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A phonetic study of the sound system of Taipung (Dapeng) dialect

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Abstract

Taipung or Dapeng is the dialect spoken in Dapeng Peninsula, Shenzhen, China. It has been conventionally described as a mixed language of Hakka and Cantonese, as Taipung is similar to these dialects in sounds and lexicons. In this project, the sound system of Taipung has been acoustically analysed. The phonetic and acoustic properties of the full set of the consonants, vowels, diphthongs and tones of Taipung is presented. The analysed speech data show that Taipung has 17 initial consonants, including both the unaspirated and aspirated plosives [p-, p^h-, t-, t^h-, k-, k^h-] and affricates [ts-, ts^h-], fricatives [f-, s-, h-], nasals [m-, n-, ŋ-], and approximants [l-, w-, j-]; 6 final consonants, including three stop endings [-p, -t, -k] and three nasal endings [-m, -n, -ŋ]; 6 vowels [i, u, o, ɔ, ɐ, a]; 9 diphthongs [iu, ia, io, iɔ, oi, ɐi, ɐu, ai, au]; 7 tones, including 5 long tones [55, 33, 22, 25, 21] and 2 short entering tones [5, 3]; and 2 syllabic nasals [m̩, ŋ̍]

Most Chinese media refer to Taipung as a kind of ‘military speech’ (or *Junyu* in Chinese), which consists of the phonological features of various dialects spoken in the regions of China. A comparison of the sound systems of Taipung, Hong Kong Cantonese, Meixian Hakka and Standard Chinese made in the present study shows that Taipung bears striking similarities to Hakka and Cantonese and may even be considered as a hybrid of the two languages. However, it has no observable historical relationship to Mandarin phonetically as claimed in the literature.

Key words: Taipung (Dapeng), military speech (*Junyu*), phonetic study, speech sounds and tones

Table of Contents

List of Maps

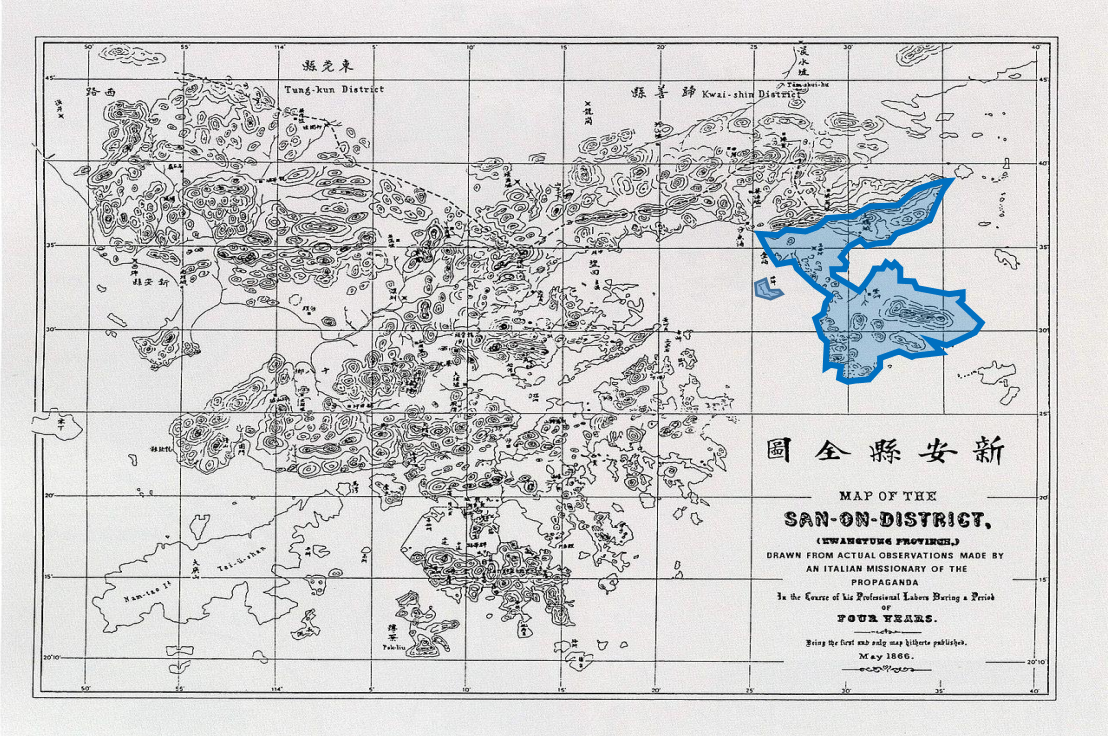
List of Tables

List of Figures

Chapter 1 Introduction

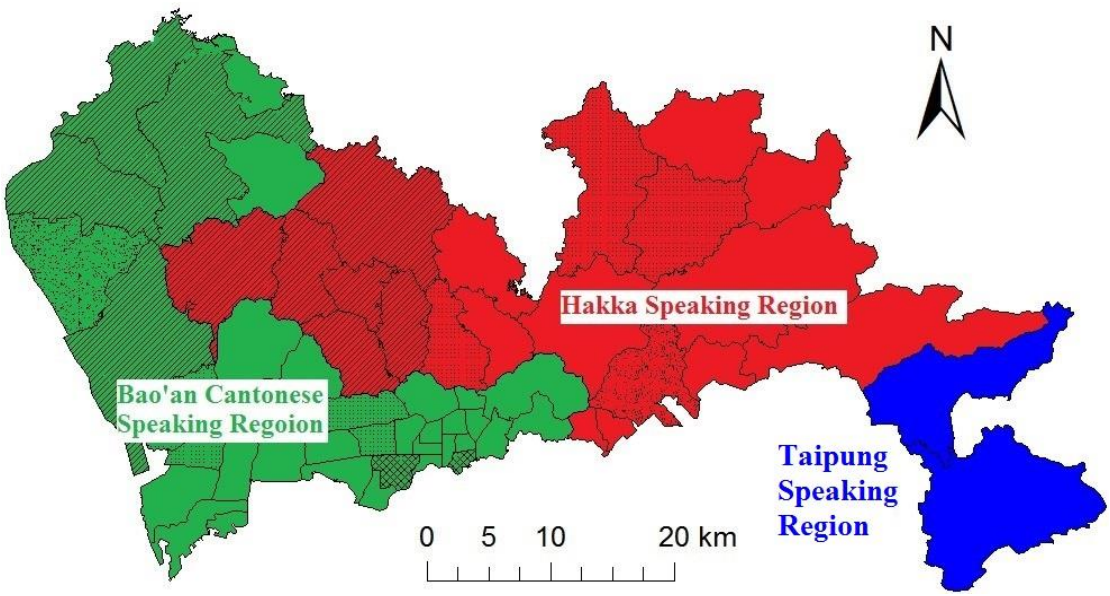
1.1 Background

Hong Kong and most part of Shenzhen are in the same administrative county called San On County before the British ceded Hong Kong in the 19th century (Jin, 1988). The major languages of the inhabitants spoken in the region are Waitauwa (圍頭話), which is a Cantonese dialect, and Hakka (客家話). There is another dialect, called Dapeng or Taipung [t^hai^{55} $p^hoŋ^{21}$] (大鵬話) in the dialect, spoken in the southeast part of the county highlighted in blue in Map 1.



Map 1: A 19th century map of San On County which consists of the contemporary Hong Kong and parts of Shenzhen.

The dialect which is referred to as Taipung in this paper is mainly spoken in Dapeng and Nan'ao districts in the Dapeng peninsula of Shenzhen, Guangdong Province, China and Tung Ping Chau of Hong Kong. The dialect is strongly influenced by the two major dialects, Cantonese and Hakka, spoken in the region. Map 2, which is made on the basis of the description in Tang (2012), shows the distribution of the three dialects spoken in Shenzhen. As shown in the map, the western part of Shenzhen is the Bao'an Cantonese speaking region (in green), while Hakka is widely spoken in the eastern part (in red). Taipung is only spoken in the southern part of Dapeng Peninsula (in blue) which is obstructed by mountains in the north and surrounded by the sea, separating from the Hakka and Cantonese speaking regions.



Map 2: Distribution of the three dialects, Bao'an Cantonese (in green), Hakka (in red) and Taipung (in blue), spoken in Shenzhen.

In Dapeng District, there is a military fortress called Dapeng Fortress (大鵬所城), built in Ming Dynasty (1394), for defence against the pirates and protecting the inhabitants living nearby (Lin, 2017). Taipung is often referred to as a 'military

speech' or called *Junyu* (軍語) in the news articles in mainland China because of its historical military background. Conventionally, Taipung dialect is considered as a lingua franca or common speech in Dapeng Fortress for communication between the soldiers and officials who were from different speaking regions around the country. Taipung is described as the product of language mixing of Mandarin, Cantonese and Hakka. So, it is often claimed that Taipung has the phonological features of these languages.

1.2 Literature Reviews

There are only a few literatures and publications on Taipung so far. One of them is Lau & Yuan (2010), in which a rather detailed discussion on the sound system of Taipung dialect spoken in Dapeng peninsula is made. In the paper, the consonants, vowels, tones and other phonological features of the dialect are described based on the recordings of the speakers in Nan'ao, the southern part of Dapeng peninsula. However, according to many native speakers of Taipung in Dapeng peninsula in an oral interview with the investigator of this project, Nan'ao accent is not considered as a representative of Taipung, rather it is referred to a so-called 'village accent' (村聲/音) compared to the accent spoken in the other regions of Dapeng district, such as Dapeng Fortress (大鵬城), Wangmu Community (王母社區) and Longqi village (龍岐村), etc. Furthermore, there are some variations in the description of the sound system of Taipung in Lau & Yuan (2010) compared to other papers. According to the authors, Taipung has 16 initial consonants [p-, p^h-, t-, t^h-, ts-, ts^h-, k-, k^h-, m-, l-, ɲ-/ŋ-, f-, s-, h-, j-, ʋ-], where [n-] and [l-] have merged and only [l-] is retained, and [ɲ-] and [ŋ-] is an allophone of [ŋ-]; 5 vowels [i, u, ɔ, ɐ, a]; 9 diphthongs: [iu, iɛ, iɔ, ia, ui, ɐi, ɐu, ai, au]; 6 tones, including 5 long tones [55, 33, 11, 35, 13] and 1 short entering tone [5]; and 2

syllabic nasals [m̩, ŋ̍]. However, there is no experimental data or phonological analysis made available in Lau & Yuan's paper to substantiate the description.

Lau later did a research on the indigenous Yue dialects spoken in Hong Kong, namely Waitau (圍頭話), Pingchau (平洲話) and Tingkok (汀角話) (Lau, 2013). Lau categorised Pingchau and Tingkok as two sub-dialects of Taipung. His view is supported by both the speakers of Taipung and Pingchau in Tung Ping Chau, when the investigator of this project visited there in January 2017. These speakers generally agree the two dialects more or less the same and consider themselves as the same group of people. As a native speaker of Taipung, I agree with Lau that Pingchau and Tingkok do have great similarities to Taipung and his categorisation is acceptable. Lau puts Taipung and Waitau under the Yue dialect group and says Taipung has received a lot of influence from Hakka dialect. A description of the sound system of Pingchau (considered as a variety of Taipung) is given in Lau (2013). In Pingchau, as compared to Taipung described in Lau & Yuan (2010), there are 16 consonants [p-, p^h-, t-, t^h-, ts-, ts^h-, k-, k^h-, m-, n-/l-, ŋ-, f-, s-, h-, j-, w-], where [n-] and [l-] are allophones and not distinguishable for the speakers, and [w-] instead of [ʋ-] occurs in the dialect; 7 vowels [i, u, ɔ, ɐ, a] and additional [ɛ] and [o]; 8 diphthongs [iu, iɔ, ia, ui, ɐi, ɐu, ai, au], without [iɛ]; and 6 tones, including 5 long tones [55, 33, 11, 35, 13] and a single short entering tone [5]. Again, no experimental data are available in the paper to substantiate the description.

Recently, a PhD dissertation on Taipung dialect was published (Chen, 2016). The author carried out a three-month fieldwork to collect data not merely for the sound system but also the phonology, vocabulary and syntax of Taipung. A comparison of Taipung, Hakka and Cantonese was also made in the study, demonstrating that

Taipung is a mixed language of Hakka and Cantonese. Based on the speech data from native speakers of Taipung, Chen described that Taipung has 17 initial consonants [p-, p^h-, t-, t^h-, ts-, ts^h-, k-, k^h-, m-, n-, ŋ-, f-, s-, h-, l-, j-, w-], with [n-] and [l-] as two separate phonemes; 5 vowels [i, u, ɔ, ɐ, a]; 9 diphthongs [iu, iɛ, ia, iɔ, ui, ɐi, ɐu, ai, au]; 7 tones, including 5 long tones [54, 42, 22, 35, 31] and 2 short entering tones [54, 42]; and 1 syllabic nasal [m̩].

Between Chen's study and Lau's works, while there are striking similarities in their descriptions of the sound system of Taipung, some differences are also observed. This is especially in the description of the tones of the dialect. There are two pairs of falling tones [54, 42], a long pair and a short pair, described in Chen (2016), but not in Lau & Yuan (2010) and Lau (2013). The differences are possibly related to the accent of the subjects who provided speech data in the studies. Since no detailed information about the language background of the subjects given in Chen's study and the accent of the subjects in Lau's studies is not considered as the representative of the dialect, further studies of the sound system of Taipung are called for.

1.3 Purpose of Present Study

The present study investigates the sound system, including the consonants, vowels, diphthongs and tones, of Taipung by carrying out a phonetic and phonological analysis of the speech data from native speakers whose accent is considered as a representative of the dialect. A comparison is also made among the sound systems of Taipung, Cantonese, Hakka and Mandarin for evaluating the claim that Taipung is not just a mixed language of Cantonese and Hakka but also of the Northern dialects due to its historical background. As a native speaker of this dialect, it is somehow doubtful

whether the claim is true, as based on my intuition and impression, Taipung does not share the phonological features with any northern dialects. An acoustic analysis of the speech data collected from native speakers of Taipung is carried out to provide empirical evidence to complement the previous works on the dialect.

Chapter 2 Methodology

2.1 Subjects

Speech samples were collected from two subjects, one male and one female, who are native speakers of Taipung. Due to limited time, four months, for this project, only the speech samples from the male speaker were analysed for the study. The speaker aged 79 years old when he took part in the recording. He was born and grew up in Longqi village (龍岐村), located in the central region of the Dapeng Peninsula, where the dialect spoken in the village is considered as a representative of Taipung. He migrated to Hong Kong in his early twenties, but he has been living with Taipung people until now.

2.2 Test Materials

The subject took part in an individual audio recording on a voluntary basis. He was asked to utter a set of selected Chinese monosyllabic words in his dialect. For some of the test words which do not have the written form, the meanings were given and were orally described to the speaker by the investigator of this project.

