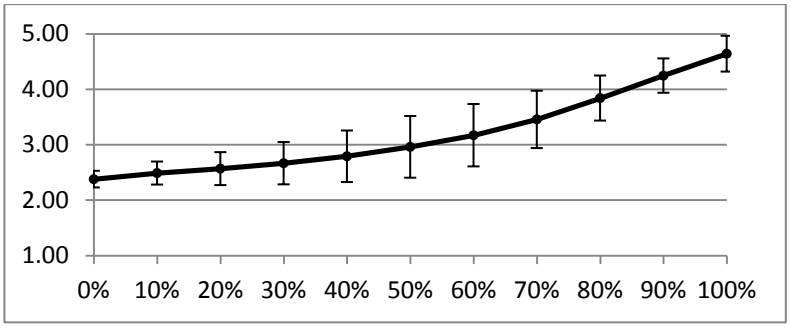

Figure 12: Tone 4 Standard Deviation on a Graph

In Figure 12, the line indicates the average tonal contour of the rising tone. It starts from 2.5 and rises to 4.5 approximately on the scale. The bars above and below the line refer to the standard deviation, which means that some tonal values fall above or below the average among the four informants. Based on the total average and the standard deviation, the tonal value of this rising tone is marked as 25 in this study.

Another pitch contour is also found within the Tone IIb category. About one third of the tested words are found to have a falling pitch curve. For example, monosyllabic words with voiced consonant [bh] such as 尾 and 米, words with nasal consonant [m] such as 免 and 晚, and vowel beginning words such as 以 [i] and 引[i] are found to have a mid-high falling contour, same like the pitch contour of Tone IIa in the pronunciation of the SD.

In the following figure, it describes the pitch contour of the monosyllabic words 尾 米 免 晚 以 引 based on the average.

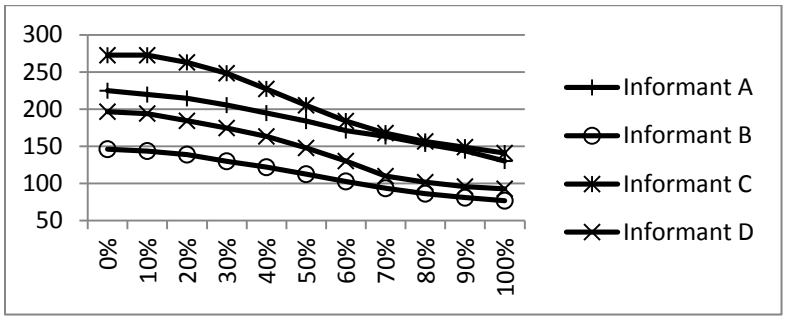

Figure 13: Tone 4' Pitch Contour in Hz

The following is the graph of the falling tonal contour found in the category of Tone IIb. It shows that the pitch drops smoothly from a high beginning, around degree 5 on the scale to a lower degree of 1.

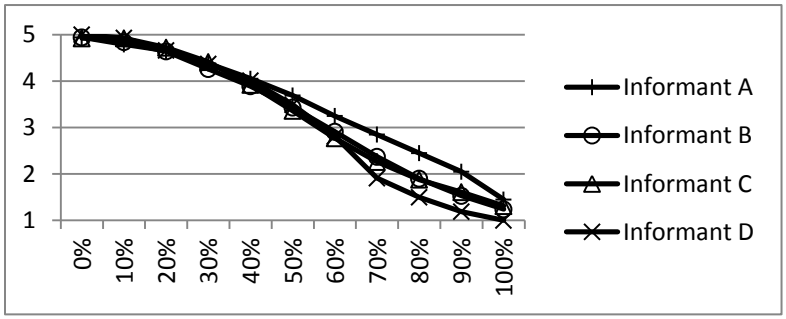

Figure 14: Tone 4' Contour on a Five Degree Scale

Informant	$F_{Starting}$	T	F_{Ending}	T
A	224.8	4.94	128.1	1.45
B	146.2	4.94	76.9	1.24
C	259.3	4.92	160.0	1.31
D	196.6	5.00	92.9	1.00
Avg.	210.0	4.95	110.3	1.25

Table13: Data of Tone 4'

Therefore, according to the measurement, the value of this falling tone can be marked as 51. This falling tone is found to share a great similarity with the tonal contour (in Figure 8) found in Tone IIa. Based on the chart and comparison with Tone IIa, it can

be concluded that the falling tone found in the category of Tone IIb are the same pitch 51 like Tone IIa.

It is an interesting tonal phenomenon that there are words from the Tone IIb category that share the same tone contour with Tone IIa in the SD. In previous studies, it is commonly believed that the eight tones of the SD symmetrically align with the four MC tones splitting into the upper and lower register. However, in the current study, the evidence that the rising tone in the MC with a lower register can have the same tonal value like those with an upper register is found.

As to the reasons of this phenomenon, there may be several explanations: one is the happening of a merge; the tonal category of Tone IIb may be gradually merging into that of Tone IIa. Examples may be found in other Min dialects. For example, different from the SD, the other Min dialects have 7 tones, which lack Tone IIb, the *Yangshang* tone. It is one possibility that the *Yangshang* tone in the SD is merging into the *Yinshang* tonal category like the other Min dialects did.

The other possibility may be that the SD is not aligning with the four MC tones splitting into the *Yin* and *Yang* as the previous studies showed before. Another possibility may be that some pronunciation in the Tone IIb category has been influenced and changed into Tone IIa in the past few decades since the previous studies conducted by other scholars. These possibilities remain as questions that require further studies and research.

In order to step closer to understand this interesting phenomenon, further research is conducted in this study. First, the chance that the tonal pitch of Tone IIb has

been changed in the past few decades is relatively low since in this current study, the older age informant is selected in order to consider the differences between the young informants and older informants. For example, Informant C is aged 50 and Informant D is over 70, while Informant A and Informant B are age 25 and 34 respectively. However, the statistics show that the difference between each informant's tone pronunciations of each monosyllabic word is little. There is no obvious evidence in the current study that some items in the Tone IIb category have been changing into the Tone IIa category in the past several decades.

However, the change might have happened further in the past. Back in 1883, a scholar named Adele M. Fielde recorded the eight tones in the SD, and compiled a dictionary of the SD. In his book *A Pronouncing and Defining Dictionary the Shantou Dialect, Arranged According to Syllables and Tones,* words are recorded with tonal pronunciation. In order to detect whether there is tonal value changes during the past century, his tool book is referred to look at the tones of the selected words in the present study.

In the present study, 19 monosyllabic words are selected from the category of Tone IIb in the MC to examine their tonal values in the pronunciation of the SD. During the analysis, about 7 words are found to have the tonal value 51, which is a high dropping tone. These monosyllables begin with nasal consonants, voiced consonants and vowel initials. They are [mi] [mun], [mian], [bhue], [iaŋ], [i] and [in].

According to the dictionary *A Pronouncing and Defining Dictionary the Shantou Dialect, Arranged According to Syllables and Tones* by Adele M. Fielde, all the words

except 远 are pronounced as a falling tone, which refers to the *Shangshang* (upper high) tone in his recording. 远 is recorded as a rising tone, which refers to the *Shangxia* (low high) tone. It refers to what we call Tone IIb (*Yangshang* tone), a mid-rising tone.

In the present study, the monosyllable 远 is pronounced as [iaŋ] with a tonal contour 51 by all four selected informants. In Fielde's dictionary, 远 is recorded as [hug] with a rising tone.

In fact, according to the later study, 远 can have two pronunciations, one is the so called the colloquial layer while the other is called the literary layer. Specifically, the colloquial layer is pronounced as [həŋ] and the literary layer is pronounced as [iaŋ].

One of the distinguishing features of the SD is that it has the layers of colloquial and literary. The differences between colloquial pronunciation and literary pronunciation can be huge. Generally speaking, colloquial pronunciation represents an earlier period of the language while the literary layer represents a later period. The literary pronunciation is usually generated and borrowed, affected by other dominant languages. It is called literary pronunciation because people from earlier periods used pronunciation that is close to the dominant language/dialect as a standard to teach and learn because of its "orthodoxy". Thus, it is easy to find that some literary pronunciation is closer to the official language Mandarin. 远 is one of these examples. Other examples are listed: such as 等 [teŋ] (literary) vs 等 [taŋ] (colloquial); 方 [huaŋ] (literary) vs 方 [həŋ] (colloquial). The colloquial pronunciation usually refers to the original pronunciation in one language/dialect that is used for daily communication.