On the basis of the previous studies and the intuition of the investigator of this project who is a native speaker of Taipung, it is assumed that Taipung has 17 initial consonants [p-, p^h-, t-, t^h-, k-, k^h-, ts-, ts^h-, f-, s-, h-, m-, n-, ŋ-, l-, w-, j-]; 6 final consonants [-p, -t, -k, -m, -n, -ŋ]; 6 vowels [i, u, o, ɔ, ɐ, a]; 8 diphthongs [iu, iɔ, ia, oi, ɐi, ɐu, ai, au]; 7 tones, including 5 long tones [55, 33, 22, 25, 21] and 2 short entering tones [5, 3], and 2 syllabic nasals [m̩, ŋ̍]. Similar to many other Chinese dialects, the

monosyllables in Taipung have three major types of structure, namely CV, CVN and CVS, where C = an initial consonant, V = a vowel or diphthong, N = a final nasal and S = a final stop. There are some monosyllables have no initial consonants or a zero-initial, i.e. V, VN and VS syllables, and some have a single syllabic nasal, i.e. N. Each monosyllable is produced with a tone. A lone tone is produced on the CV, CVN, V, VN and N syllables, whereas a short entering tone is produced on the CVS and VS syllables only.

Regarding the phonotactics in Taipung, Table 1 and Table 2 present the possible combinations of the 4 vowels with the 17 initial consonants in CV syllables and the 6 vowels with the 6 final consonants in CVS and CVN syllables. As shown in the two tables, while all the combinations of the vowels and initial consonants in Taipung are possible, there are some combinations of the vowels and the final consonants not available in the dialect. For instance, the vowel [i] can be followed by the bilabial [-p, -m] or alveolar [-t, -n], but not the velar [-k, -ŋ]; the vowels [u] is followed by [-t, -n] only; and the vowels [o] and [ɔ] are followed by [-k, -ŋ] only. In Taipung, only the vowels [a] and [ɐ] can be followed by any one of the 6 final consonants.

Initial consonants	**Vowels**				**Initial consonants**	**Vowels**			
	i	u	ɔ	a		i	u	ɔ	a
p-	✓	✓	✓	✓	s-	✓	✓	✓	✓
p^h-	✓	✓	✓	✓	h-	✓	✓	✓	✓
t-	✓	✓	✓	✓	m-	✓	✓	✓	✓
t^h-	✓	✓	✓	✓	n-	✓	✓	✓	✓
k-	✓	✓	✓	✓	ŋ-	✓	✓	✓	✓
k^h-	✓	✓	✓	✓	l-	✓	✓	✓	✓
ts-	✓	✓	✓	✓	w-	✓	✓	✓	✓
ts^h-	✓	✓	✓	✓	j-	✓	✓	✓	✓
f-	✓	✓	✓	✓					

Table 1: Possible combinations of vowel and initial consonant in CV syllables in Taipung.

Vowels	Final plosives			Final nasals		
	-p	-t	-k	-m	-n	-ŋ
i	✓	✓	×	✓	✓	×
u	×	✓	×	×	✓	×
o	×	×	✓	×	×	✓
ɔ	×	×	✓	×	×	✓
ɐ	✓	✓	✓	✓	✓	✓
a	✓	✓	✓	✓	✓	✓

Table 2: Possible combinations of vowel and final consonant in CVS and CVN syllables in Taipung.

The possible combinations of the diphthongs and initial consonants in CV, CVS and CVN syllables available in Taipung are presented in Table 3 and Table 4. In CV syllables (Table 3), the diphthongs [ai, ɐi, au, ɐu] beginning with a low vowel can be preceded by any type of the initial consonant, except for the combinations of [au] with [f-] and [ɐu] with [w-]. The diphthong [oi] can also be preceded by many types of the initial consonant, except for [h-] and [w-]. The diphthong [iu] can be preceded by various types of the initial consonant as well, except for [f-], [ŋ-] and [w-]. As for the diphthongs [iɔ] and [ia] beginning with a high vowel [i], they can be preceded by less types of the initial consonant as compared to the other diphthongs in CV syllables.

Initial consonants	Diphthongs								Initial consonants	Diphthongs							
	iu	iɔ	ia	oi	ɐi	ɐu	ai	au		iu	iɔ	ia	oi	ɐi	ɐu	ai	au
p-	✓	×	✓	✓	✓	✓	✓	✓	s-	✓	✓	✓	✓	✓	✓	✓	✓
p^h-	✓	×	✓	✓	✓	✓	✓	✓	h-	✓	✓	×	×	✓	✓	✓	✓
t-	✓	✓	✓	✓	✓	✓	✓	✓	m-	✓	✓	✓	✓	✓	✓	✓	✓
t^h-	✓	✓	×	✓	✓	✓	✓	✓	n-	✓	×	✓	✓	✓	✓	✓	✓
k-	✓	×	×	✓	✓	✓	✓	✓	ŋ-	×	×	×	✓	✓	✓	✓	✓
k^h-	✓	✓	✓	✓	✓	✓	✓	✓	l-	✓	✓	×	✓	✓	✓	✓	✓
ts-	✓	✓	✓	✓	✓	✓	✓	✓	w-	×	×	×	×	✓	×	✓	✓
ts^h-	✓	✓	✓	✓	✓	✓	✓	✓	j-	✓	✓	✓	✓	✓	✓	✓	✓
f-	×	×	✓	✓	✓	✓	✓	×									

Table 3: Possible combinations of diphthong and initial consonant in CV syllables in Taipung.

The two diphthongs [iɔ] and [ia] as well as the diphthong [iɛ] are the only three that can occur in CVS and CVN syllables (Table 4), and they can only be followed by a final velar consonant.

Diphthongs	Final stops			Final nasals		
	-p	-t	-k	-m	-n	-ŋ
iɔ	×	×	✓	×	×	✓
iɛ	×	×	×	×	×	✓
ia	×	×	✓	×	×	×

Table 4: Possible combinations of diphthong and final consonant in CVS and CVN syllables in Taipung.

Based on the above assumption, a set of about 300 test words was selected for this project. The selected test words are familiar to the subject and are commonly used in his daily speech. They were divided into 10 groups for the investigation of the initial consonants (Group 1), final consonants (Group 2), syllabic consonants (Group 3), vowels in CV (Group 4), CVS (Group 5) and CVN (Group 6) syllables, diphthongs in CV (Group 7), CVS (Group 8) and CVN (Group 9) syllables, and tones (Group 10) in Taipung. The test words used for the investigation are listed in the tables below. The words are provided with IPA transcription and English translation for reference.

Table 5 displays the 85 test words in Group 1 that contain the 17 Taipung initial consonants [p-, p^h-, t-, t^h-, k-, k^h-, ts-, ts^h-, f-, s-, h-, m-, n-, ŋ-, l-, w-, j-] followed by one of the 9 vowels/diphthongs [a, i/oi, u/ʊu, ɔ/oi, ʊi/ʊu] in CV syllables. In Table 6, there are all together 52 test words in Group 2 that contain the 6 Taipung final consonants [-p, -t, -k, -m, -n, -ŋ] preceded by one of the 7 vowels [a, ʊ, i, u, o, ɔ] and 3 diphthongs [ia, iɛ, iɔ]. For the impossible combinations, a blank is left. The 4 test

words in Group 3 that contain a single syllabic nasal [m̩] or [ŋ̍] in Taipung are given in Table 7.

Initial consonants	**Following vowels**				
	[a]	[i/oi]	[u/ɐu]	[ɔ/oi]	[ɐi]
[p-]	爸 [pa^{33}] ‘father’	碑 [pi^{33}] ‘monument’	埔 [pu^{33}] ‘plain’	波 [pɔ^{33}] ‘ball’	跛 [pɐi^{33}] ‘cripple’
[p^{h}-]	怕 [p^{h}a^{22}] ‘scare’	鼻 [p^{h}i^{55}] ‘nose’	舖 [p^{h}u^{22}] ‘shop’	頗 [p^{h}ɔ^{25}] ‘quite’	批 [p^{h}ɐi^{33}] ‘approval’
[t-]	打 [ta^{55}] ‘a dozen’	知 [ti^{33}] ‘to know’	都 [tu^{33}] ‘capital’	多 [tɔ^{33}] ‘many’	低 [tɐi^{33}] ‘low’
[t^{h}-]	他 [t^{h}a^{33}] ‘he’	地 [t^{h}i^{55}] ‘earth’	度 [t^{h}u^{55}] ‘degree’	拖 [t^{h}ɔ^{33}] ‘drag’	梯 [t^{h}ɐi^{33}] ‘stairs’
[k-]	家 [ka^{33}] ‘home’	居 [ki^{33}] ‘live’	姑 [ku^{33}] ‘aunt’	哥 [kɔ^{33}] ‘brother’	雞 [kɐi^{33}] ‘chicken’
[k^{h}-]	誇 [k^{h}a^{33}] ‘exaggerate’	區 [k^{h}i^{33}] ‘district’	箍 [k^{h}u^{33}] ‘hoop’	課 [k^{h}ɔ^{22}] ‘lesson’	規 [k^{h}ɐi^{33}] ‘rule’
[ts-]	渣 [tsa^{33}] ‘dregs’	之 [tsi^{33}] particle	租 [tsu^{33}] ‘rent’	左 [tsɔ^{25}] ‘left’	劑 [tsɐi^{33}] ‘medicine’
[ts^{h}-]	車 [ts^{h}a^{33}] ‘car’	痴 [ts^{h}i^{33}] ‘crazy’	粗 [ts^{h}u^{33}] ‘crude’	初 ts^{h}ɔ^{33}] ‘first’	妻 [ts^{h}ɐi^{33}] ‘wife’
[f-]	花 [fa^{33}] ‘flower’	飛 [fi^{33}] ‘fly’	夫 [fu^{33}] ‘husband’	火 [fɔ^{25}] ‘fire’	輝 [fɐi^{33}] ‘shine’
[s-]	沙 [sa^{33}] ‘sand’	詩 [si^{33}] ‘poem’	蘇 [su^{33}] surname	梳 [sɔ^{33}] ‘comb’	西 [sɐi^{33}] ‘west’
[h-]	蝦 [ha^{33}] ‘shrimp’	希 [hi^{33}] ‘hope’	邱 [hɐu^{33}] surname	賀 [hɔ^{55}] ‘congrats’	係 [hɐi^{55}] ‘yes’
[m-]	媽 [ma^{33}] ‘mother’	味 [mi^{55}] ‘taste’	霧 [mu^{55}] ‘fog’	魔 [mɔ^{33}] ‘magic’	謎 [mɐi^{21}] ‘riddle’
[n-]	拿 [na^{21}] ‘pick’	你 [ni^{22}] ‘you’	怒 [nu^{55}] ‘angry’	糯 [nɔ^{55}] ‘glutinous’	泥 [nɐi^{21}] ‘mud’
[ŋ-]	瓦 [ŋa^{25}] ‘tile’	二 [ŋi^{55}] ‘two’	勾 [ŋɐu^{33}] ‘hook’	餓 [ŋɔ^{55}] ‘hungry’	魏 [ŋɐi^{55}] surname
[l-]	啦 [la^{33}] particle	利 [li^{55}] ‘profit’	露 [lu^{55}] ‘dew’	擺 [lɔ^{25}] ‘to take’	麗 [lɐi^{55}] ‘beauty’
[w-]	蛙 [wa^{33}] ‘frog’	會 [woi^{55}] ‘meeting’	烏 [wu^{55}] ‘dark’	窩 [wɔ^{33}] ‘nest’	威 [wɐi^{33}] ‘prestige’
[j-]	夜 [ja^{55}] ‘night’	衣 [ji^{33}] ‘clothes’	又 [jɐu^{55}] ‘again’	銳 [joi^{22}] ‘sharp’	曳 [jɐi^{22}] ‘naughty’

Table 5: Test words in Group 1 that contain the 17 Taipung initial consonants [p-, p^{h}-, t-, t^{h}-, k-, k^{h}-, ts-, ts^{h}-, f-, s-, h-, m-, n-, ŋ-, l-, w-, j-] followed by one of the 9 vowels/diphthongs [a, i/oi, u/ɐu, ɔ/oi, ɐi/ɐu] in CV syllables.

Preceding vowels	Following vowels					
	[-m]	[-n]	[-ŋ]	[-p]	[-t]	[-k]
[a]	三 [sam^{33}] ‘three’	山 [san^{33}] ‘hill’	生 [saŋ^{33}] ‘raw’	插 [ts^{h}ap^{3}] ‘insert’	擦 [ts^{h}at^{3}] ‘erase’	拆 [ts^{h}ak^{3}] ‘break’
	柑 [kam^{33}] ‘tankan’	奸 [kan^{33}] ‘cunning’	更 [kaŋ^{22}] ‘change’	蠟 [lap^{5}] ‘wax’	辣 [lat^{5}] ‘spicy’	肋 [lak^{5}] ‘rib’
[ɐ]	心 [sɐm^{33}] ‘heart’	新 [sɐn^{33}] ‘new	升 [sɐŋ^{33}] ‘raise’	緝 [ts^{h}ɐp^{3}] ‘wanted’	七 [ts^{h}ɐt^{3}] ‘seven’	力 [lɐk^{5}] ‘force’
	金 [kɐm^{33}] ‘gold’	巾 [kɐn^{33}] ‘towel’	京 [kɐŋ^{55}] ‘capital’	粒 [lɐp^{3}] ‘granule’	掘 [k^{h}ɐt^{5}] ‘dig’	
[i]	閃 [sim^{25}] ‘flash’	先 [sin^{33}] ‘prior’		妾 [ts^{h}ip^{3}] ‘concubine’	切 [ts^{h}it^{3}] ‘cut’	
	兼 [kim^{33}] ‘and’	堅 [kin^{33}] ‘hard’		粒 [lip^{5}] ‘lift’	烈 [lit^{5}] ‘intense’	
[u]		安 [un^{33}] ‘secure’			撥 [put^{3}] ‘dial’	
		官 [kun^{33}] ‘official’			豁 [k^{h}ut^{3}] ‘exempt’	
[o]			鬆 [soŋ^{33}] ‘loose’			速 [ts^{h}ok^{3}] ‘speed’
			公 [koŋ^{33}] ‘public’			六 [lok^{5}] ‘six’
[ɔ]			商 [sɔŋ^{33}] ‘trade’			確 [k^{h}ɔk^{3}] ‘firm’
			江 [kɔŋ^{33}] ‘river’			落 [lɔk^{5}] ‘down’
[ia]						劇 [k^{h}iak^{3}] ‘drama’
						叻 [liak^{3}] ‘smart’
[iɛ]			腥 [siɛŋ^{33}] ‘fishy’			
			驚 [kiɛŋ^{33}] ‘scary’			
[iɔ]			箱 [siɔŋ^{33}] ‘box’			卻 [k^{h}iɔk^{3}] ‘but’
			薑 [kiɔŋ^{33}] ‘ginger’			略 [liɔk^{5}] ‘brief’

Table 6: Test words in Group 2 that contain the 6 Taipung final consonants [-p, -t, -k, -m, -n, -ŋ] followed by one of the 7 vowels [a, ɐ, i, u, o, ɔ] and 3 diphthongs [ia, iɛ, iɔ].

Syllabic nasals			
[m̩]	[ŋ̍]		
唔 [m̩^{21}] ‘not’	誤 [ŋ̍^{55}] ‘mistake’	五 [ŋ̍^{25}] ‘five’	午 [ŋ̍^{25}] ‘noon’

Table 7: Test words in Group 3that contain a single syllabic nasal [m̩] or [ŋ̍] in Taipung.

As for the test words in Groups 4, 5 and 6 for eliciting the Taipung vowels, those containing the test vowels in CV, CVS and CVN syllables are presented respectively in Tables 8, 9 and 10. For the impossible combinations, a blank is left in the tables.

Vowels	**CV structure**				
	[p-]	[k^h-]	[s-]	[ts^h-]	[f-/h-]
[i]	碑 [pi^{33}] ‘monument’	區 [k^hi^{33}] ‘district’	詩 [si^{33}] ‘poem’	痴 [ts^hi^{33}] ‘crazy’	飛 [fi^{33}] ‘fly’
[u]	埔 [pu^{33}] ‘plain’	箍 [k^hu^{33}] ‘hoop’	蘇 [su^{33}] surname	粗 [ts^hu^{33}] ‘crude’	夫 [fu^{33}] ‘husband’
[ɔ]	波 [$pɔ^{33}$] ‘ball’	課 [$k^hɔ^{22}$] ‘lesson’	梳 [$sɔ^{33}$] ‘comb’	初 [$ts^hɔ^{33}$] ‘first’	賀 [$hɔ^{55}$] ‘congrats’
[a]	爸 [pa^{33}] ‘father’	誇 [k^ha^{33}] ‘exaggerate’	沙 [sa^{33}] ‘sand’	車 [ts^ha^{33}] ‘car’	花 [fa^{33}] ‘flower’

Table 8: Test words in Group 4 that contain the 4 Taipung vowels [i, u, ɔ, a] preceded by one of the 6 initial consonants [p-, k^h-, s-, ts^h-, f-, h-] in CV syllables.

Vowels	**CVS structure**				
	[p-]	[k^h-]	[s-]	[ts^h-]	[f-/h-]
[i]	必 [pit^3] ‘must’	缺 [k^hit^3] ‘lack’	舌 [sit^3] ‘tongue’	切 [ts^hit^3] ‘cut’	血 [hit^3] ‘blood’
[u]	撥 [put^3] ‘dial’	豁 [k^hut^3] ‘exempt’	活 [wut^5] ‘alive’		闊 [fut^3] ‘wide’
[o]	仆 [p^hok^3] ‘fall’	曲 [k^hok^3] ‘curve’	叔 [sok^3] ‘uncle’	速 [ts^hok^3] ‘speed’	哭 [hok^3] ‘cry’
[ɔ]	博 [$pɔk^3$] ‘plentiful’	確 [$k^hɔk^3$] ‘firm’	索 [$sɔk^3$] ‘wire’	着 [$ts^hɔk^5$] ‘on’	學 [$hɔk^5$] ‘study’
[ɐ]	筆[$pɐt^3$] ‘pen’	咳 [$k^hɐt^3$] ‘cough’	失 [$sɐt^3$] ‘lost’	七 [$ts^hɐt^3$] ‘seven’	忽 [$fɐt^3$] ‘sudden’
[a]	八 [pat^3] ‘eight’	卡 [k^hak^5] ‘card’	殺 [sat^3] ‘kill’	擦 [ts^hat^3] ‘erase’	乞 [hat^3] ‘beg’

Table 9: Test words in Group 5 that contain the 6 Taipung vowels [i, u, o, ɔ, ɐ, a] preceded by one of the 7 initial consonants [p-, k^h-, s-, w-, ts^h-, f-, h-] in CVS syllables.

Vowels	CVN structure				
	[p-]	[k^h-]	[s-/w-]	[ts^h-/Ø-]	[f-/h-]
[i]	辮 [pin^{33}] ‘whip’	健 [k^hin^{55}] ‘strength’	先 [sin^{33}] ‘prior’	千 [ts^hin^{33}] ‘thousand’	軒 [hin^{33}] ‘room’
[u]	般 [pun^{33}] ‘kind’	看 [k^hun^{22}] ‘look’	換 [wun^{55}] ‘change’	安 [un^{33}] ‘secure’	歡 [fun^{33}] ‘happy’
[o]	鵬 [$p^hoŋ^{21}$] ‘giant bird’	共 [$k^hoŋ^{55}$] ‘together’	鬆 [$soŋ^{33}$] ‘loose’	充 [$ts^hoŋ^{33}$] ‘charge’	胸 [$hoŋ^{33}$] ‘chest’
[ɔ]	幫 [$pɔŋ^{33}$] ‘help’	康 [$k^hɔŋ^{33}$] ‘health’	商 [$sɔŋ^{33}$] ‘trade’	倉 [$ts^hɔŋ^{33}$] ‘stock’	糠 [$hɔŋ^{33}$] ‘bran’
[ɐ]	賓 [$pɐn^{33}$] ‘guest’	昆 [$k^hɐn^{33}$] ‘brother’	身 [$sɐn^{33}$] ‘body’	親 [$ts^hɐn^{33}$] ‘relatives’	分 [$fɐn^{33}$] ‘score’
[a]	班 [pan^{33}] ‘class’	框 [$k^haŋ^{33}$] ‘frame’	山 [san^{33}] ‘hill’	餐 [ts^han^{33}] ‘meal’	慳 [han^{33}] ‘frugal’

Table 10: Test words in Group 6 that contain the 6 Taipung vowels [i, u, o, ɔ, ɐ, a] preceded by one of the 7 initial consonants [p-, k^h-, s-, w-, ts^h-, f-, h-] or the zero-initial (Ø) in CVN syllables.

Tables 11, 12 and 13 present the test words that contain the Taipung diphthongs [iɔ, ia, oi, ɐi, ɐu, ai, au] in CV syllables (Group 7), CVS syllables (Group 8) and CVN syllables (Group 9).

Diphthongs	CV structure				
	[p-/t^h-]	[k-/k^h-]	[s-]	[ts^h-]	[f-/h-]
[iɔ]		茄 [$k^hiɔ^{21}$] ‘aubergine’			靴 [$hiɔ^{33}$] ‘boots’
[ia]	啤 [pia^{55}] ‘beer’	his [k^hia^{33}] ‘his’	些 [sia^{33}] ‘some’	謝 [ts^hia^{55}] ‘thank’	啡 [fia^{55}] ‘brown’
[oi]	隊 [t^hoi^{55}] ‘team’	劾 [k^hoi^{55}] ‘tired’	衰 [soi^{33}] ‘bad’	吹 [ts^hoi^{33}] ‘blow’	開 [foi^{33}] ‘open’
[ɐi]	第 [$t^hɐi^{55}$] ‘rank’	雞 [$kɐi^{33}$] ‘chicken’	西 [$sɐi^{33}$] ‘west’	妻 [$ts^hɐi^{33}$] ‘wife’	輝 [$fɐi^{33}$] ‘shine’
[ɐu]	豆 [$t^hɐu^{55}$] ‘bean’	鳩 [$kɐu^{33}$] ‘dove’	修 [$sɐu^{33}$] ‘fix’	抽 [$ts^hɐu^{33}$] ‘pull’	邱 [$hɐu^{33}$] surname
[ai]	大 [t^hai^{55}] ‘big’	街 [kai^{33}] ‘street’	嘥 [sai^{33}] ‘waste’	搓 [ts^hai^{33}] ‘rub’	揩 [hai^{33}] ‘wipe’
[au]	滔 [t^hau^{33}] ‘overflow’	高 [kau^{33}] ‘tall’	騷 [sau^{33}] ‘disturb’	操 [ts^hau^{33}] ‘conduct’	浩 [hau^{33}] ‘grand’

Table 11: Test words in Group 7 that contain the 7 Taipung diphthongs [iɔ, ia, oi, ɐi, ɐu, ai, au] preceded by one of the 8 initial consonants [p-, t^h-, k-, k^h-, s-, ts^h-, f-, h-] in CV syllables.

Diphthongs	CVS structure				
	[t^h-]	[k-/k^h-]	[s-]	[ts^h-]	[f-/h-]
[ia]	踢 [$t^h iak^3$] ‘kick’	劇 [$k^h iak^3$] ‘drama’	錫 [$siak^3$] ‘tin’		
[iɔ]		腳 [$kiɔk^3$] ‘leg’	削 [$siɔk^3$] ‘peel’	卓 [$ts^h iɔk^3$] ‘excellent’	

Table 12: Test words in Group 8 that contain the 2 Taipung diphthongs [iɔ, ia] preceded by one of the 7 initial consonants [t^h-, k-, k^h-, s-, ts^h-, f-, h-] in CVS syllables.

Diphthongs	CVN structure				
	[t^h-]	[k-/k^h-]	[s-]	[ts^h-]	[f-/h-]
[iɛ]	廳 [$t^h iɛŋ^{33}$] ‘hall’	驚 [$kiɛŋ^{33}$] ‘scary’	腥 [$siɛŋ^{33}$] ‘fishy’	青 [$ts^h iɛŋ^{33}$] ‘green’	輕 [$hiɛŋ^{33}$] ‘light’
[iɔ]		薑 [$kiɔŋ^{33}$] ‘ginger’	箱 [$siɔŋ^{33}$] ‘box’	槍 [$ts^h iɔŋ^{33}$] ‘gun’	香 [$hiɔŋ^{33}$] ‘fragrant’

Table 13: Test words in Group 9 that contain the 2 Taipung diphthongs [iɔ, iɛ] preceded by one of the 7 initial consonants [t^h-, k-, k^h-, s-, ts^h-, f-, h-] in CVN syllables.

In Table 14, there are 35 test words in Group 10 that are associated with the 7 Taipung tones, namely [55, 33, 22, 25, 21, 5, 3], on the CV or CVS syllables.

Tones	Syllables				
	[p^hu/o(k)]	[si(t)]	[sa(k)]	[ji(p)]	[fu/o(k)]
[55]	步 [$p^h u^{55}$] ‘step’	是 [si^{55}] ‘be’	射 [sa^{55}] ‘shoot’	異 [ji^{55}] ‘strange’	負 [fu^{55}] ‘lose’
[33]	鋪 [$p^h u^{33}$] ‘pave’	詩 [si^{33}] ‘poem’	沙 [sa^{33}] ‘sand’	衣[ji^{33}] ‘clothes’	夫 [fu^{33}] ‘husband’
[22]	舖 [$p^h u^{22}$] ‘shop’	試 [si^{22}] ‘test’	社 [sa^{22}] ‘society’	以 [ji^{22}] ‘as’	富 [fu^{22}] ‘rich’
[25]	普 [$p^h u^{25}$] ‘common’	史 [si^{25}] ‘history’	捨 [sa^{25}] ‘give up’	椅 [ji^{25}] ‘chair’	府 [fu^{25}] ‘house’
[21]	葫 [$p^h u^{21}$] ‘gourd’	時 [si^{21}] ‘time’	蛇 [sa^{21}] ‘snake’	而 [ji^{21}] ‘and’	胡 [fu^{21}] ‘foreign’
[5]	僕 [$p^h ok^5$] ‘slave’	食 [sit^5] ‘eat’	石 [sak^5] ‘stone’	頁 [jip^5] ‘page’	服 [fok^5] ‘wear’
[3]	仆 [$p^h ok^4$] ‘fall’	舌 [sit^4] ‘tongue’	slice [sak^4] ‘slice’	醃 [jip^4] ‘pickle’	福 [fok^4] ‘prosperity’

Table 14: Test words in Group 10 that contain the 7 Taipung tones [55, 33, 22, 25, 21, 5, 3] on the CV or CVS syllables.

2.3 Data Collection and Analysis

For elicitation of speech samples, the test words in each group with 2 to 5 repetitions were randomised on a list. The subjects were asked to read aloud the words on the lists one by one at a normal rate of speech. The recording took place in the sound-proof booth in the Phonetics Laboratory of the Department of Linguistics and Translation at the City University of Hong Kong. The speech samples were digitally recorded and saved in the format of WAV for subsequent acoustic analysis by using the speech analysis software, Praat or Computerised Speech Lab (CSL).

In this study, all the audio files were at first transcribed into International Phonetic Alphabet (IPA) based on the perceptual judgement of the investigator of this project who is a native speaker of Taipung and has received phonetic training in transcription. For the consonants part, a total of 292 test tokens, including 178 for the initial consonants (89 test words x 2 repetitions), 104 for the final consonants (52 test words x 2 repetitions) and 10 for the syllabic nasals (5 test words x 2 repetitions), were analysed. The analysis was mainly based on the investigator's perceptual judgement, but spectrographic analysis was also performed when necessary.

The test tokens for the vowels (250) and diphthongs (194) were acoustically analysed by using the Praat software for the frequency values of the first three formants ($F_1F_2F_3$). The spectral measurements were made at the mid-point of the steady-state portion of the formant trajectories of each vowel and each of the two vowel elements of the diphthongs. The obtained formant frequencies were then plotted on an acoustic chart with F_1 shown on the y-axis and F_2 on the x-axis, in order to show the

relationship between F_1 and the tongue height and between F_2 and the tongue backness for the vowels and diphthongs in Taipung.

As for the tones, a total of 175 test tokens of the 7 tones in Taipung were acoustically analysed (7 tones x 5 test words x 5 repetitions). Fundamental frequency (F_0) analysis was performed for obtaining the pitch contour of each tone using the CSL software. For each pitch contour, the F_0 value was measured at 11 points, including the onset point and the points at every 10% of the total duration of the contour. A mean pitch contour for each tone was then drawn on a chart by averaging the F_0 values at the same time points of the contours for all the tokens of a given tone.

Chapter 3 Results

The results of the analysed data for the Taipung consonants, vowels, diphthongs and tones are presented in the following sections.

3.1 Consonants

3.1.1 Initial consonants

Taipung dialect is found to have 17 initial consonants as presented in Table 15. The initial consonants in Taipung can be categorised into 6 groups according to their manner of articulation, namely plosive, fricative, affricate, nasal, approximant and lateral approximant, or another 6 groups according to their place of articulation, including bilabial, labiodental, alveolar, palatal, velar/labio-velar and glottal.

	Manner of articulation	Place of articulation					
		Bilabial	**Labiodental**	**Alveolar**	**Palatal**	**Velar/ Labio-velar**	**Glottal**
Obstruent	**Plosive**	p p^h		t t^h		k k^h	
	Fricative		f	s			h
	Affricate			ts ts^h			
Sonorant	**Nasal**	m		n		ŋ	
	Approximant		(ʋ)		j	w	
	Lateral approximant			l			

Table 15: Initial consonant chart of Taipung.

In Taipung, all the initial obstruent consonants, i.e., plosives, fricatives and affricates, are voiceless, and the plosives and affricates can be further categorised as unaspirated, i.e. [p-, t-, k-, ts-], and aspirated, i.e. [p^h-, t^h-, k^h-, ts^h-]. Fricative group only consists

of 3 initial consonants: labiodental [f-], alveolar [s-] and glottal [h-]. As for the initial sonorant consonants in Taipung, they include 3 nasals: bilabial [m-], alveolar [n-] and velar [ŋ-], and 3 approximants: labio-velar [w-], palatal [j-] and lateral [l-]. All the sonorant consonants are voiced.