In conclude, in the tonal studies of the Tone IIb category from the MC. There are two distinctive tonal contours are found in the pronunciation of the SD. One is a rising tone 25 while the other is a falling tone of 51. Specifically, among the selected monosyllabic words: 是，士，弟，以，免，晚，尾，引，米，有，远，妇，稻，似，市，柱，件，舅，旱, words begin with nasal consonant [m] initials, voiced consonants like [bh] or with no consonant initials like [i], such as 以，免，晚，尾，引，米，远 are found to have tone value 51. Words such as 是，士，弟，妇，稻，似，市，柱，件，舅，旱, which pronounce with voiceless consonants in the SD, show a rising contour. And the rising tone of value 25 is marked as the fourth tone in the SD in this study.

3.5 Tone IIIa

Tone IIIa is called the *Yinqu* tone in the MC. Referred to the previous studies, the Tone IIIa in the SD is considered as a curve tone of 213. Its pitch drops to a lower point and rise up back, which is similar to the third tone in Modern Mandarin. However, in the present study, measurement and statistics show that its pitch contour is actually a fairly low and flat pitch compared to the auditory perception.

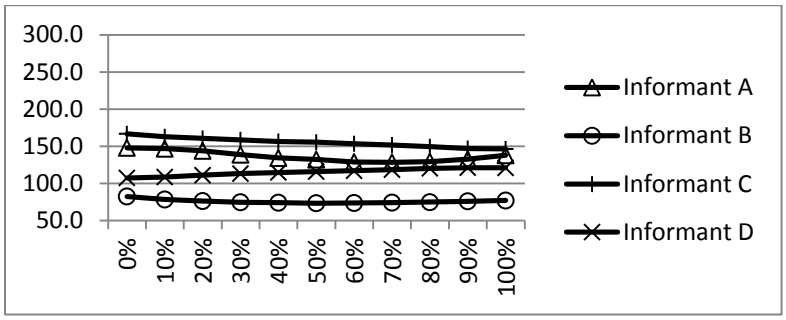

Figure 15: Tone 5 Pitch Contour in Hz

In the following, on a Five Degree Scale, it indicates that Informant A and B share more similarity with their tonal contours. Specifically, their pitch starts at around degree 2 on the scale; declines quite mildly then slowly shows a rising tendency. In comparison, Informant C indicates a graduate decline while Informant D shows a gentle rise.

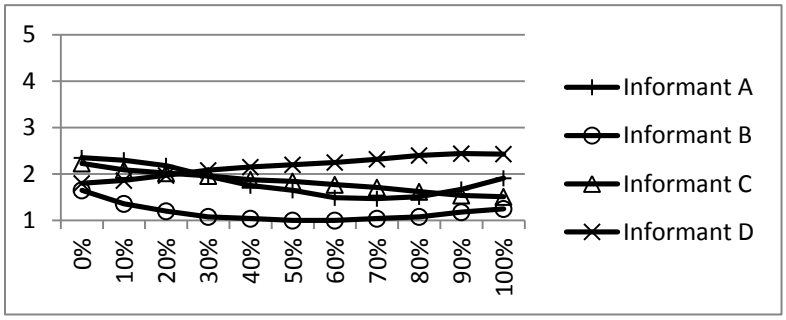

Figure 16: Tone 5 Contour on a Five Degree Scale

Using the rounding off method based on the data in the Table 14, the beginning and the ending pitch are measured as 22 on the Five Degree Scale. Although Informant C's pitch shows a falling tendency and D's pitch shows a climbing tendency, their tonal contours still range within the degree of 2.5. Therefore, it seems that the tonal value of Tone IIIa can be marked as 22.

However, from Figure 16 we can see that Informant A and Informant B's pitch contours decline after the beginning points, and reach a relatively lower point before going up again. More data is listed in Table 15 for this tonal study in order to decide whether it is a tone of 212 or 22.

Informant	$F_{Starting}$	T	F_{Ending}	T
A	148.0	2.35	138.0	1.91
B	82.6	1.65	77.1	1.25
C	166.9	2.23	146.4	1.51
D	107.5	1.80	121.0	2.43
Avg.	126.3	2.01	120.6	1.78

Table 14: Data of Tone 5

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
A	2.35	2.30	2.18	1.95	1.75	1.65	1.49	1.47	1.51	1.67	1.91
B	1.65	1.36	1.20	1.08	1.04	1.00	1.00	1.04	1.08	1.18	1.25
C	2.23	2.09	2.02	1.96	1.88	1.84	1.77	1.71	1.62	1.54	1.51
D	1.80	1.86	1.97	2.08	2.15	2.20	2.25	2.32	2.40	2.44	2.43
Avg.	2.01	1.90	1.84	1.77	1.71	1.67	1.63	1.64	1.65	1.71	1.78

Table 15: Detailed Data of Tone 5 by Percentages

According to Figure 16, the tonal contour of each informant shows a little diversity. For example, Informant A's and B's show concaved arc-shaped contours. For example, Informant A's tonal contour falls to a little lower than 2.5 and rise back again to around 2 on the degree scale. Informant B starts at a relatively lower point around 1.7 and declines to the lowest point 1 before rise a little to 1.3. Informant C shows a flat falling tendency in her tonal contour within 2. In contrast, Informant D shows a flat rising tonal contour, however, it ranges within degree 2.

In Figure 17 below, the line indicates the average tonal contour of Tone 5. Overall, it starts from 2 and slightly declines then climbs back a little within the range of

degree 2 on the scale. The bars above and below the line refer to the standard deviation, which means that some tonal values fall above or below the average among the four informants.

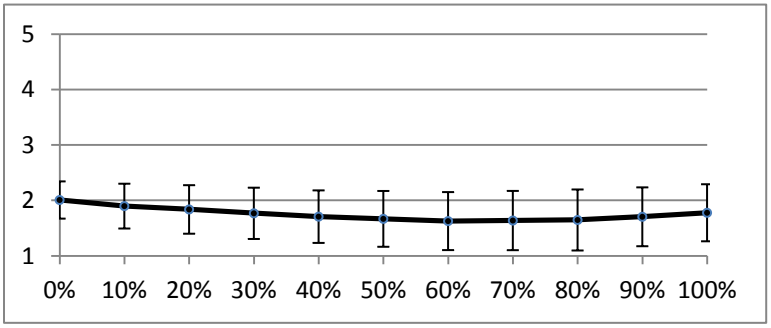

Figure 17: Tone 5 Standard Deviation on a Graph

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Avg.	2.01	1.90	1.84	1.77	1.71	1.67	1.63	1.64	1.65	1.71	1.78
Stdev.	.34	.40	.44	.46	.47	.50	.52	.53	.55	.53	.51

Table 16: Standard Deviation of Tone 5

From the numbers of standard deviation in Table 16, we can tell that the differences between each informant in Tone 5 are relatively big. Their contour values of Tone 5 are quite different between each informant. In the later summary, each informant's tonal system will be listed to compare separately.

3.6 Tone IIIb

Tone IIIb refers to the *Yangqu* tone in the MC. In the present study, 13 monosyllabic words from the Tone IIIb category are selected to be pronounced in the SD. During the analysis, two distinctive pitch contours are found. The result shows that about one third of the words have a falling tone while the rest have a rising tone.

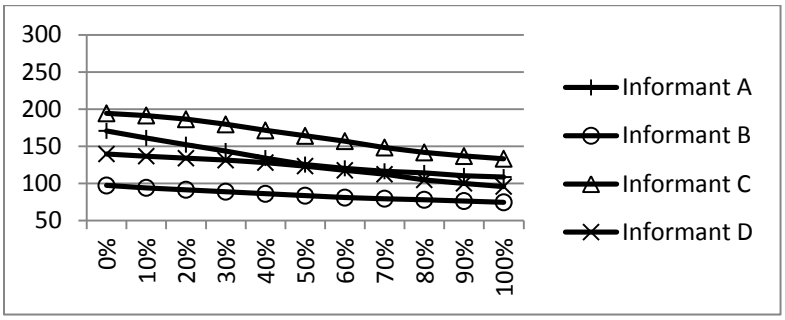

Figure 18: Tone 6 Pitch Contour in Hz

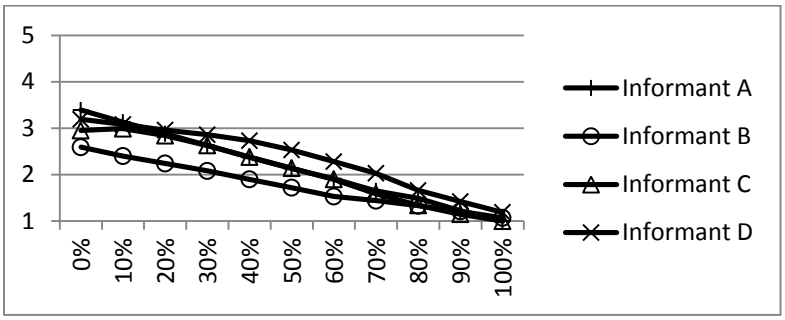

Figure 19: Tone 6 Contour on a Five Degree Scale

In Figure 19, we can tell that four informants show a consistence in the falling contour. Their tonal contour all fall from around degree 3 to 1 on the scale, which is considered a mid-falling tone.