For the initial approximant [w-] in Taipung, it is found to have a labiodental allophone [ʋ-] in the present study. When the initial [w-] precedes a low vowel [a], it changes to [ʋ-]. This may explain why the labial approximant is described as [w-] in Lau (2013) and Chen (2016), but as [ʋ-] in Lau & Yuan (2010). The initial [w-] and [ʋ-] are clearly distinct acoustically in the speech of the speaker in the present study. Figure 1 shows the waveform and spectrogram of the test word 蛙 ('frog') which is pronounced as [ʋa^{33}] by the speaker. As can be seen, there is a clear boundary between the initial consonant (in green line frame) and the following vowel in the word. In the waveform, the intensity or amplitude is noticeably low for the initial [ʋ-] as compared to the following vowel [a] and there is a sudden large increase in amplitude when the vowel starts. Correspondingly, on the spectrogram the energy is weaker for the initial [ʋ-] than the vowel [a].

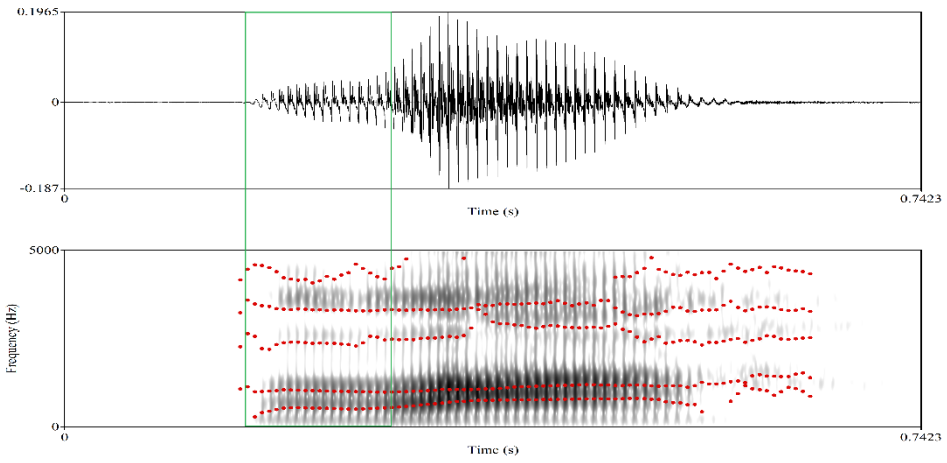


Figure 1: Waveform and spectrogram of the test word 蛙 ('frog') [ʋa^{33}].

When the initial [w-] occurs in other vowel contexts, it remains as a labio-velar approximant. Figure 2 and Figure 3 show the waveforms and spectrograms of the test words 烏 (‘dark’) [wu^{33}] and 威 (‘prestige’) [wɐi^{33}], in which the initial consonant is pronounced as [w-]. As shown in the two figures, there is no clear boundary separating the initial [w-] and the following vowel or diphthong, and the intensity of the waveform keeps increasing from the beginning of the word.

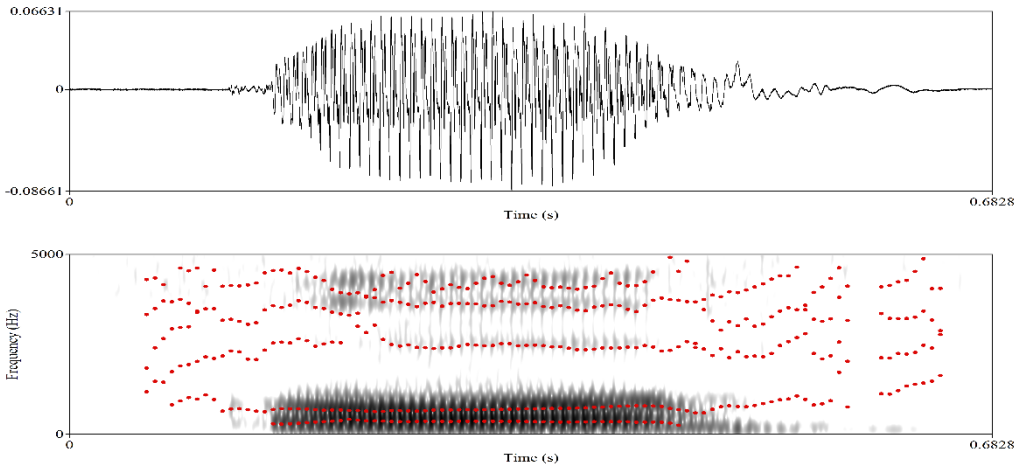


Figure 2: Waveform and spectrogram of the test word 烏 (‘dark’) [wu^{33}].

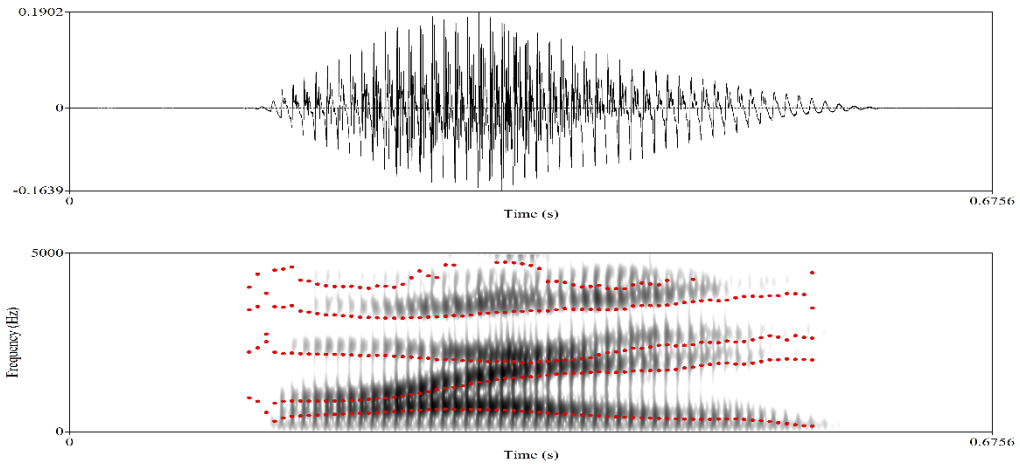


Figure 3: Waveform and spectrogram of the test word 威 (‘prestige’) [wɐi^{33}].

Besides the approximant [w], there is also a discrepancy in the description of the initial nasal [n-] among the previous studies of Taipung. In some studies, such as Lau & Yuan

(2010) and Lau (2013), the initial nasal [n-] is considered as an allophone of [l-]. In the present study, however, the initial [n-] and [l-] are found to be clearly distinct in the test words, such as [n-] in 拿 (‘to pick’) [na^{21}], 你 (‘you’) [ni^{22}] and 泥 (‘mud’) [nɐi^{21}] and [l-] in 啦 (‘a particle’) [la^{33}], 利 (‘profit’) [li^{55}] and 麗 (‘beauty’) [lɐi^{55}]. Figure 4 to Figure 9 show the waveforms and spectrograms of these test words. A comparison of the spectrograms of the initial [n-] in Figures 4, 6 and 8 (in blue line frame) and those of the initial [l-] in Figures 5, 7 and 9 (in green line frame) show that the energy in any case is weaker for [n-] than [l-], indicating a clear distinction between the two types of initial consonants.

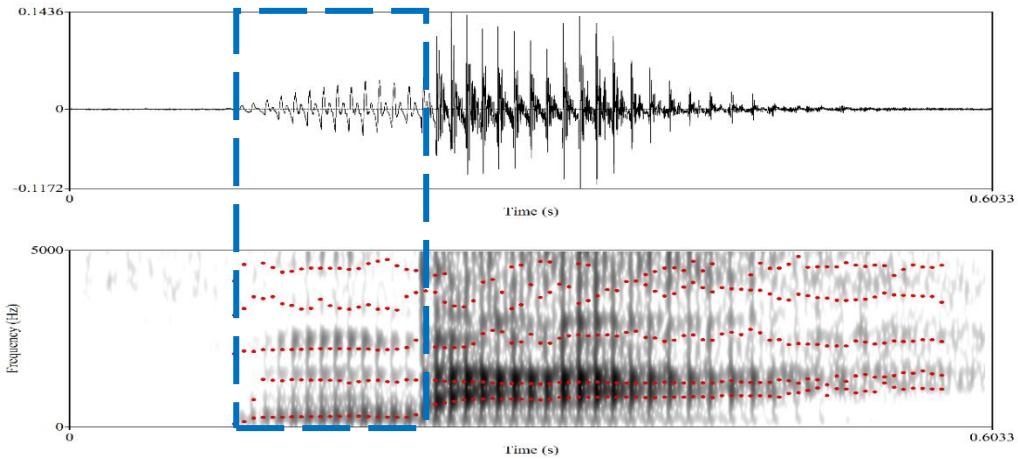


Figure 4: Waveform and spectrogram of the test word 拿 (‘to pick’) [na^{21}].

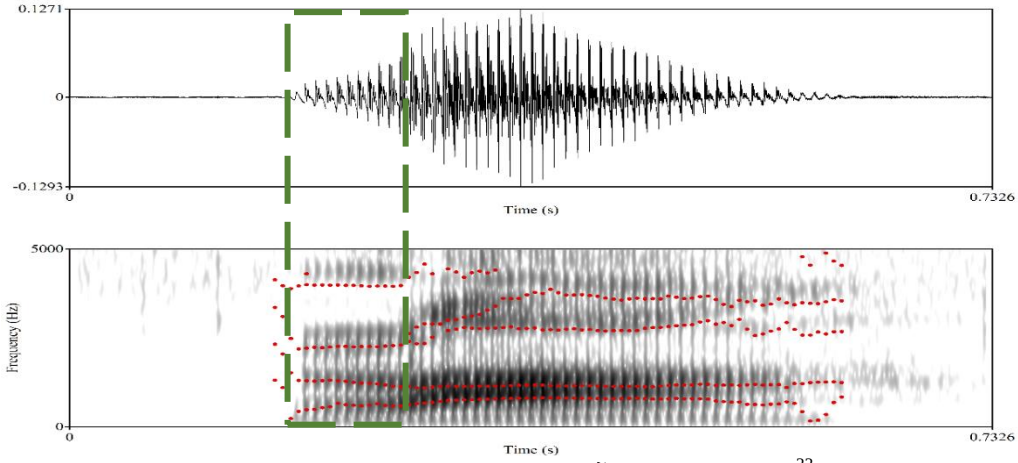


Figure 5: Waveform and spectrogram of the test word 啦 (‘a particle’) [la^{33}].

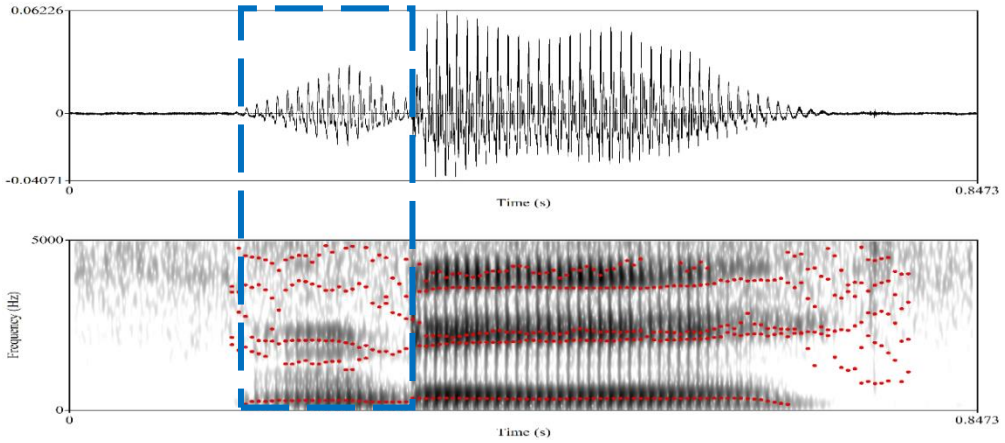


Figure 6: Waveform and spectrogram of the test word 你 (‘you’) [ni^{22}].

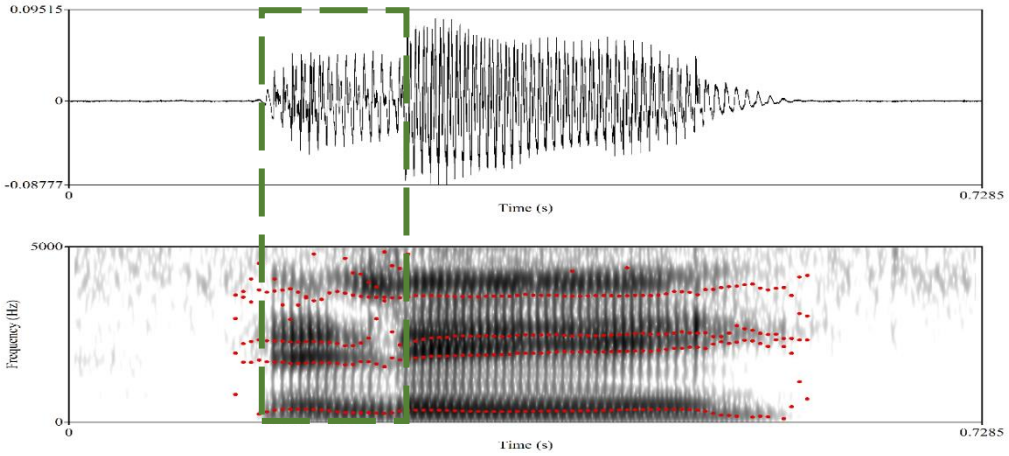


Figure 7: Waveform and spectrogram of the test word 利 (‘profit’) [li^{55}].

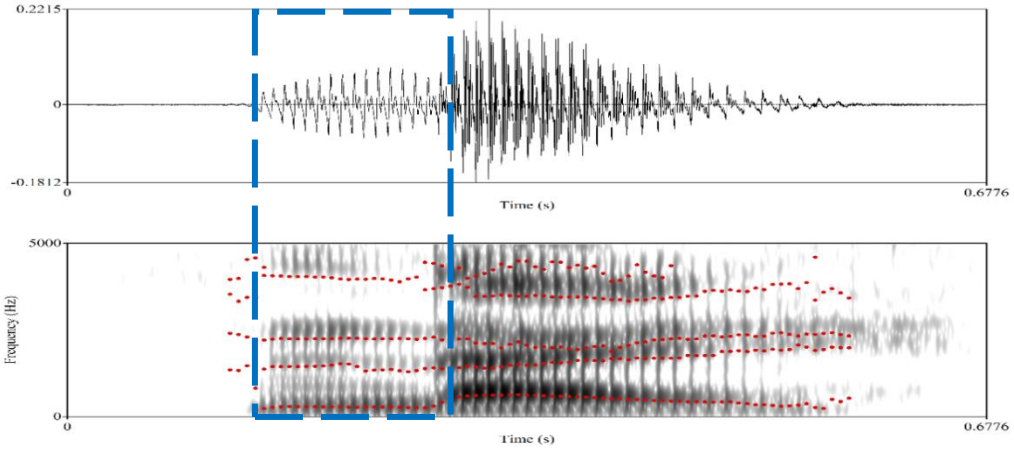


Figure 8: Waveform and spectrogram of the test word 泥 (‘mud’) [nɐi^{21}].