Based on average T value of the beginning point and the ending point (shown in Table 17), this tonal value is marked as 31. Similar to the tone of 51 that is discussed in the earlier section, the tone of 31 and the tone of 51 are both falling tone in the SD. Also they both share a same interval of degree in falling. However, one distinguishing feature is that the tone of 51 has a very high beginning pitch, and sharper falling in the comparison to the tone of 31. This difference can be carefully distinguished by auditory as well.

Informant	$F_{Starting}$	T	F_{Ending}	T
A	170.8	3.39	108.6	1.00
B	97.3	2.59	74.7	1.07
C	194.4	2.95	133.3	1.00
D	139.7	3.19	95.9	1.19
Avg.	150.6	3.03	103.1	1.07

Table 17: Data of Tone 6

Another pitch contour found in the Tone IIIb category is a rising pitch. About one third of the tested words have the rising tone. The rising tonal contours in Hz and on the Five Degree Scale are shown in Figure 20 and 21 separately:

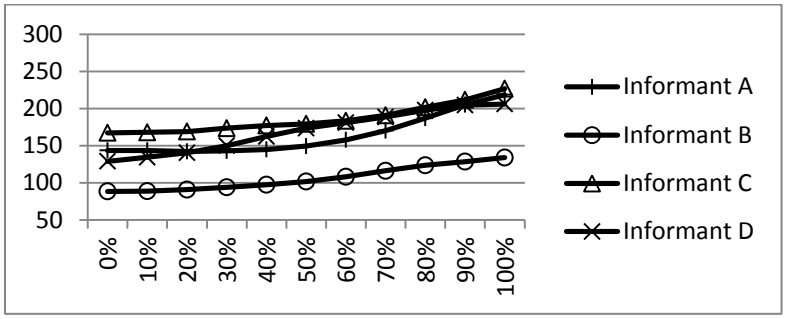

Figure 20: Tone 6's Pitch Contour in Hz

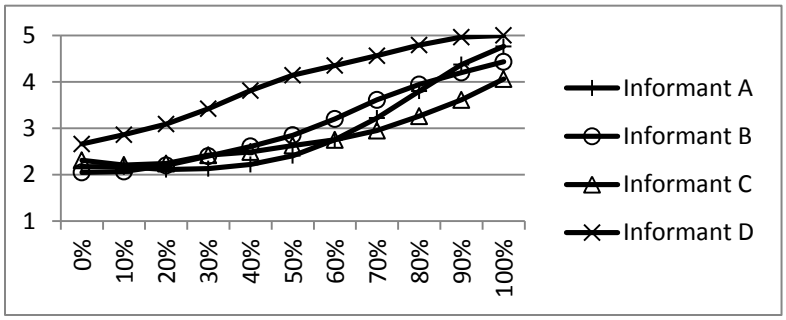

Figure 21: Tone 6' Contour on a Five Degree Scale

Informant	$F_{Starting}$	T	F_{Ending}	T
A	143.7	2.17	218.6	4.76
B	88.6	2.05	134.0	4.43
C	167.4	2.31	226.7	4.06
D	129.1	2.66	206.1	5.00
Avg.	132.2	2.30	196.4	4.56

Table 18: Data of Tone 6'

The figures above shows the details of the rising tone of 25. Starting at degree 2, the tonal contours of Informant A, B and C prolong to 40% of the time duration and then gradually rise to about the same at degree 5. By contrast, Informant D, which rises up relatively smoothly continuously. These tonal features have been found in the category of Tone IIa before in the study. Compared to the pitch contour of Tone IIa in Figure11, we can easily notice they both have the same pitch.

Beyond that, characters such as 侍 异 附 示 are found to have different pitch from different informants. For example, 侍 is pronounced by Informant A as a falling tone while by other informants, it is pronounced as a rising tone. Such examples are listed in Table 19.

	Informant A	Informant B	Informant C	Informant D
事	31	31	31	31
侍	31	24	24	35
第	25	24	N/A	35
异	31	24	24	31
面	31	31	31	31
附	31	N/A	31	22
盗	35	24	24	25
寺	31	31	31	31
示	24	24	31	31
住	35	25	34	35
健	25	24	24	35
旧	31	31	31	31
汗	31	31	31	N/A

Table 19: Differences between the Informants in Tone 6

In conclude, similar to the category of Tone IIb, there are also two pitch contours found in the category of Tone IIIb. One is a middle falling tone of 31, while the other is a low rising tone of 25. In other word, that is to say, there are monosyllabic words from the Tone IIIb (*Yanqu sheng*) category pronouncing as Tone IIb (*Yangshang sheng*) in the SD dialect. Findings of this tonal phenomenon have illustrated that the eight tones in the SD does not strictly align with the four MC tones into the *Yin* and *Yang* categories as it said before.

Compare to the previous study, the tonal value of monosyllabic words from the Tonal IIIb category has been described as the seventh tone with value of 11 in the SD by Lin's study in 1995, as well as quoted in many other studies. However, in the current study, according to the acoustic experimental calculation, they are believed to have the tonal value 31, which is marked as Tone 6 in this study. Moreover, tonal value 25, a rising tone is also found in this category, which refers to Tone 4.

3.7 Tone VIa

Tone IVa refers the *Yinru* tone in the MC. Nowadays, Modern Mandarin and some other Chinese dialects have no *Ru* tone. The words from the *Ru* category are pronounced with other tones, such as *Yinping, Yangping* etc. However, the SD is one of a few Chinese dialects that preserve the *Ru* tone. One of the distinguishing features in the words with *Ru* tone in the SD is that they end with consonants [p], [h] [ʔ] or [k]. Another distinctive feature is that the *Ru* tone is pronounced as a very short and sharp tone in the SD. In later chapter, the comparison of each tone's time duration will be displayed. Previous studies have released that the SD has two *Ru* tones which are *Yinru* and *Yangru.* The following graphs show its pitch contour in Hz and on a Five Degree Scale. Notice that the horizontal axis shows the percentage of the time duration, instead of the actual timing. In an actual pitch graph shown in Praat, its pitch curve is very short.

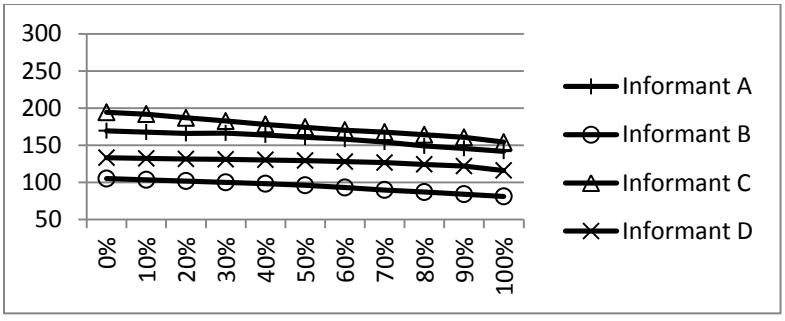

Figure 22: Tone 7 Pitch Contour in Hz

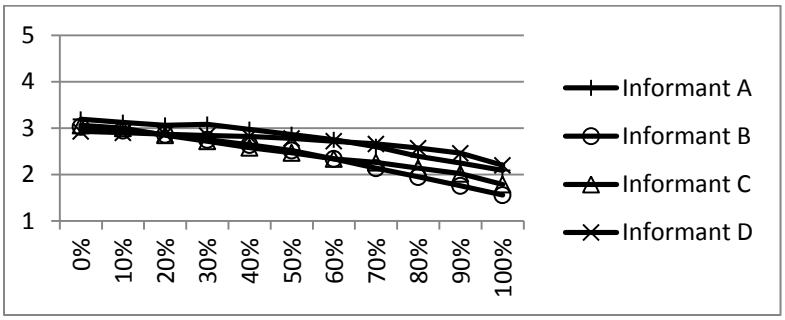

Figure 23: Tone 7 Contour on a Five Degree Scale

Informant	$F_{Starting}$	T	F_{Ending}	T
A	169.5	3.19	141.9	2.09
B	105.1	3.03	81.2	1.56
C	194.3	3.06	154.1	1.79
D	133.2	2.93	116.1	2.20
Avg.	149.5	3.05	123.3	1.91

Table 20: Data of Tone 7

Based on the measurement, the *Ru* tone in the SD is marked as the tone of 32, which is a sharp and short tone with a light falling tendency. In this study, the tone of 32 is marked as Tone 7 in the SD.