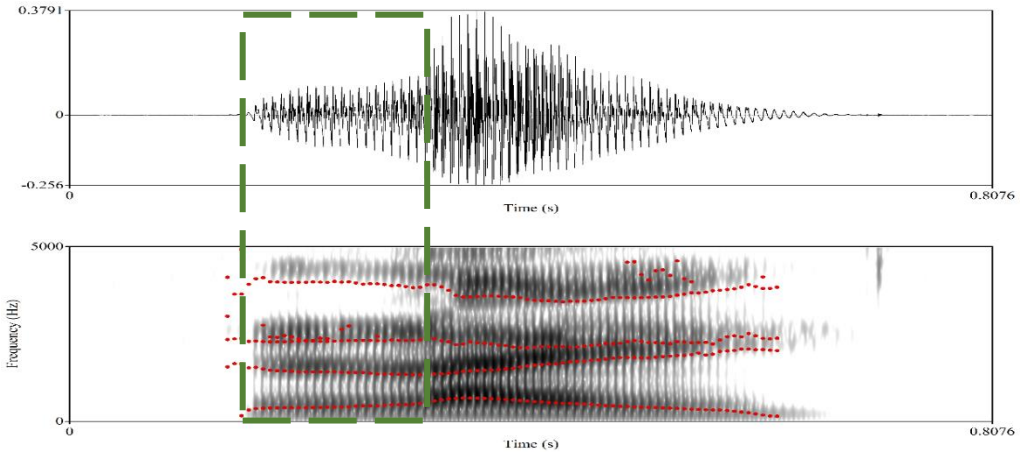


Figure 9: Waveform and spectrogram of the test word 麗 ('beauty') [lɐi^{55}].

3.1.2 Final consonants

The analysed speech data in this study reveal that there are all together 6 final consonants in Taipung. They can be grouped into 2 categories, namely plosives and nasals, as presented in Table 16.

Manner of articulation	**Place of articulation**		
	Bilabial	Alveolar	Velar
Plosive	-p	-t	-k
Nasal	-m	-n	-ŋ

Table 16: Final consonant chart of Taipung.

The final plosives of Taipung include [-p], [-t] and [-k]. Similar to many other southern Chinese dialects, like Cantonese and Hakka, the final plosives are unreleased in Taipung. As for the final nasal group, there are also 3 members which are [-m], [-n] and [-ŋ] in Taipung. The three place categories of the final plosives and nasals in Taipung are clearly distinct in perception.

3.1.3 Syllabic consonants

Taipung also similar to many other southern Chinese dialect to have syllabic nasal consonants. There are two in Taipung, including the syllabic bilabial nasal [m̩] and syllabic velar nasal [ŋ̍]. The syllabic bilabial nasal [m̩] appears only in a single word 唔 (‘not’) [m̩^{21}], while the syllabic velar nasal [ŋ̍] is the single sound in the words like 誤 (‘mistake’) [ŋ̍^{55}], 五 (‘five’) [ŋ̍^{25}] and 午 (‘noon’) [ŋ̍^{25}].

3.2 Vowels

The speech samples from the speaker in this study show that there are totally 6 vowels in Taipung. They are the high front vowel [i], high back vowel [u], high-mid back vowel [o], low-mid back vowel [ɔ], low-mid central vowel [ɐ] and lastly low front vowel [a]. All the 6 vowels can occur in CVS and CVN syllables closed with a final stop or nasal, while only the vowels [i, u, o, a] can occur in CV syllables. Figure 10 shows the F_1F_2 acoustic vowel chart for the Taipung vowels [i, u, o, a] in CV syllables (in black) and [i, u, o, ɔ, ɐ, a] in CVS (in red) and CVN (in green) syllables. On the chart, each vowel is plotted based on the mean F_1 and mean F_2 values by averaging across all the test tokens that contain a given vowel in the same type of syllable. The chart also shows the vowel loops which are drawn by connecting the F_1F_2 data points for the corner vowels [i, u, o, a] or [i, u, o, ɔ, a] in each syllable type.

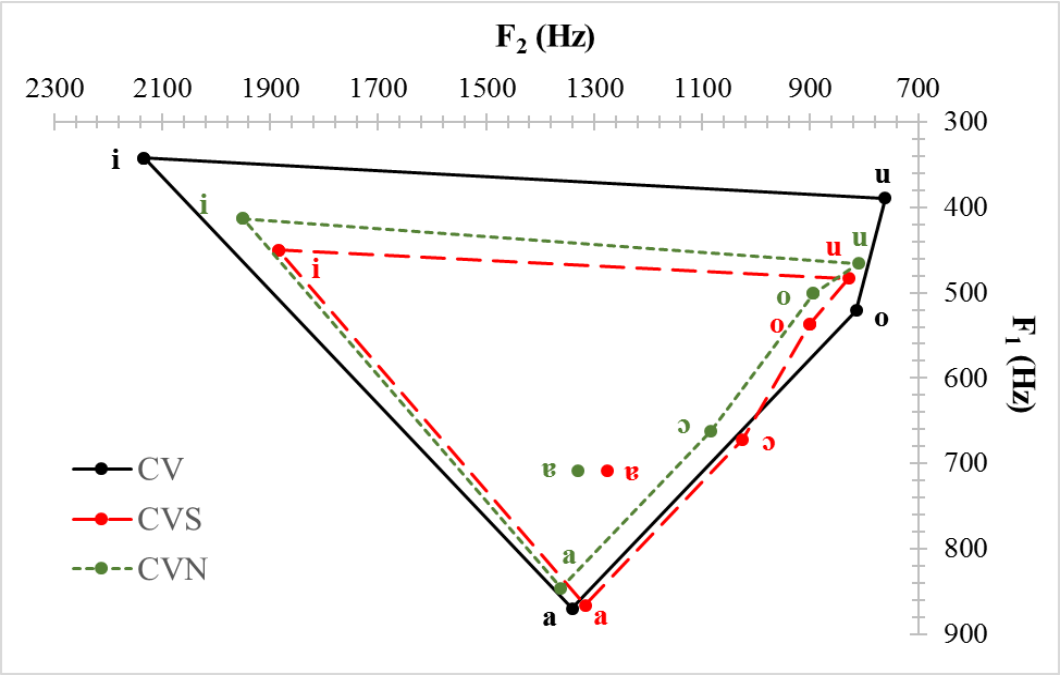


Figure 10: F_1F_2 acoustic vowel chart for the Taipung vowels [i, u, o, ɔ, ɐ, a] in CV (in black), CVS (in red) and CVN (in green) syllables.

Tables 17-19 give the mean values in Hertz (Hz) of the F_1, F_2 and F_3 for the 6 vowels [i, u, o, ɔ, ɐ, a] in CV, CVS and CVN syllables, where the mean F_1 and mean F_2 are used for plotting the vowel chart in Figure 10.

Vowels in CV syllables	F_1	F_2	F_3
i	342	2134	2715
u	390	760	2664
o	521	815	2805
a	870	1341	2655

Table 17: Mean formant frequencies ($F_1F_2F_3$) in Hz for the vowels in CV syllables.

Vowels in CVS syllables	F_1	F_2	F_3
i	450	1885	2349
u	483	829	2426
o	537	901	2455
ɔ	672	1025	2588
ɐ	709	1275	2214
a	866	1317	2606

Table 18: Mean formant frequencies ($F_1F_2F_3$) in Hz for the vowels in CVS syllables.

Vowels in CVN syllables	F_1	F_2	F_3
i	413	1950	2463
u	466	811	2428
o	501	894	2474
ɔ	662	1084	2561
ɐ	708	1331	2386
a	846	1362	3476

Table 19: Mean formant frequencies ($F_1F_2F_3$) in Hz for the vowels in CVN syllables.

As shown in Figure 10, the vowel [i, u, o, a] are positioned more peripheral in the vowel space when they occur in CV syllables than in CVS and CVN syllables. The reduction of the vowels in closed syllables is expected due to the shortened duration of the vowels. In closed CVS and CVN syllables, the high vowels [i] and [u] shift noticeably downward and more centralised in the vowel space, as compared to [i] and [u] in open CV syllables. This is because [i] has a larger F_1 and a smaller F_2 in CVS (450 Hz, 1885 HZ) and CVN (413 Hz, 1950 Hz) syllables than in CV syllables (342 Hz, 2134 Hz); and [u] has larger F_1 and F_2 in CVS (483 Hz, 829 Hz) and CVN (466 Hz, 811 Hz) syllables than in CV syllables (390 Hz, 760 Hz). Centralisation is also observed for the mid back vowel [o] in closed syllables, which is mainly due to an increase in F_2 in CVS (901 Hz) or CVN (894 Hz) syllables relative to the F_2 of [o] in CV syllables (815 Hz). A for the low vowel [a], the F_1 is slightly reduced in CVS (866 Hz) and CVN (846 Hz) syllables, relative to the F_1 of [a] in CV syllables (870 Hz), resulting in a small upward shift for [a] in the vowel space. In CVS and CVN syllables, there are two other vowels [ɔ] and [ɐ] found in Taipung. In the vowel space, the vowel [ɔ] is in general positioned mid-way in between [o] and [a], whereas [ɐ] is a central vowel positioned mid-way in between [ɔ] and [a].

3.3 Diphthongs

The findings in this study show that there are 9 diphthongs in Taipung. They can be grouped into two categories according to the direction of movement of the two vowel elements in the diphthongs. One group contains the diphthongs [ia/iɛ, io, iɔ] with a high-to-low movement. The other group include the diphthongs [oi, ɐi, ɐu, ai, au] with a low-to-high movement. There is one more diphthong [iu] in Taipung that begins and ends with a high vowel with a front-to-back movement. However, this diphthong by accident is missing from the investigation. Figure 11 is a diphthong chart for Taipung [ia/iɛ, io, iɔ, oi, ɐi, ɐu, ai, au] in CV (in black), CVS (in red) and CVN (in green) syllables. On the chart, an arrow is used to indicate the positions and movements of the two vowel elements in a diphthong, which is drawn based on the mean F_1 and mean F_2 for each of the diphthongs as presented in Tables 20-22.

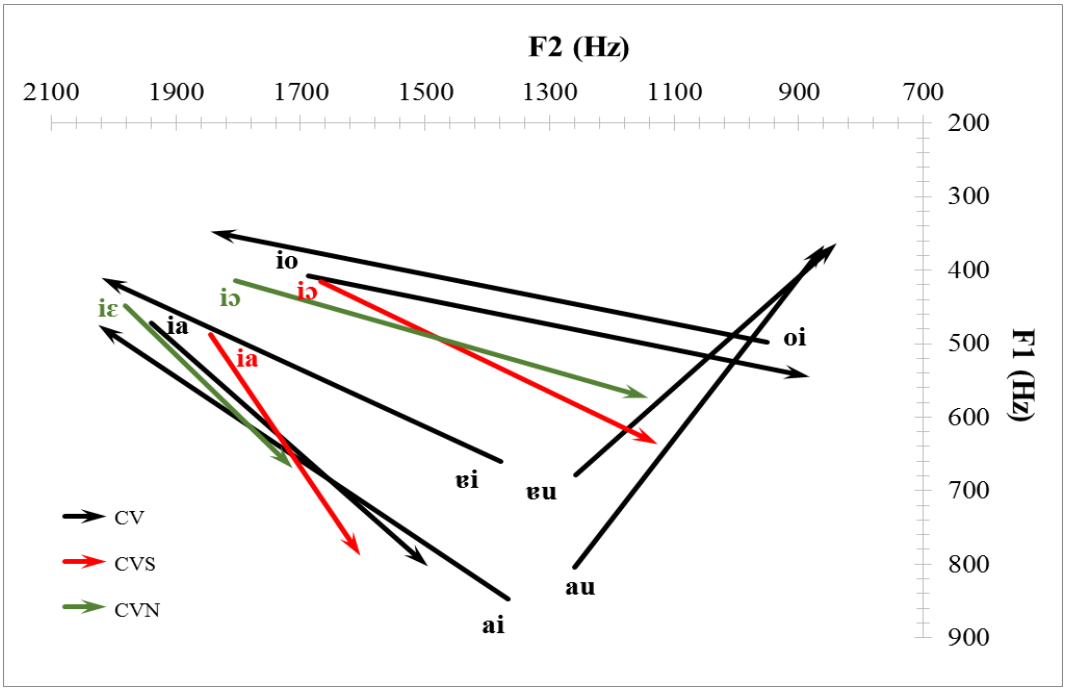


Figure 11: F_1F_2 acoustic chart for the Taipung diphthongs [ia/iɛ, io, iɔ, oi, ɐi, ɐu, ai, au] in CV (in black), CVS (in red) and CVN (in green) syllables.

Diphthongs in CV syllables	First vowel			Second vowel		
	F_1	F_2	F_3	F_1	F_2	F_3
io	408	1687	2215	545	883	2785
ia	472	1940	2513	803	1495	2370
oi	498	951	2542	348	1845	2534
ɐi	660	1378	2374	410	2020	2613
ɐu	678	1259	2514	363	839	2799
ai	847	1367	2551	475	2025	2645
au	804	1260	2625	366	859	2682

Table 20: Mean formant frequencies ($F_1F_2F_3$) in Hz for the two vowel elements of the diphthongs in CV syllables.

Diphthongs in CVS syllables	First vowel			Second vowel		
	F_1	F_2	F_3	F_1	F_2	F_3
iɔ	415	1668	2191	637	1127	2314
ia	487	1844	2404	788	1604	2220

Table 21: Mean formant frequencies ($F_1F_2F_3$) in Hz for the two vowel elements of the diphthongs in CVS syllables.

Diphthongs in CVN syllables	First vowel			Second vowel		
	F_1	F_2	F_3	F_1	F_2	F_3
iɔ	414	1805	2268	574	1142	2261
iɛ	448	1982	2504	669	1712	2259

Table 22: Mean formant frequencies ($F_1F_2F_3$) in Hz for the two vowel elements of the diphthongs in CVN syllables.

In order to determine the positions in the acoustic vowel space for the diphthongs relative to the monophthongs, Figure 12 shows the superimposed vowel loop for the monophthongs [i, u, o, a] in CV syllables (in black dash line) on the F_1F_2 acoustic vowel chart for the diphthongs [ia/iɛ, io, iɔ, oi, ɐi, ɐu, ai, au] that occur in CV syllables. In the figure, the position for the central vowel [ɐ] that only occurs in CVS and CVN syllables is also plotted, which is based on the mean F_1 and mean F_2 for [ɐ] in the two types of closed syllables. Figure 13 and Figure 14 show the respective F_1F_2 acoustic vowel charts for the monophthongs [i, u, o, ɔ, a] and the diphthongs [iɔ, ia] in

CVS syllables and the monophthongs [i, u, o, ɔ, a] and the diphthongs [iɔ, iɛ] in CVN syllables.

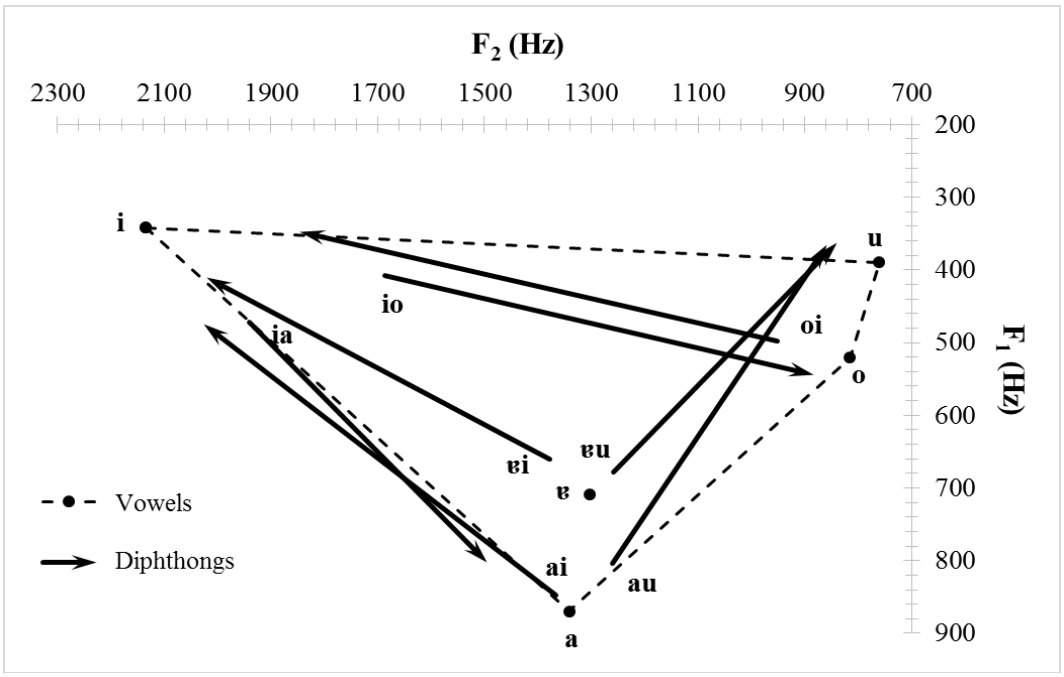


Figure 7: F_1F_2 acoustic chart for the Taipung diphthongs [ia/iɛ, io, iɔ, oi, ɐi, ɐu, ai, au] and vowels [i, u, o, a] in CV syllables and [ɐ] in CVS and CVN syllables.

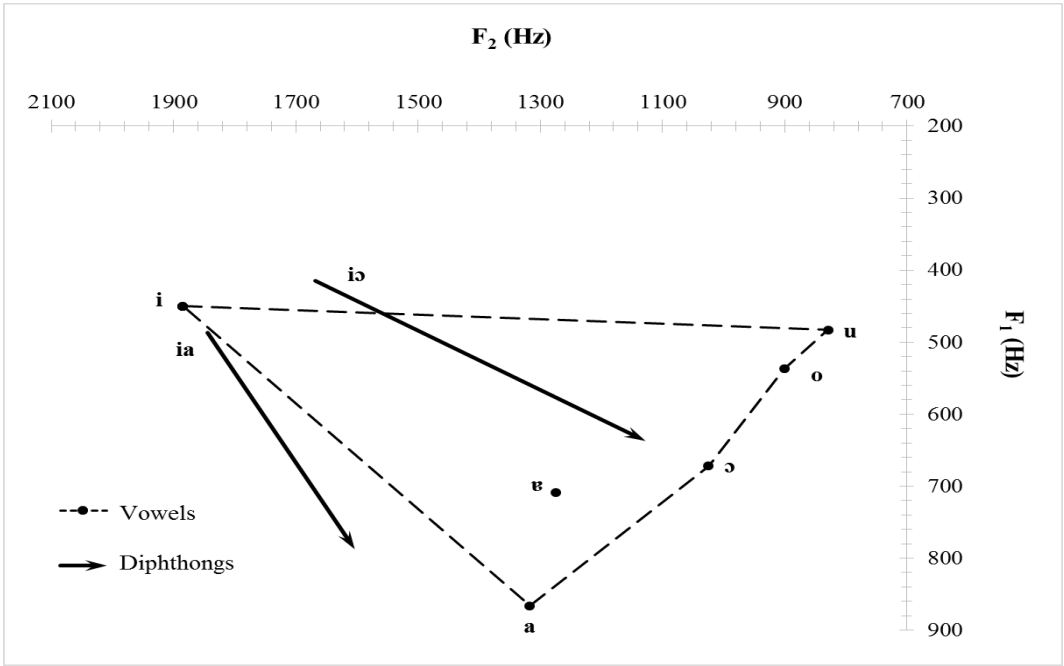


Figure 13: F_1F_2 acoustic chart for the Taipung diphthongs [iɔ, ia] and vowels [i, u, o, ɔ, a, ɐ] in CVS syllables.

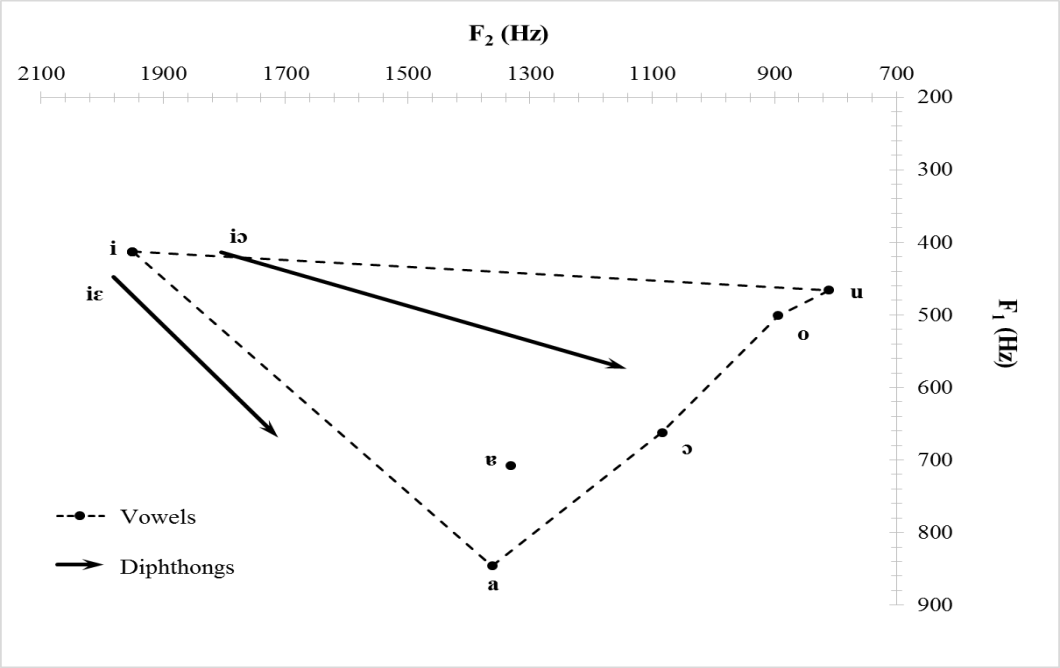


Figure 8: F_1F_2 acoustic chart for the Taipung diphthongs [iɔ, iɛ] and vowels [i, u, o, ɔ, a, ɐ] in CVN syllables.

As shown in Figure 12, [i] in the diphthongs [io, ia, oi, ɐi, ai] is reduced, relative to the monophthong [i]. For the [i] in [io, oi] adjacent to a round back vowel [o], there is a large decrease in F_2 (1687 Hz, 1845 Hz) as compared to the F_2 of the monophthong [i] (2134 Hz). For [i] in [ia, ɐi, ai] preceding or following a low vowel, there is a large increase in F_1 (472 Hz, 410 Hz, 475 Hz) as compared to the F_1 (342 Hz) for the monophthong [i]. As for [u] in [ɐu, au], reduction is also observed, which is mainly due to an increase in F_2 (839 Hz, 859 Hz) as compared to the F_2 (760 Hz) for the monophthong [u]. The vowel elements [o] in [io, oi], [ɐ] in [ɐi, ɐu] and [a] in [ai, au] are centralised, mainly due to an increase in F_1 for the low [ɐ] in [ɐi, ɐu] (660 Hz, 678 Hz) and [a] in [ai, au] (847 Hz, 804 Hz) relative to the F_1 of the monophthongs [ɐ] (709 Hz) and [a] (870 Hz); and an increase in F_2 for the back [o] in [io, oi] (883 Hz, 951 Hz) relative to the F_2 of the monophthong [o] (815 Hz).

As for the diphthongs in CVS and CVN syllables, reduction or centralisation is also observed as compared to the monophthongs. In CVS (Figure 13) or CVN (Figure 14) syllables, [i] in [ia, iɛ] before a low or mid vowel is more downward and has a larger F_1 (487 Hz, 448 Hz) than the monophthong [i] (450 Hz, 413 Hz) and [i] in [iɔ] before a rounded back vowel is more backward and has a smaller F_2 (1668 Hz, 1805 Hz) than the monophthong [i] (1885 Hz, 1950 Hz). As for [ɔ] in [iɔ], it is more centralised to have a smaller F_1 and larger F_2 in CVS (637 Hz, 1127 Hz) and CVN (574 Hz, 1142 Hz) syllables than the monophthong [ɔ] in CVS (672 Hz, 1025 Hz) and CVN (662 Hz, 1084 Hz) syllables. As for [a] in [ia] in CVS syllables, it is more upward and forward in the vowel space with a smaller F_1 (788 Hz) and a larger F_2 (1604 Hz) than the F_1F_2 for the monophthong [a] (866 Hz, 1317 Hz) in CVS syllables. As for [ɛ] in [iɛ] in CVN syllables, since the monophthong [ɛ] is not available in Taipung, no comparison is made for determining the variation of [ɛ] in the diphthong. Nonetheless, as shown in Figure 14, the position for [ɛ] in [iɛ] is generally mid-way in between the monophthongs [i] and [a] in CVN syllables.

3.4 Tones

There are 1 rising tone, 1 falling tone and 3 level tones as well as 2 short tones, making up a total of 7 tones in Taipung. Figure 15 shows the F_0 contours of the 7 tones distributed in 5 zones in equidistance, which are determined by the highest and lowest F_0 for the 7 tones, corresponding to the conventional 5-point tone scale (Chao, 1930). The contour of each tone is drawn based on the mean F_0 for each of the 11 points taken proportionally at every 10% of the total duration of the tone starting from the onset of a given tone. Table 23 displays the mean F_0 data in Hz by averaging 25 tokens (5 test words x 5 repetitions) for each tone.

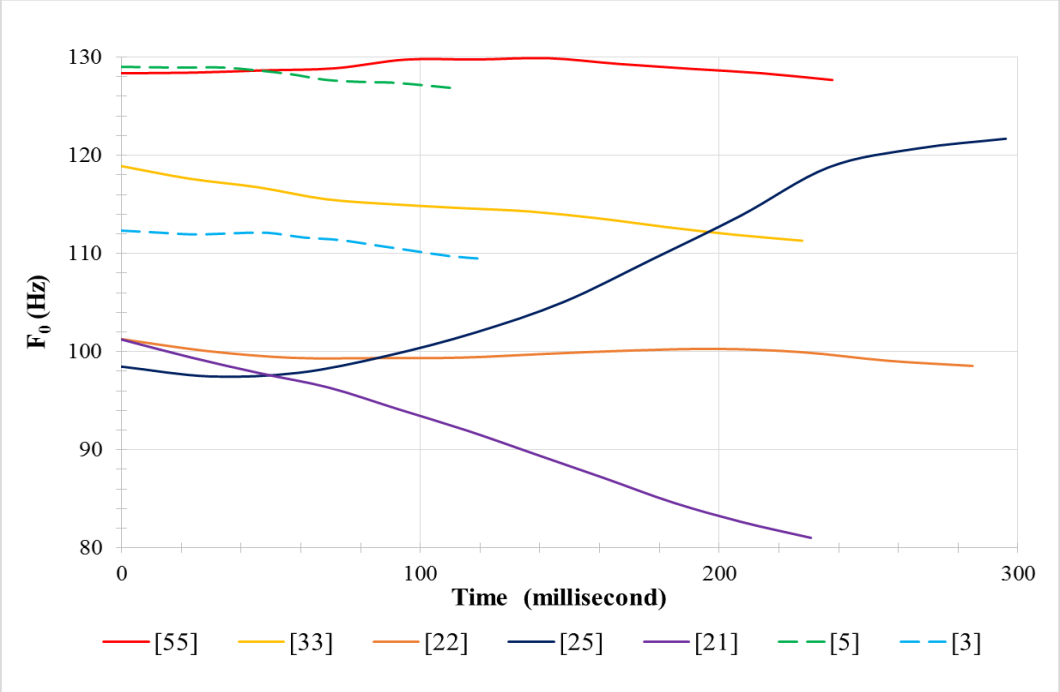


Figure 9: Mean F_0 contours of the Taipung tones [55, 33, 22, 25, 21, 5, 3].

	11 points proportionally taken at the F_0 contours of the tones											
Tones	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	Duration
[55]	128	128	129	129	130	130	130	129	129	128	128	238
[33]	119	118	117	116	115	115	114	114	113	112	111	228
[22]	101	100	99	99	99	100	100	100	100	99	99	285
[25]	98	97	98	100	102	105	109	114	119	121	122	296
[21]	101	99	98	96	94	92	90	87	85	83	81	231
[5]	129	129	129	129	129	128	128	127	127	127	127	113
[3]	112	112	112	112	112	112	111	111	110	110	109	122

Table 23: Mean F_0 (in Hz) and duration (in ms) for the tones [55, 33, 22, 25, 21, 5, 3] in Taipung.

In Figure 15, it can be seen the F_0 contours of the long tones [55, 33, 22] as well as the two short tones [5, 3] are relatively flat, whereas the F_0 contour is rising for [25] and falling for [21]. Among all the tones, the F_0 of [55] is the highest (135 Hz) and its

F_0 contour (in red) lies in the upper zone on the 5-point scale, and thus [55] is characterised as the high level tone in Taipung. The F_0 values of [33] (115 Hz) and [22] (100 Hz) are lower than the F_0 of [55]. The F_0 contour of [33] (in yellow) lies mainly in the second upper zone, with a gradual drop toward to the middle zone at the end of the tone. Due to such moderate drop in F_0 for [33], it perceptually sounds as a mid tone rather than a mid-high tone, and thus it may be characterised as a mid level tone in Taipung. As for [22], its F_0 contour (in orange) tends to lie slightly beyond the lowest boundary of the middle zone, and perceptually it sounds as a low-mid tone. As for the two short tones (in dash-line), the F_0 of [5] (128 Hz) is similar to that of [55] (135 Hz) and [3] (111 Hz) is close to [33] (115 Hz), while both [5] (113 ms) and [3] (122 ms) are just about a half of the duration of [55] (238 ms) and [33] (228 ms). In Taipung, the long tones are produced on CV or CVN syllables and the short tones are only associated with CVS syllables, so the tones [5, 3] can be characterised as the short variants of the tones [55, 33].