3.8 Tone VIb

Tone VIb refers to the *Yangru* tone. In the SD, *Yangru* tone carries the same features as the *Yinru* tone. However, their tonal contours are quite different.

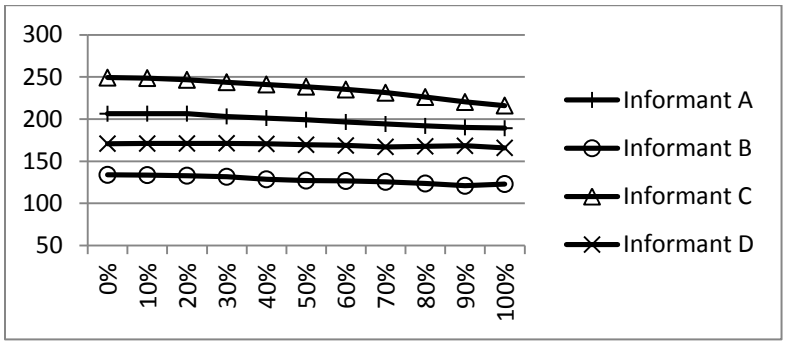

Figure 24: Tone 8 Pitch Contour in Hz

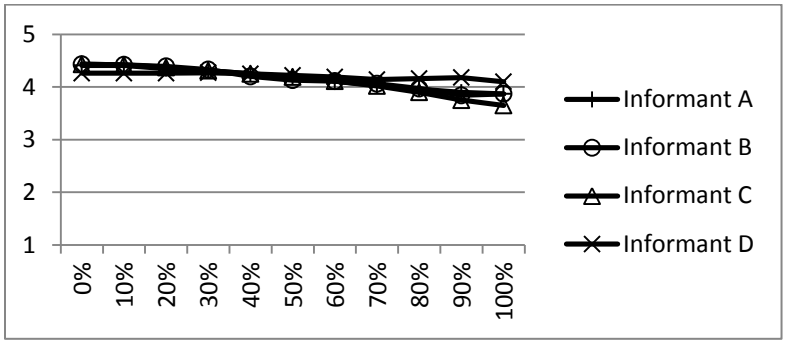

Figure 25: Tone 8 Contour on a Five Degree Scale

Informant	$F_{Starting}$	T	F_{Ending}	T
A	206.4	4.41	189.2	3.87
B	133.9	4.43	121.5	3.87
C	249.2	4.43	216.1	3.65
D	170.9	4.26	165.9	4.10
Avg.	190.1	4.38	173.6	3.87

Table 21: Data of Tone 8

Little difference is found in the tonal contour of Tone IVb among tested informants. From the graph and data above, we can see each informant's tone consistently starts at 4 on the degree scale and remains about the same place before a little decline at the end. In all, the pitch of Tone IVb remains at 4 degree in the SD during the whole articulation. Based on the measurement, its tonal value can be marked as 4. The reason why it is labeled as 4 instead of 44 is that in order to distinguish with Tone Ib,

which has value of 44. Compare to Tone Ib, Tone IVb has shorter and more rapid pitch sound. In this study, the tone of 4 is marked as Tone 8 in the SD.

3.9 Time Duration of Each Tone

In order to understand differences of the average time duration between each tone, especially the *Ru* tone and the other tones in the SD, the time duration of each tone from each informant are shown below:

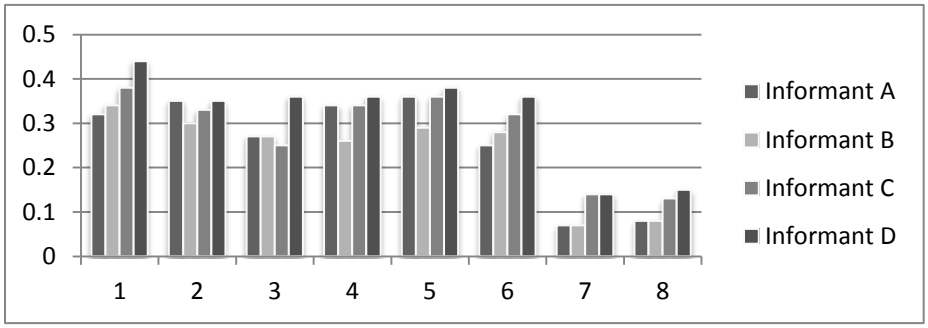

Figure 26: Time Duration of Each Tone

One distinguishing feature is that Tone 7 and Tone 8---–the two *Ru* tones are quite short in contrast to other tones. In average, the time duration of Tone 7 and of Tone 8 is approximately one to two times shorter than of the other tones.

Further, there is no evidence that the male informants have longer time duration of the tone articulation than the female informants, or vice versa. (The compared graph is shown in Figure 27). Other feature is Informant D has a long time duration pronouncing each tone among the informants, but it can be inferred as a personal pitch feature.

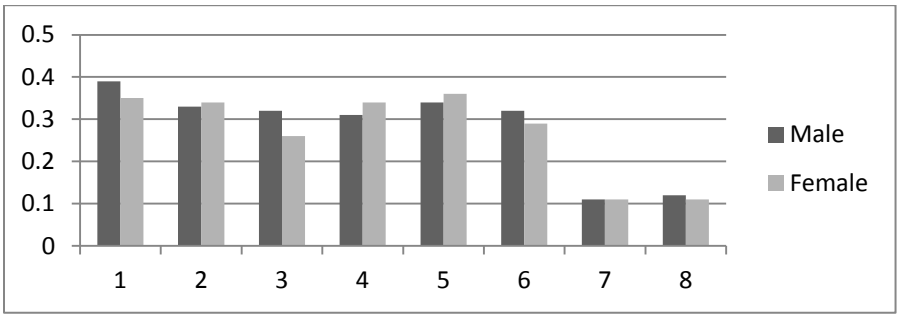

Figure 27: Comparison of Time Duration between Each Tone

In conclusion, one distinguishing difference between the *Ru* tones and the other tones in the SD is that the *Ru* tones are a very short and rapid tone while the others are relatively prolonged.

3.10 Summary on the Eight Tonal Values

In this acoustical experimental study, using the word list that is categorized by the four Middle Chinese into *Yin* and and *Yang* register, I tested the monosyllabic words' pronunciation in the SD. Based on the data collected from the four native speaker informants and the pitch analysis of Praat, eight tones are found and I present that their tonal values are:

Tone	1	2	3	4	5	6	7	8
Value	33	44	25	51	22	31	32[6]	4

Table 22: My Description on the Eight Tonal Values

[6]The underline below 32 indicates that tone of 32 is a very short tonal contour with a slight falling tendency, in order to distinguish it with other prolongs tones.

CHAPTER 4

REMARKS ON PREVIOUS STUDIES AND CURRENT STUDIES

4.1 Remarks on Previous Studies

4.1.1 Fielde's Study

Early in 1883, Fielde recorded the eight tones in the SD. Back then, he did not indicate the tonal value of each tone but presented tones visually on a four degree scale (shown in Figure 2).

When I compared the pitch of the selected monosyllables that the informants pronounced in my study to Fielde's previous studies, I found most of the pitches were matched. However, differences are found in Tone IIb (Tone 4) and Tone IIIb (Tone 6). They are listed below:

Tone IIb	Fielde	Present Study
尾	Upper high	51
引	Upper high	51
以	Upper high	51
远	Upper high	51
免	Upper high	51
晚	Upper high	51
Tone IIIb		
第	Lower high	25
住	Upper high	25
附	Lower high	22
异	Lower high	31/25
健	Lower high	25
侍	Lower high	25
示	Lower going	31/25

Table 23: Comparison of Words' Pitches Descriptions

In the previous chapter 3.4 we have discussed that in the SD, several monosyllabic words such as syllables starts with voice consonants, nasal consonants or semi-vowels in the Tone IIb category of MC carry a falling pitch, which is the same pitch found in the Tone IIa category. Compared to the records by Fielde, the result is observed as the same as the one in the current acoustical study.