As for the two contour tones [25] and [21], the beginning portions of their F_0 contours overlap with the F_0 contour of [22]. Toward the end of the tone, the F_0 is largely increased and reaches the upper zone for [25], indicating its high rising tonal characteristic, whereas the F_0 drops to the lowest level for [21], indicating its low falling tonal feature.

Chapter 4 Discussion

4.1 Comparisons with Previous Works

In this section, the findings in the present study about the sound system of Taipung are compared with those of the previous works, including Lau & Yuan (2010), Lau (2013) and Chen (2016), with respect to the discrepancies in the description of the sound system among the different studies. As mentioned in Chapter 1, it is in agreement with Lau (2013) that Pingchau is a variety of Taipung dialect, so the sound system of Pingchau is also included in the comparison.

4.1.1 Consonants

For comparison purposes, the initial and syllabic consonant inventories of Taipung, including Pingchau, presented in the present study and previous studies are listed in Table 24. In the table, allophones, if any, are put next to each other with a dash in between. The unique features, which make the findings in the present and previous studies differ, are in bold letters.

Sources	Initial consonants	Syllabic consonants
Taipung (Present study)	[p-, p^h-, t-, t^h-, k-, k^h-, ts-, ts^h-, f-, s-, h-, m-, n-, ŋ-, l-, j-, **w-/ʋ-**]	[m̩, ŋ̩]
Pingchau (Lau, 2013)	[p-, p^h-, t-, t^h-, k-, k^h-, ts-, ts^h-, f-, s-, h-, m-, **n-/l-**, ŋ-, j-, w-]	No information
Taipung (Lau & Yuan, 2010)	[p-, p^h-, t-, t^h-, k-, k^h-, ts-, ts^h-, f-, s-, h-, m-, **l-**, **ɲ-/ŋ-**, j-, ʊ-]	[m̩, ŋ̩]
Taipung (Chen, 2016)	[p-, p^h-, t-, t^h-, k-, k^h-, ts-, ts^h-, f-, s-, h-, m-, n-, ŋ-, l-, j-, w-]	**[m̩]**

Table 24: Initial and syllabic consonants of Taipung found in different studies.

From Table 24, it can be observed that the four studies have very similar results of the obstruent consonants. All the studies agree that the obstruent consonants in Taipung

are voiceless, and the plosives and affricates have a contrast in aspiration. The differences among the studies are mainly in the sonorant consonants. The findings of Lau & Yuan (2010) and Lau (2013) suggest that the speakers of Taipung and Pingchau do not distinguish the initial [n-] and [l-]. In Lau & Yuan (2010), [n-] has disappeared and merged with [l-], whereas in Lau (2013) [n-] and [l-] are described as free allophones. However, in Chen (2016), both [n-] and [l-] are considered as two distinct phonemes in Taipung, and it is supported by the data obtained in the present study. As presented earlier in Chapter 3 of this report, the Taipung speaker pronounces the initial [n-] and [l-] distinctly in all the test words. Since the Taipung data obtained in Lau & Yuan (2010) and Lau (2013) are not from the speakers who are considered to have a representative accent of Taipung, it may be a possible reason for the different findings of [n-] and [l-] found in the their studies. Nonetheless, further confirmation is needed by collecting more speech samples from Taipung speakers who have a standard accent.

There are other differences in the Taipung sonorant consonants between Lau & Yuan (2013) and other studies. They include the derivation of a palatal allophone [ɲ-] from the velar nasal [ŋ-] and substitution of a labiodental approximant [ʋ-] for the labio-velar approximant [w-]. These two descriptions are not supported by the data obtained in the present study, as no palatal nasal [ɲ-] is found in the test words elicited from the Taipung speaker and the labiodental [ʋ-] is only derived when [w-] is followed by a low vowel [a]. There are also no palatal [ɲ-] and labiodental [ʋ-] reported in Lau (2013) and Chen (2016).

One more difference between the present and previous studies is in the syllabic consonants. In Chen (2016), there is only 1 bilabial [m̩] included in Taipung's sound

system, but two syllabic nasals, the bilabial [m̩] and velar [ŋ̍], are reported in Lau & Yuan (2010). The present study support Lau & Yuan (2010) that there are two syllabic nasals in Taipung, where the bilabial [m̩] is more restricted to occur in a single word 唔 (‘not’) and the velar [ŋ̍] occurs in a few words, e.g. 誤 (‘mistake’), 五 (‘five’) and 午 (‘noon’).

After summing up the similarities and differences among the present and previous studies, the initial and syllabic consonants inventories of Taipung listed in Table 25 are proposed.

Initial consonants	Syllabic consonants
[p-, p^h-, t-, t^h-, k-, k^h-, ts-, ts^h-, f-, s-, h-, m-, n-, ŋ-, l-, j-, w-]	[m̩, ŋ̍]

Table 25: Proposed initial and syllabic consonant inventories of Taipung.

Table 26 presents the final consonants of Taipung, including Pingchau (as a variety of Taipung), found in the present and previous studies. Since all the studies agree that Taipung has 6 final consonants, 3 final stops [-p, -t, -k] and 3 final nasals [-m, -n, -ŋ], these 6 final consonants are included in the proposed Taipung’s sound system as listed in Table 27.

Sources	Final consonants
Taipung (Present study)	[-p, -t, -k, -m, -n, -ŋ]
Pingchau (Lau, 2013)	[-p, -t, -k, -m, -n, -ŋ]
Taipung (Lau & Yuan, 2010)	[-p, -t, -k, -m, -n, -ŋ]
Taipung (Chen, 2016)	[-p, -t, -k, -m, -n, -ŋ]

Table 26: Final consonants of Taipung found in different studies.

Final consonants	[-p, -t, -k, -m, -n, -ŋ]

Table 27: Proposed final consonant inventory of Taipung.

4.1.2 Vowels

The vowels of Taipung and Pingchau in the present and previous studies are listed in Table 28. The vowels that are not consistently described in different studies are in bold letters.

Sources	Vowels
Taipung (Present study)	[i, u, **o**, ɔ, ɐ, a]
Pingchau (Lau, 2013)	[i, u, **o**, ɔ, **ɛ**, ɐ, a]
Taipung (Lau & Yuan, 2010)	[i, u, ɔ, ɐ, a]
Taipung (Chen, 2016)	[i, u, ɔ, ɐ, a]

Table 28: Vowels of Taipung found in different studies.

As shown in Table 28, there are 5 vowels [i, u, ɔ, ɐ, a] in Taipung's sound inventory proposed in each of the four studies. The 5 sounds are the only vowels in the inventory given in Lau & Yuan (2010) and Chen (2016). In Lau (2013), there are two other vowels included in the inventory, i.e. the mid front [ɛ] and mid back [o]. The word example given by Lau that contains the vowel [ɛ] is 些 ('some') [sɛ]. This word however is transcribed as [siɛ] in Lau & Yuan (2010), where [ɛ] is no longer a monophthong but a diphthong [iɛ]. According to Chen (2016), [siɛ] is an illegal syllable in Taipung. In the present study, there is no mid front vowel [ɛ] found in Taipung, although there is a diphthong [iɛ] found in the CVN syllables with a final nasal [-ŋ]. Furthermore, the word 些 ('some') produced by the speaker in the present study is [sia], instead of [sɛ] as transcribed in Lau (2013). Figure 16 shows the waveform and spectrogram of the word 些 ('some') produced by the male speaker in the present study. From the spectrogram, it can be seen that the formant pattern continuously changes after the initial fricative [s-] toward the end of the word, indicating that the vowel in the word is produced with dynamic quality. The formants,

in particular F_1 and F_2, suggest the word has a diphthong composing of two vowel components. In the figure, the second component of the diphthong is in a dash-line frame, which is determined based on the first three formants shown on the spectrogram. The values of $F_1F_2F_3$ measured at the mid-point of the framed part are 827 Hz, 1508 Hz and 2376 Hz respectively, where the F_1 is close to the mean F_1 value of 870 Hz for the monophthong [a] in the CV syllables. Thus, the formant data do not support the second vowel component in the word 些 ('some') is a mid vowel [ɛ] as described in Lau (2013) and Chen (2016).

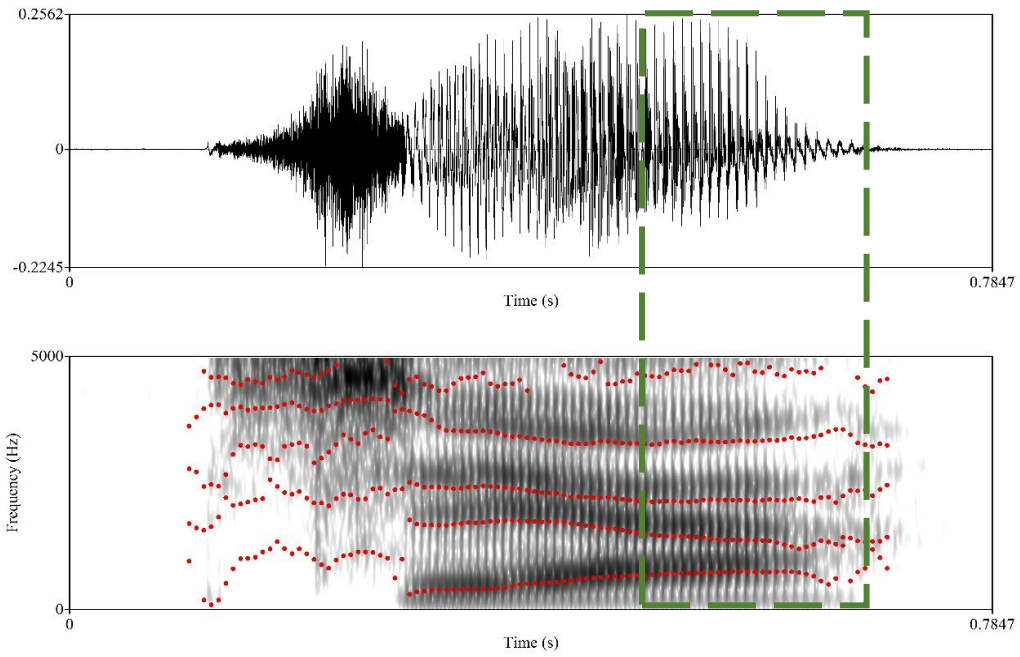


Figure 10: Waveform and spectrogram of 些 ('some') [sia^{33}] from a male speaker in the present study.

Another vowel which is also included in the sound inventory of Taipung proposed in Lau (2013) but not in the other previous studies is [o]. According to Lau, the vowel [o] in Taipung does not occur in CV syllables but in CVS or CVN syllables preceding a velar final consonant. In the present study, however, there is a mid-high back vowel [o]

found in CV syllables but a mid-low back vowel [ɔ] in CVS or CVN syllables preceding a velar final consonant. Thus, it is proposed to include the two mid back vowels [o, ɔ] in the sound inventory of Taipung as listed in Table 29.

Vowels	[i, u, o, ɔ, ɐ, a]

Table 29: Proposed vowel inventory of Taipung.

4.1.3 Diphthongs

The diphthongs of Taipung as well as Pingchau (a variety of Taipung) found in the present and previous studies are listed in Table 30. Allophones, if any, are put next to each other with a dash in between. The diphthongs that are not the same in all the studies are in bold letters.

Sources	Diphthongs
Taipung (Present study)	[(iu), **io**, iɔ, **ia/iɛ**, **oi**, ɐi, ɐu, ai, au]
Pingchau (Lau, 2013)	[iu, iɔ, ia, ui, ɐi, ɐu, ai, au]
Taipung (Lau & Yuan, 2010)	[iu, **iɛ**, iɔ, ia, ui, ɐi, ɐu, ai, au]
Taipung (Chen, 2016)	[iu, **iɛ**, iɔ, ia, ui, ɐi, ɐu, ai, au]

Table 30: Diphthongs of Taipung found in different studies.

From Table 30, it can be seen that there are 6 diphthongs [iu, iɔ, ɐi, ɐu, ai, au] found in all the 4 studies. For the diphthong [iu], it has been noted earlier in this report that the test words for [iu] were by accident missing from the recording lists, so in Table 30 [iu] is placed in the parentheses in the diphthong set proposed in the present study. In addition to the 6 diphthongs [iu, iɔ, ɐi, ɐu, ai, au], one more diphthong [ia] is included in the set given in Lau (2013), and both [ia] and [iɛ] are additionally included in the diphthong sets given in Lau & Yuan (2013) and Chen (2016). In the present study, the

diphthongs [ia] and [iɛ] are allophones, instead of two separate phonemes. Furthermore, there are two diphthongs [io] and [oi] found in the speech of the Taipung speaker in the present study, which are not included in the diphthong inventory proposed in the three previous studies. Based on the findings in all the 4 studies, the proposed diphthong inventory of Taipung is given in Table 31.

Diphthongs	[iu, io, iɔ, ia/iɛ, oi, ɐi, ɐu, ai, au]

Table 31: Proposed diphthong inventory of Taipung.

4.1.4 Tones

Table 32 presents the sets of the long tones and short tones in Taipung and Pingchau in the present and three previous studies. The tones are not the same in the four studies are in bold letters.

Sources	Long tones	Short tones
Taipung (Present study)	[55, 33, 22, **25**, **21**]	[5, **3**]
Pingchau (Lau, 2013)	[55, 33, 11, 13, 35]	[5]
Taipung (Lau & Yuan, 2010)	[55, 33, 11, 13, 35]	[5]
Taipung (Chen, 2016)	[**54**, **42**, 22, **31**, 35]	**[42, 54**]

Table 32: Tones of Taipung found in different studies.

As presented in Table 32, there are a number of differences in the tone inventory of Taipung given in the four studies. First, there are 7 tones found in Chen (2016) and the present study, but 6 in the two studies of Lau, which lies mainly in the difference in the number of the short entering tones. In Chen (2016) and the present study, 2 short tones are found, but there is only 1 in Lau & Yuan (2010) and Lau (2013). Furthermore, the short tones are described differently in the studies. In the two Lau's

works, the only short tone in Taipung is [5], whereas the two short tones are [54, 42] in Chen (2016) and [5, 3] in the present study. Second, in Lau's studies, there is no falling tone found in Taipung and Pingchau, but there are four falling tones, long [54, 42] and short [54, 42], found in Chen (2016) and only one falling tone [21] in the present study. Third, there are three long level tones [55, 33, 22] in the present study, but there is only one level tone [22] in Chen (2016). In Chen (2016), the long tones [54, 42, 22] are corresponding to the level tones [55, 33, 11] in Lau's studies and [55, 33, 22] in the present study. In Chen's study, frequency analysis was performed for the F_0 contours of the tones which demonstrate the falling feature of [54] and [42]. In the present study, the F_0 contours of the tones are also obtained. The F_0 contour is basically level for [55] in the present study which corresponds to Chen's [54] tone. As for the tone [33] in the present study which corresponds to Chen's [42] tone, while the F_0 contour of [33] in the present study is slightly falling, the F_0 value remains at the same tone level and thus [33] in the present study is characterised as a level tone. As for the tone [22] in the present study and Chen (2016), its F_0 contour does not reach the tone level as low as the final portion of the low falling tone [21] (the present study) or [31] (Chen, 2016), and thus it should be characterised as [22], not in agreement with the description of [11] in Lau's studies.