4.1.2 Lin's Study

There are not many studies on the tonal system in the SD even since Fielde's research. A recent one is done by Lin in 1995. In his study, he describes the eight tones in the SD as a result of the splitting of the four Middle Chinese tones into the upper register and the lower register. He said that the tonal system of the SD dialect preserves the format of the four MC tones in the alignment of the *Yin* and *Yang*. Further, the tonal system in the SD that he describes is shown in Table 2 in the previous introduction.

However, his methodology is inexplicit. For example, there is no detailed description on the informants and how the tonal value is marked. His record is probably based on personal auditory estimation.

4.2 Remarks on the Current Study

The current study reveals that the eight tones in the SD is not symmetrically in the alignment with the four Middle Chinese tones and types of registers as spoken in the previous studies. Among the tested words of each Middle Chinese tonal category, *Yinping, Yangping, Yinshang, Yinqu, Yinru* and *Yangru* category are found to have a consistent tonal contour in the pronunciation of the Shantou dialect. Further, their tonal contours can be marked as 33, 44, 51, 22, 32 and 4 in the Shantou dialect.

However, in the *Yangshang* and *Yangqu* category, words are found to have two distinctive tonal contours in the Shantou dialect. They are 25 and 51 in the *Yangshang* category, 25 and 31 in the *Yangqu* category.

Notice that the values of eight tones are based on the average values collected from the four informants. In fact, among each informant, their eight tonal values are slightly different from each other.

	1	2	3	4	5	6	7	8
Informant A	33	44	51	25	22	31	32	4
Informant B	33	44	51	24	21	31	32	4
Informant C	33	44	51	24	22	31	32	4
Informant D	33	44	51	35	22	31	32	4

Table 24: The Eight Tones Values of Each Informant

From Table 24 we notice that there are differences between the four informants in the contour values of Tone 4 and Tone 5. Taking Tone 4 as an example, Informant D has the tone value of 35, which is same to the tonal record in the previous studies. However, the rest of the informants show different cases. Informant A has the value of 25 while Informant B and C have the tonal value of 24.

The rest of the tonal contours share the same values among each informant. The four figures below represent the eight tonal contours of the four informants separately, from which we can see that each informant shares great similarity in their tonal contours except Tone 4 and Tone 5. The short lines with hollow circles indicate the *Ru* tones (Tone 7 and Tone 8).

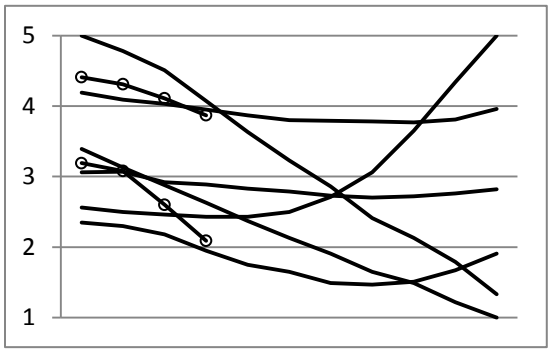

Figure 28: Informant A's Eight Tones

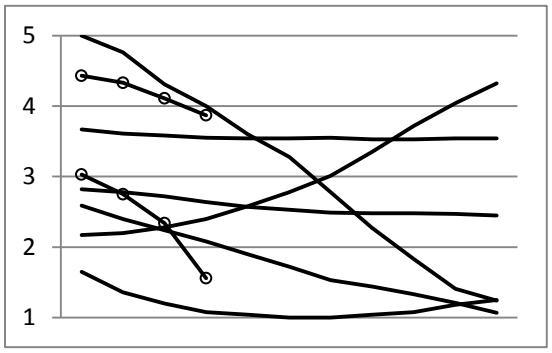

Figure 39: Informant B's Eight Tones

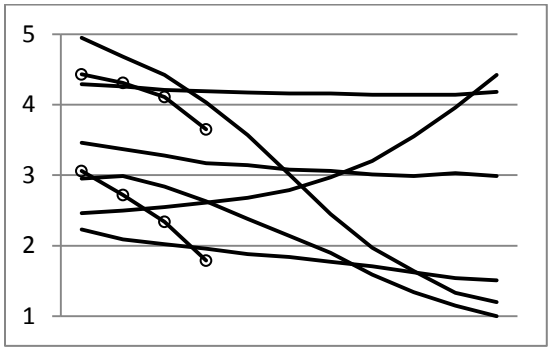

Figure 30: Informant C's Eight Tones

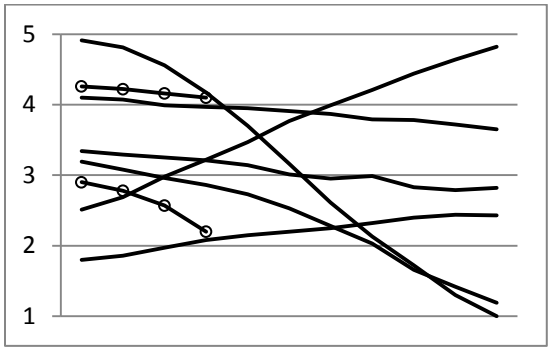

Figure 31: Informant D's Eight Tones

For example, Informant B has a relatively low pitch contour of Tone 5 (the one with a concaved arc-shaped near degree 1) compared to the others'. Informant A also shows a concaved arc-shaped contour in her fifth tone but her contour is relatively higher (ranges around degree 2) compared to Informant B's. Informant C and D shows a quite different contour shape in their fifth tones compared to the other informants. For

example, Informant C has a falling contour (ranges from degree 2 to about 1.5) while Informant D shows a slight rising contour (ranges from about degree 2 to 2.5).

When discussing the differences of the eight tonal values between each informant, we come across interesting questions: why would they have different tonal contours for the same category? Can any of their individual eight tones values or their average represent the tonal system in the Shantou dialect?

Saussure once identified the differences between Langue and Parole (which refers to idiolect). The langue itself is a complicate system (Wang 2006). The language exists in idiolects and is a systematic summary of idiolects (Shen 2014).

In many previous languages' or dialectal studies including this current study, researchers selected a few native-speaker informants to have their sounds recorded, thus to describe the phonological systems of the studied languages or dialects.

However, each individual informant may have more or less discrepancies in his/her idiolect. The languages' or dialectal systems described by the represent informants may not represent every speaker in that language or dialect (Shen 2014). Shen's viewpoint of Idiolect well explains the slight tonal value differences exist among the informants included in the current study.

Although there are some slight differences of the tonal values found between each informant within this study, overall, the tested informants generally show a great consistence in the eight tonal contours in the Shantou dialect. Based on the collecting data from the four informants and my acoustical experimental analysis, the tonal system in the Shantou dialect can be drawn as:

Tone	1	2	3	4	5	6	7	8
Value	33	44	25	51	22	31	32[7]	4

I conclude the eight tonal values as shown above is hope to provide a general idea of the eight tonal values in the Shantou dialect. This tonal system may not represent every individual Shantou dialect native speaker since idiolect can be various from one to one. However, it overall summarizes the tonal system in the Shantou dialect.

4.3 Comparison between Current Studies and Previous Studies

I compared the findings in the current study to the previous studies and I found that there are some similar results as well as differences.

On one hand, the similarity is that all the results show eight distinctive tones in the Shantou dialect.

On the other hand, one distinguishing difference compared to previous studies by Lin is that two distinctive tones are found in the *Yangshang* and *Yangqu* categories. Specifically, there are words from the *Yangshang* category that are pronounced with a *Yinshang* tone in my study. There are some words from the *Yangqu* category that are also share the same tonal contour with the words of the *Yangshang* category.

Another distinguishing difference compared to Lin's studies is the records of the tonal values. For example, one distinctive difference is that Tone 6 is marked as the tone of 31 in the study, however, he indicates Tone 6 as 11. In the previous similar studies in

[7]The underline below 32 indicates that tone of 32 is a very short tonal contour with a slight falling tendency, in order to distinguish it with other prolongs tones.

the tones of the Chaozhou dialect, Lin (1995) also indicated that the tonal value of the *Yangshang* tone (Tone 6 in the Chaozhou dialect) is 11. However, in the later acoustical studies conducted by Li and Zheng (2010) found that the tonal value of the Tone 6 in the Chaozhou dialect is 31 with the experimental analysis. These similar studies and results may provide us supporting evidence to question the accuracy of the previous records of the tonal values.

Moreover, the other noticeable difference is that Tone 5 is marked as a low tone of 22 in this study. Previous studies indicate it as a curve tone of 213. Notice that in this acoustic experiment, there is data showing that the tonal contour decline a little and climb back at the end. The pitch contour shows a fairly low position around 2 on the Five Degree Scale. However, two informants show no curve in their pitch, but a flat rise tone of 22 and a flat decline tone of 22 respectively, although it is hard to tell their differences by auditory perception. Therefore, Tone 5 is marked as a low tone of 22 in this study.

4.4 Notes

1. The analysis of the eight tones in the Shantou dialect within this study is based on the data collected from the four native Shantou dialect speakers. There is a limited number of informants included in this study. Thus, the data may not represent all the people who speak the Shantou dialect. There may be differences between each individual Shantou dialect speaker.
2. The selected monosyllabic words for this acoustic analysis is referred to the word

list in the *Fangyan diaocha zibiao.* Differences may exist in other words that are not included in this current study.

CHAPTER 5

CONCLUSION

In all, in the current acoustic study, around one hundred monosyllabic characters from the four Middle Chinese tonal categories with *Yin* and *Yang* register differences are tested in the pronunciation of the Shantou dialect. Based on the fundamental frequencies collected from the four native Shantou dialect speakers, the data are converted from hertz into Y.R. Chao's Five Degree Scale.

During the studies, eight distinctive tonal contours are found. Based on the tonal analysis, I found that values of the eight tonal contours can be concluded as 33, 44, 51, 25, 22, 31, 32, and 4 in general. However, notice that different individual may possible have a slight discrepancy. Compared to the previous studies in the eight tonal values in the Shantou dialect, my finding shows a different result in certain tonal categories.

Moreover, my study shows that the eight tones in the Shantou dialect are not in the exact alignment with the four Middle Chinese tones splitting into the *Yin* and *Yang* as spoken in the previous studies. For example, in the *Yangshang* category, items with nasal consonants are found to pronounce the same tonal contour with those in the *Yinshang* cateogory by all the tested informants.

APPENDIX A

THE WORD LIST SELECTED FROM *FANGYAN DIAOCHA ZIBIAO*

聲調

詩	梯
時	題
使矢	體
是士	弟
試世	替
事侍	第
識	滴
石食	笛

衣	移
椅	以
意	異
一	逸

燈	棉
等	免
凳	面
得	滅

方—房
天—田
初—鋤
昏—魂
胸—雄

碗—晚
委—尾
隱—引
比：米
九：有
捲：遠

付—婦—附
到—稻—盜
四—似—寺
試—市—示
注—柱—住
見—件—健
救—舅—舊
漢—旱—汗

八—拔
發—罰
督—毒
桌—濁
失—實
濕—十

高	猪	專	尊	低	邊		安
開	抽	初	粗	天	偏		
婚		傷	三		飛		
窮	陳	牀	才	唐	平		
寒		神	徐		扶		
鵝	娘	人	龍	難	麻	文	雲
古	展	紙	走	短	比		碗
口	丑	楚	草	體	普		
好		手	死		粉		
五	女	染	老	暖	買	網	有
近	柱	是	坐	淡	抱		
厚		社	似		父		
蓋	帳	正	醉	對	變		愛
抗		唱	菜		怕		
漢		世	送		放		
共	陣	助	賤	大	病		
害		樹	謝		飯		
岸		讓	漏	怒	帽	望	用
急	竹	織	積	得	筆		一
曲		出	七	禿	匹		
黑		濕	錫		福		
割	桌	窄	接	搭	百		約
缺		尺	切	鐵	拍		
歇		說	削		發		
月		入	六	納	麥	襪	藥
局	宅	食	雜	讀	白		
合		舌	俗		服		

APPENDIX B

THE TABLE FROM *CONTROL METHOD USED IN A STUDY OF THE VOWELS*

TABLE II. Averages of fundamental and formant frequencies and formant amplitudes of vowels by 76 speakers.

		i	ɪ	ɛ	æ	ɑ	ɔ	ʊ	u	ʌ	ɝ
Fundamental frequencies (cps)	*M*	136	135	130	127	124	129	137	141	130	133
	W	235	232	223	210	212	216	232	231	221	218
	Ch	272	269	260	251	256	263	276	274	261	261
Formant frequencies (cps)											
F_1	*M*	270	390	530	660	730	570	440	300	640	490
	W	310	430	610	860	850	590	470	370	760	500
	Ch	370	530	690	1010	1030	680	560	430	850	560
F_2	*M*	2290	1990	1840	1720	1090	840	1020	870	1190	1350
	W	2790	2480	2330	2050	1220	920	1160	950	1400	1640
	Ch	3200	2730	2610	2320	1370	1060	1410	1170	1590	1820
F_3	*M*	3010	2550	2480	2410	2440	2410	2240	2240	2390	1690
	W	3310	3070	2990	2850	2810	2710	2680	2670	2780	1960
	Ch	3730	3600	3570	3320	3170	3180	3310	3260	3360	2160
Formant amplitudes (db)	L_1	−4	−3	−2	−1	−1	0	−1	−3	−1	−5
	L_2	−24	−23	−17	−12	−5	−7	−12	−19	−10	−15
	L_3	−28	−27	−24	−22	−28	−34	−34	−43	−27	−20

APPENDIX C

THE *T*-DISTRIBUTION TABLE FROM *STATISTICS IN DIALECTOLOGY*

Table A-1. *t*-Distribution

Degrees of Freedom	Levels of Confidence							
	.25	.10	.05	.025	.001	.005	.0025	.001
1	3.078	6.314	12.706	31.821	63.657	127.321	318.309	636.619
2	1.886	2.920	4.303	6.975	9.925	14.089	22.327	31.599
3	1.638	2.353	3.182	4.541	5.841	7.453	10.214	12.924
4	1.533	2.132	2.776	3.747	4.604	5.598	7.713	8.610
5	1.476	2.015	2.571	3.365	4.032	4.773	5.583	6.879
6	1.440	1.993	2.447	3.143	3.707	4.317	5.208	5.959
7	1.415	1.895	2.365	2.998	3.499	4.029	4.785	5.408
8	1.397	1.860	2.306	2.896	3.355	3.833	4.501	5.041
9	1.383	1.833	2.262	2.821	3.250	3.690	4.297	4.781
10	1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.587
11	1.363	1.796	2.201	2.718	3.106	3.497	4.025	4.437
12	1.356	1.782	2.179	2.681	3.055	3.428	3.930	4.318
13	1.350	1.771	2.160	2.650	3.012	3.372	3.852	4.221
14	1.345	1.761	2.145	2.624	2.977	3.326	3.787	4.140
15	1.341	1.753	2.131	2.602	2.947	3.286	3.733	4.073
16	1.337	1.746	2.120	2.583	2.921	3.252	3.686	4.015
17	1.333	1.740	2.110	2.567	2.898	3.222	3.646	3.965
18	1.330	1.734	2.101	2.552	2.878	3.197	3.610	3.922
19	1.328	1.729	2.093	2.539	2.861	3.174	3.579	3.883
20	1.325	1.725	2.086	2.528	2.845	3.153	3.552	3.850
21	1.323	1.721	2.080	2.518	2.831	3.135	3.527	3.819
22	1.321	1.717	2.074	2.518	2.819	3.119	3.505	3.792
23	1.319	1.714	2.069	2.500	2.807	3.104	3.485	3.767
24	1.318	1.711	2.064	2.492	2.797	3.091	3.467	3.745
25	1.316	1.708	2.060	2.485	2.787	3.078	3.450	3.725
26	1.315	1.706	2.056	2.479	2.779	3.067	3.435	3.707
27	1.314	1.703	2.052	2.473	2.771	3.057	3.421	3.690
28	1.313	1.701	2.048	2.467	2.763	3.047	3.408	3.674
29	1.311	1.699	2.045	2.462	2.756	3.038	3.396	3.659
30	1.310	1.697	2.042	2.457	2.750	3.030	3.385	3.646
∞	1.282	1.645	1.960	2.326	2.576	2.807	3.090	3.297

APPENDIX D

THE *T* VALUE CALCULATION REFERRED TO *STATISTICS IN DIALECTOLOGY*

MAJOR STATISTICAL FORMULAS USED IN THIS TEXT

1. Standard deviation:

$$\sqrt{\frac{\Sigma (O - m)^2}{n - 1}}$$

2. Differences between means: large samples:

a.

$$s_D = \sqrt{\frac{s_1^2}{n_1} + \frac{s_1^2}{n_2}}$$

b.

$$z = \frac{m_1 - m_2}{s_D}$$

3. *t*-test for differences between means: small samples:

a.

$$s_D = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_1 - 1)s_2^2}{n_1 + n_2 - 2}} \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

b.

$$z = \frac{m_1 - m_2}{s_D}$$

c. $df = m_1 + m_2 - 2$

APPENDIX E

THE LISTS OF DATA

Informant A											
Tone 1	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Avg.	166.1	166.3	162.4	161.4	160.1	158.9	157.5	156.7	157.0	158.2	159.7
S.D.	9.0	8.5	8.6	7.7	7.4	7.2	6.8	6.9	7.9	8.1	8.1
T value	3.06	3.07	2.92	2.89	2.83	2.79	2.73	2.70	2.72	2.76	2.82
Tone 2											
Avg.	199.4	196.0	194.0	191.8	189.1	187.0	186.9	186.5	186.3	187.5	192.0
S.D.	9.2	9.6	8.5	7.8	5.9	5.0	4.7	4.6	4.8	5.2	5.8
T value	4.19	4.09	4.03	3.95	3.87	3.80	3.79	3.78	3.77	3.81	3.96
Tone 3											
Avg.	227.1	219.2	209.7	195.5	182.1	170.5	160.8	149.6	142.9	135.2	125.5
S.D.	10.0	12.0	11.6	13.3	15.8	16.8	17.5	18.7	17.2	16.5	12.7
T value	5.00	4.78	4.51	4.07	3.63	3.23	2.86	2.41	2.13	1.79	1.33
Tone 4											
Avg.	148.6	153.2	150.6	150.0	150.0	151.8	157.0	166.1	182.7	204.3	226.9
S.D.	10.0	7.5	7.0	7.7	9.5	10.9	13.4	14.9	19.6	23.4	16.2
T value	2.37	2.56	2.46	2.43	2.43	2.50	2.71	3.06	3.65	4.34	5.00
Tone 5											
Avg.	148.0	146.8	144.0	138.8	134.3	132.1	128.9	128.5	129.4	132.7	138.0
S.D.	8.7	3.8	4.2	6.2	8.8	6.7	10.8	9.7	8.7	9.4	11.2
T value	2.35	2.30	2.18	1.95	1.75	1.65	1.49	1.47	1.51	1.67	1.91

Tone 6											
Avg.	175.2	167.9	161.3	154.9	148.4	142.9	137.9	132.2	128.8	123.4	119.1
S.D.	13.5	11.3	9.0	8.7	8.8	10.2	10.1	8.2	6.8	7.6	7.1
T value	3.39	3.13	2.88	2.63	2.37	2.13	1.91	1.65	1.49	1.22	1.00
Tone 7											
Avg.	169.5	167.7	165.9	166.5	163.8	160.8	158.0	154.1	149.0	145.8	141.9
S.D.	12.2	11.4	10.8	10.4	9.2	8.7	9.0	9.7	10.5	9.5	10.3
T value	3.19	3.12	3.06	3.08	2.97	2.86	2.75	2.60	2.39	2.25	2.09
Tone 8											
Avg.	206.4	206.5	204.5	203.2	201.3	199.3	196.6	194.2	191.9	190.2	189.2
S.D.	13.7	13.8	13.3	12.2	11.4	10.9	10.7	9.8	9.5	9.8	10.0
T value	4.41	4.41	4.35	4.31	4.25	4.19	4.11	4.03	3.96	3.90	3.87
Informant B											
Tone 1	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Avg.	101.3	100.6	99.4	98.1	96.8	96.2	95.6	95.4	95.5	95.3	95.0
S.D.	5.3	3.8	2.8	2.9	2.5	2.7	2.7	3.0	3.0	2.5	1.8
T value	2.82	2.78	2.72	2.64	2.57	2.53	2.49	2.48	2.48	2.47	2.45
Tone 2											
Avg.	117.3	116.0	115.5	115.0	114.6	114.7	114.9	114.6	114.5	114.7	114.8
S.D.	3.5	3.3	2.6	1.5	1.0	0.9	1.2	2.5	3.4	3.8	3.2
T value	3.67	3.61	3.58	3.55	3.54	3.54	3.55	3.53	3.53	3.54	3.54
Tone 3											
Avg.	147.9	141.9	131.2	124.2	115.8	111.5	100.6	92.0	85.2	79.2	76.9

S.D.	9.1	11.9	19.9	18.7	16.8	8.6	9.0	7.2	5.7	4.7	4.1
T value	5.00	4.76	4.31	4.00	3.60	3.38	2.78	2.27	1.83	1.41	1.24
Tone 4											
Avg.	90.4	90.8	92.0	94.3	97.1	100.5	104.7	111.0	118.3	125.1	131.3
S.D.	5.2	5.7	5.7	5.9	6.4	6.8	7.4	8.7	9.9	10.2	11.4
T value	2.17	2.20	2.27	2.41	2.58	2.78	3.01	3.35	3.72	4.04	4.32
Tone 5	82.6	78.5	76.4	74.8	74.2	73.5	73.8	74.3	74.9	76.1	77.1
Avg.	4.5	3.5	4.1	5.0	5.1	6.1	7.1	8.6	8.9	9.6	10.2
S.D.	1.65	1.36	1.20	1.08	1.04	0.98	1.00	1.04	1.08	1.18	1.25
T value											
Tone 6											
Avg.	97.3	94.2	91.6	89.0	86.3	83.6	81.0	79.6	78.1	76.5	74.7
S.D.	8.4	12.9	12.6	11.2	8.5	5.4	2.3	1.0	2.4	3.4	4.4
T value	2.59	2.40	2.24	2.08	1.90	1.72	1.53	1.44	1.33	1.21	1.07
Tone 7											
Avg.	105.1	103.5	101.9	100.1	98.2	96.1	93.1	89.9	87.0	84.2	81.2
S.D.	7.5	7.4	7.2	7.2	7.1	6.9	6.5	6.8	7.1	8.0	8.2
T value	3.03	2.95	2.86	2.75	2.64	2.52	2.34	2.14	1.95	1.76	1.56
Tone 8											
Avg.	133.9	133.6	132.9	131.6	128.6	127.1	126.6	125.6	123.6	120.9	121.5
S.D.	8.8	8.9	9.0	8.8	9.9	11.9	12.3	12.9	13.7	13.4	13.7
T value	4.43	4.42	4.39	4.33	4.20	4.13	4.11	4.06	3.97	3.84	3.87

Informant C

Tone 1	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Avg.	209.0	205.3	202.0	198.0	197.0	195.0	194.0	192.4	191.8	193.1	191.4
S.D.	5.9	5.7	6.5	7.6	8.6	8.3	7.5	7.7	8.1	9.5	10.1
T value	3.46	3.37	3.28	3.17	3.14	3.08	3.06	3.01	2.99	3.03	2.98
Tone 2											
Avg.	243.1	241.8	239.5	238.6	237.6	237.2	237.3	236.6	236.3	236.6	238.4
S.D.	13.5	12.4	12.6	11.8	9.9	9.0	9.1	9.5	9.1	9.3	9.4
T value	4.29	4.26	4.21	4.19	4.17	4.16	4.16	4.14	4.14	4.14	4.18
Tone 3											
Avg.	274.2	260.7	248.9	231.8	213.2	192.3	173.6	159.1	149.0	141.5	138.2
S.D.	14.9	32.1	30.7	27.7	25.6	21.9	20.0	15.5	12.5	9.6	7.3
T value	4.95	4.68	4.42	4.03	3.57	3.01	2.45	1.97	1.61	1.33	1.20
Tone 4											
Avg.	174.0	175.1	176.8	178.8	181.2	185.0	191.0	199.2	212.4	228.6	248.8
S.D.	10.0	11.6	11.6	10.2	11.2	11.6	12.2	13.0	15.1	17.4	14.7
T value	2.46	2.50	2.55	2.61	2.68	2.79	2.97	3.20	3.55	3.96	4.42
Tone 5											
Avg.	166.9	162.8	160.6	158.7	156.5	155.4	153.4	151.8	149.4	147.1	146.4
S.D.	15.0	14.2	13.4	12.7	12.7	11.6	10.7	11.0	11.3	10.8	10.1
T value	2.23	2.09	2.02	1.96	1.88	1.84	1.77	1.71	1.62	1.54	1.51
Tone 6											
Avg.	190.4	187.5	182.7	176.3	169.1	162.6	156.3	148.4	142.8	138.9	135.2
S.D.	17.8	19.1	18.2	16.4	13.0	10.8	9.4	8.5	7.6	9.8	10.6

T value	2.95	2.87	2.73	2.53	2.30	2.09	1.87	1.59	1.38	1.23	1.08
Tone 7											
Avg.	194.3	191.9	186.8	182.5	177.9	174.3	170.3	167.6	164.1	160.6	154.1
S.D.	12.7	10.7	9.1	9.1	10.0	9.6	11.1	9.7	8.8	7.6	8.0
T value	3.06	3.00	2.85	2.72	2.58	2.47	2.34	2.26	2.14	2.02	1.79
Tone 8											
Avg.	249.2	248.7	246.6	243.8	241.1	238.5	235.1	231.3	226.2	220.3	216.1
S.D.	15.6	14.6	13.3	12.3	11.7	11.3	10.9	11.5	11.8	11.9	15.0
T value	4.43	4.42	4.37	4.31	4.25	4.19	4.11	4.02	3.90	3.75	3.65
Informant D											
Tone 1	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Avg.	136.2	135.1	134.2	132.0	129.6	128.3	127.8	128.0	125.0	124.1	123.0
S.D.	10.9	10.6	10.1	9.5	9.6	10.9	9.8	10.2	10.0	9.9	11.3
T value	3.05	3.01	2.97	2.88	2.79	2.74	2.72	2.72	2.60	2.56	2.51
Tone 2											
Avg.	166.0	164.9	162.4	161.8	161.3	160.2	158.9	156.6	156.2	154.5	152.4
S.D.	10.8	11.9	11.4	10.6	9.5	8.7	9.0	9.3	10.4	10.5	10.8
T value	4.10	4.07	3.99	3.97	3.95	3.91	3.87	3.79	3.78	3.72	3.65
Tone 3											
Avg.	193.4	189.8	180.9	168.2	154.0	139.1	125.4	114.5	105.9	97.9	92.5
S.D.	19.3	18.1	12.9	9.0	11.5	14.7	16.8	22.9	25.0	26.0	27.1
T value	4.91	4.81	4.56	4.17	3.70	3.16	2.61	2.13	1.72	1.30	1.00

Tone 4											
Avg.	125.3	129.8	137.5	144.2	151.8	161.2	168.3	176.1	184.2	191.9	199.0
S.D.	8.2	9.7	11.2	13.3	14.1	15.4	13.4	11.5	11.9	13.0	12.3
T value	2.51	2.69	2.98	3.22	3.47	3.77	3.99	4.21	4.44	4.64	4.82
Tone 5											
Avg.	107.5	108.7	111.1	113.3	114.9	116.0	117.1	118.6	120.4	121.3	121.0
S.D.	9.3	9.3	9.8	9.6	9.5	9.4	9.5	9.8	9.9	9.3	9.2
T value	1.80	1.86	1.97	2.08	2.15	2.20	2.25	2.32	2.40	2.44	2.43
Tone 6											
Avg.	139.7	136.8	133.9	131.3	128.1	123.4	117.7	112.4	104.8	100.2	95.9
S.D.	29.0	29.3	29.6	28.7	26.4	21.3	16.4	13.7	7.9	6.1	4.1
T value	3.19	3.08	2.96	2.86	2.73	2.53	2.28	2.03	1.66	1.42	1.19
Tone 7											
Avg.	133.2	132.2	131.5	131.0	130.4	129.4	127.9	126.6	124.3	121.9	116.1
S.D.	5.8	4.9	3.8	3.5	3.5	3.5	4.2	4.8	5.6	6.0	8.6
T value	2.82	2.78	2.76	2.74	2.71	2.67	2.62	2.57	2.47	2.38	2.13
Tone 8											
Avg.	170.9	171.0	171.1	171.3	170.6	169.6	168.7	167.1	167.7	168.3	165.9
S.D.	26.5	26.4	25.9	25.3	25.4	25.5	24.6	23.6	23.6	23.6	24.0
T value	4.26	4.26	4.26	4.27	4.25	4.22	4.19	4.14	4.16	4.18	4.10

APPENDIX F

DATA OF THE TONAL TIME DURATION

Time Duration	Tone 1	Tone 2	Tone 3	Tone 4	Tone 5	Tone 6	Tone 7	Tone 8
Informant A	0.29	0.29	0.32	0.33	0.31	0.19	0.07	0.09
	0.31	0.34	0.23	0.34	0.41	0.16	0.08	0.10
	0.23	0.36	0.26	0.38	0.38	0.25	0.09	0.10
	0.23	0.44	0.18	0.28	0.32	0.24	0.05	0.07
	0.46	0.35	0.36	0.26	0.37	0.23	0.06	0.08
	0.38	0.35	0.30	0.33		0.25	0.10	0.08
	0.41	0.35	0.27	0.32		0.31	0.02	0.06
	0.29	0.33		0.29		0.34	0.11	0.04
	0.33	0.38		0.43			0.07	0.08
				0.43				0.07
Average.	**0.32**	**0.35**	**0.27**	**0.34**	**0.36**	**0.25**	**0.07**	**0.08**

Time Duration	Tone 1	Tone 2	Tone 3	Tone 4	Tone 5	Tone 6	Tone 7	Tone 8
Informant B	0.35	0.27	0.27	0.25	0.23	0.27	0.03	0.05
	0.35	0.30	0.24	0.28	0.26	0.31	0.08	0.08
	0.35	0.28	0.32	0.28	0.35	0.24	0.07	0.10
	0.33	0.36	0.22	0.28	0.31	0.34	0.08	0.09
	0.37	0.24	0.22	0.25	0.27	0.25	0.09	0.07
	0.32	0.30	0.29	0.33	0.27		0.09	0.06
	0.43	0.30	0.32	0.25	0.29		0.07	0.08
	0.37	0.32	0.28	0.23	0.28		0.09	
	0.33	0.33	0.25	0.20	0.32		0.06	

	0.30		0.29	0.24	0.32		0.07	
	0.36			0.32	0.34			
	0.28				0.26			
Average	**0.34**	**0.30**	**0.27**	**0.26**	**0.29**	**0.28**	**0.07**	**0.08**
Time Duration	**Tone 1**	**Tone 2**	**Tone 3**	**Tone 4**	**Tone 5**	**Tone 6**	**Tone 7**	**Tone 8**
Informant C	0.34	0.35	0.26	0.35	0.35	0.30	0.15	0.14
	0.37	0.32	0.26	0.36	0.37	0.39	0.14	0.15
	0.40	0.36	0.25	0.33	0.33	0.27	0.14	0.09
	0.41	0.35	0.28	0.21	0.44	0.34	0.13	0.10
	0.36	0.33	0.21	0.38	0.34	0.35	0.20	0.11
	0.42	0.36	0.27	0.35	0.36	0.28	0.10	0.10
	0.40	0.34	0.26	0.39	0.37		0.08	0.09
	0.32	0.31	0.24	0.41	0.39		0.12	0.09
		0.21	0.25	0.38	0.32		0.21	0.08
				0.22	0.33		0.10	
				0.36	0.29			
				0.39	0.39			
Average	**0.38**	**0.33**	**0.25**	**0.34**	**0.36**	**0.32**	**0.14**	**0.11**
Time Duration	**Tone 1**	**Tone 2**	**Tone 3**	**Tone 4**	**Tone 5**	**Tone 6**	**Tone 7**	**Tone 8**
Informant D	0.47	0.39	0.36	0.36	0.47	0.26	0.14	0.22
	0.43	0.38	0.36	0.38	0.41	0.30	0.20	0.20
	0.44	0.41	0.25	0.37	0.39	0.43	0.11	0.10
	0.37	0.33	0.49	1.84	0.29	0.35	0.14	0.14
	0.43	0.41	0.44	0.31	0.35	0.49	0.17	0.17
	0.48	0.38	0.35	0.35	0.37		0.11	0.16

	0.51	0.28	0.28	0.41	0.34		0.09	0.10
	0.35	0.22	0.30	0.34	0.39		0.11	0.14
	0.52	0.31		0.37	0.24		0.18	0.07
				0.43	0.48		0.12	0.11
				0.31	0.44			
				0.38				
Average	**0.44**	**0.35**	**0.35**	**0.49**	**0.38**	**0.36**	**0.14**	**0.14**

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