Based on the finding of all the four studies, the proposed tone inventory of Taipung is given in Table 33.

Long tones	**Short tones**
[55, 33, 22, 25, 21]	[5, 3]

Table 33: Proposed tone inventory of Taipung.

4.2 Comparison with Other Dialects

After comparing the findings in the present and previous studies, the proposed sound system of the consonants, vowels, diphthongs and tones of Taipung is compared with the sound systems of Hong Kong Cantonese (Zee, 1999), Meixian Hakka (Lee & Zee, 2009) and Beijing Mandarin (Lee & Zee, 2003) in this section. As mentioned in Chapter 1 of this report, Taipung is often referred to a 'mix' of other dialects. There are two major claims. One claim is that Taipung is mixed with Hakka and Cantonese, while the other claim says that Taipung is mixed with the southern dialects, mainly Hakka and Cantonese, and the northern dialects brought by the commanders of Dapeng Fortress in the past. The first claim is made in Chen (2016) and Lau & Yuan (2010), while the media in mainland China as well as the official website of Dapeng Fortress hold the second claim (Museum of Dapeng Fortress, 2016).

4.2.1 Initial and syllabic consonants

Table 34 lists the initial and syllabic consonants of Taipung, Hong Kong Cantonese, Meixian Hakka and Beijing Mandarin for comparison. Allophones, if any, are put next to each other with a dash in between. The different features of the four dialects are in bold letters.

Sources	Initial consonants	Syllabic consonants
Taipung (Present study)	[p-, p^{h}-, t-, t^{h}-, k-, k^{h}-, ts-, ts^{h}-, f-, s-, h-, m-, n-, ŋ-, l-, j-, **w-/ʊ-**]	[m̩, ŋ̩]
Hong Kong Cantonese (Zee, 1999)	[p-, p^{h}-, t-, t^{h}-, k-, k^{h}-, **k^{w}-**, **k^{wh}-**, ts-, ts^{h}-, f-, s-, h-, m-, n-, ŋ-, l-, j-, w-]	[m̩, ŋ̩]
Meixian Hakka (Lee & Zee, 2009)	[p-, p^{h}-, t-, t^{h}-, **c-**, **c^{h}-**, k-, k^{h}-, **k^{w}-**, **k^{wh}-**, ts-, ts^{h}-, f-, s-, **ç-**, h-, m-, n-, **ɲ-**, ŋ-, l-, j-, **ʊ-**]	[m̩, **n̩, ɹ̩**]
Beijing Mandarin (Lee & Zee, 2003)	[p-, p^{h}-, t-, t^{h}-, k-, k^{h}-, ts-, ts^{h}-, **t$\underline{ʃ}$-**, **t$\underline{ʃ}^{h}$-**, **tɕ-**, **tɕ^{h}-**, f-, s-, **$\underline{ʃ}$-**, **ɕ-**, **x-**, m-, n-, **$\underline{ɻ}$-**, l-, j-, **w-/ʊ-**]	[**ɹ̩**]

Table 34: Initial and syllabic consonant inventories of Taipung, Hong Kong Cantonese, Meixian Hakka and Beijing Mandarin.

Concerning the initial consonants, the apical post-alveolar [tʃ̺-, tʃ̺^{h}-, ʃ̺-, ɻ̺-], often referred to as the retroflex [tʂ-, tʂ^{h}-, ʂ-, ɻ-], and the alveolo-palatal [ɕ-, tɕ-, tɕ^{h}-] are the unique features in Beijing Mandarin, which are not found in many southern dialects, including Cantonese, Hakka and Taipung. Furthermore, Beijing Mandarin has a velar fricative [x-] developing from the glottal [h-], but [h-], not [x-], occurs in the other three dialects. All these features suggest the consonant system of Taipung is closer to Cantonese and Hakka than Mandarin.

However, in both Hong Kong Cantonese and Meixian Hakka, there are two labio-velar plosives [k^{w}-, k^{wh}-] which are non-occurring in Taipung. Furthermore, the labio-velar approximant [w-] in Taipung has a labiodental allophone [ʋ-], which is not true in Hong Kong Cantonese; and in Meixian Hakka the labiodental [ʋ-] has substituted for the labio-velar [w-]. Between Taipung and Meixian Hakka, difference is also in the rich set of the palatal consonants, including plosives [c-, c^{h}-], fricative [ç-] and nasal [ɲ-], that is found in Hakka, but not in Taipung.

The four dialects also have differences in the syllabic consonants. In Beijing Mandarin, there is a syllabic approximant [ɻ̩] which is often referred to as one of the two apical vowels, a non-retroflex anterior [ɿ] and a retroflex posterior [ʅ]. A syllabic anterior [ɿ̩] also occurs in Meixian Hakka, but not in Cantonese and Taipung. Furthermore, in all the three southern dialects, there are two syllabic nasal consonants. However, while both Hong Kong Cantonese and Taipung have the bilabial [m̩] and the velar [ŋ̩], Meixian Hakka has the bilabial [m̩] and alveolar [n̩]. All these findings also suggest Taipung is similar to Cantonese and Hakka, rather than Mandarin, and the degree of similarity is higher between Taipung and Cantonese than between Taipung and Hakka.

4.2.2 Final consonants

Table 35 shows the final consonants of Taipung, Hong Kong Cantonese, Meixian Hakka and Beijing Mandarin. As can be seen, Taipung is consistent with the other two southern dialects having 6 final consonants, namely [-p, -t, -k, -m, -n, -ŋ], while Beijing Mandarin lacks all the three final plosives and only has 2 final nasals [-n, -ŋ]. Thus, in terms of the final consonants, Taipung is also similar to Cantonese and Hakka, rather than Mandarin.

Sources	Final consonants
Taipung (Present study)	[-p, -t, -k, -m, -n, -ŋ]
Hong Kong Cantonese (Zee, 1999)	[-p, -t, -k, -m, -n, -ŋ]
Meixian Hakka (Lee & Zee, 2009)	[-p, -t, -k, -m, -n, -ŋ]
Beijing Mandarin (Lee & Zee, 2003)	[-n, -ŋ]

Table 35: Final consonant inventories of Taipung, Hong Kong Cantonese, Meixian Hakka and Beijing Mandarin.

4.2.3 Vowels

The vowels of Taipung, Hong Kong Cantonese, Meixian Hakka and Beijing Mandarin are listed in Table 36. The vowels differing among the four dialects are in bold letters.

Sources	Vowels
Taipung (Present study)	[i, u, **o**, ɔ, ɐ, a]
Hong Kong Cantonese (Zee, 1999)	[i, **y**, **ɪ**, u, **ʊ**, **ɛ**, **œ**, **ɵ**, ɔ, ɐ, a]
Meixian Hakka (Lee & Zee, 2009)	[i, u, **e**, **ə**, ɔ, a]
Beijing Mandarin (Lee & Zee, 2003)	[i, **y**, u, **ɤ**, **ə**, a]

Table 36: Vowel inventories of Taipung, Hong Kong Cantonese, Meixian Hakka and Beijing Mandarin.

From Table 36, it is observed that Hong Kong Cantonese has a large set of 11 vowels, whereas the other three dialects only have 6 vowels. Furthermore, Hong Kong

Cantonese has two rounded front vowels [y] and [œ]. These two vowels are not occurring in both Taipung and Meixian Hakka, and Beijing Mandarin has [y] but not [œ]. Other unique features of Hong Kong Cantonese are the two lax vowels [ɪ, ʊ] and the rounded central vowel [ɵ]. These three vowels do not occur in all the other three dialects. Cantonese also has the vowels [ɔ] and [ɐ], where both the vowels can be found in Taipung. Meixian Hakka only has [ɔ], and Beijing Mandarin lacks both. Between Beijing Mandarin and the three southern dialects, the main differences are in the back vowel [ɤ] and the mid central vowel [ə]. The former one, [ɤ], occurs in Beijing Mandarin not in the three southern dialects. The latter one, [ə], occurs in both Beijing Mandarin and Meixian Hakka, but it is a rhotacised or r-coloured [ɚ] in CV syllables in Beijing Mandarin, not in Meixian Hakka.

In general, Taipung has 6 vowels, where 5 of them, namely [i, u, ɔ, ɐ, a], are found in Hong Kong Cantonese. Taipung shares 4 vowels, i.e., [i, u, ɔ, a], with Meixian Hakka, but shares only 3 vowels, i.e., [i, u, a], with Beijing Mandarin. Thus, in terms of the vowels, it may also suggest that Taipung is closer to Cantonese than Hakka and Mandarin.

4.2.4 Diphthongs

The diphthongs of Taipung, Hong Kong Cantonese, Meixian Hakka and Beijing Mandarin are listed in Table 37. Again, the unique features of different dialects are in bold letters. A comparison of the diphthong inventories of the four dialects shows that Beijing Mandarin has four diphthongs, [ye, uo, uə, ua], which are not found in all the three southern dialects. Beijing Mandarin also has [ie, ei, ou], where [ie] occurs in Meixian Hakka and [ei, ou] in Hong Kong Cantonese, but all the three diphthongs do

not occur in Taipung. These diphthong features also suggest the influence of Mandarin on Taipung is minimal.

Sources	Diphthongs
Taipung (Present study)	[iu, **io**, iɔ, ia/iɛ, **oi**, ɐi, ɐu, ai, au]
Hong Kong Cantonese (Zee, 1999)	[iu, **ui**, **ei**, **ɛu**, **ɵy**, **ou**, ɔi, ɐi, ɐu, ai, au]
Meixian Hakka (Lee & Zee, 2009)	[iu, **ie**, iɔ, ia, **ui**, ɔi, **eu**, ai, au]
Beijing Mandarin (Lee & Zee, 2003)	[iu, **ie**, ia, **ye**, **uo**. **uə**, **ua**, **ei**, **ou**, ai, au]

Table 37: Diphthong inventories of Taipung, Hong Kong Cantonese, Meixian Hakka and Beijing Mandarin.

Furthermore, the diphthongs in Beijing Mandarin, excluding [iu], can be divided into two groups: [ie, ia, ye, uo, uə, ua] in one group, where the diphthongs begin with a high vowel gliding toward to a mid or low vowel, and [ei, ou, ai, au] in the other group, where the diphthongs begin with a non-high vowel gliding toward to a high vowel. Such two types of diphthongs are also found in Taipung: [io, iɔ, ia/iɛ] with a high-to-low movement and [oi, ɐi, ɐu, ai, au] with a low-to-high movement, and Meixian Hakka: [ie, iɔ, ia] with a high-to-low movement and [ui, ɔi, eu, ai, au] with a low-to-high movement. However, in Cantonese, except for [iu] consisting of two high vowel components, all the diphthongs begin with a non-high vowel gliding toward to a high vowel, i.e. [ei, ɛu, ɵy, ou, ɔi, ɐi, ɐu, ai, au].

In Cantonese, there are two pairs of diphthongs [ɐi, ɐu] and [ai, au] beginning with a low central vowel component. These two pairs of diphthongs also occur in Taipung, but only the pair of [ai, au] occurs in Meixian Hakka and Beijing Mandarin. All these features indicate that Taipung's diphthong system is similar to Cantonese and Hakka, rather than Mandarin.

Besides, Beijing Mandarin also has a set of triphthongs, i.e. [iau, iou, uai, uei] (Lee & Zee, 2003). In Meixian Hakka, there is a single triphthong [iau] (Lee & Zee, 2009). However, there are no triphthongs in Hong Kong Cantonese and Taipung. This finding suggests that Taipung is closer to Cantonese and less similar to Mandarin.

4.2.5 Tones

Taipung, Hong Kong Cantonese, Meixian Hakka and Beijing Mandarin have a set of tones which are listed in Table 38. In terms of tones, Taipung is again similar to Cantonese and Hakka, rather than Mandarin. One of the main differences among the four dialects is in the short tones which can be found in Taipung, Hong Kong Cantonese and Meixian Hakka, but not in Beijing Mandarin. Another difference is in the complex dipping tone [213] which is found in Beijing Mandarin but not in all the three southern dialects.

Sources	Long tones	Short tones
Present study	[55, 33, 22, 25, 21]	[5, 3]
Hong Kong Cantonese (Zee, 1999)	[55, 33, 22, 21, 23, 25]	[5, 3, 2]
Meixian Hakka (Lee & Zee, 2009)	[55, 33, 11, 53, 31]	[5, 31]
Standard Chinese (Lee & Zee, 2003)	[55, 35, 213, 51]	

Table 38: Tone inventories of Taipung, Hong Kong Cantonese, Meixian Hakka and Beijing Mandarin.

Furthermore, Beijing Mandarin has a smaller set of tones than the other three dialects, where there are only one level tones [55], one rising tone [35], one falling tone [51] and one dipping tone [213]. As for the three southern dialects, there are more number of tones in the categories of level, rising and falling. For instance, there are three level tones in Taipung, Hong Kong Cantonese and Meixian Hakka, two rising tones in Hong Kong Cantonese and two falling tones in Meixian Hakka.

Comparing among the three southern dialects, Taipung is similar to Meixian Hakka in the number of tones in the system, where both of them have 5 long tones and 2 short tones. But in terms of the type of tones in the system, both Taipung and Hong Kong Cantonese have rising and falling tones, but only falling tones and no rising tone are found in Meixian Hakka. Also, all the short tones are level in Taipung and Hong Kong Cantonese, but there is one level short tone and one falling short tone in Meixian Hakka. Thus, Taipung's tone system is closer to the tone system of Cantonese than that of Hakka.

Chapter 5 Concluding Remarks

This study has presented empirical experimental data on the consonants, vowels, diphthongs and tones of Taipung through carrying out acoustic analysis of the speech samples collected from native speakers. The results obtained are similar to the findings reported in the previous studies, contributing to a better understanding of the sound system of Taipung.

Conventionally, Taipung is claimed as a mixed language of Mandarin, Hakka and Cantonese. In the present study, the findings of the comparison made among the sound systems of the dialects involved show that while there are striking similarities among Taipung, Cantonese and Hakka, the degree of similarity between Taipung and Mandarin is small, against the claim held by the media in mainland China that the phonological development of Taipung is under the influence of the northern dialects.

To my knowledge, the research on Taipung is limited. The present one is the first experimental phonetic study of Taipung, providing the spectrographic data on the consonants, formant frequency data on the vowels and diphthongs and fundamental frequency data on the tones of the dialects. To be honest, the analysed speech samples from only one subject in the present study are not too sufficient, which is due to the limited time for carrying out the project in a semester. It is hoped that in the near future a large-scale fieldwork of Taipung will be conducted to provide further confirmative data.

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Appendix A: Formant frequency values ($F_1F_2F_3F_4$ in Hz) of the vowels in Taipung

Vowels	Test CV Syllables	F_1	F_2	F_3	F_4
[i]	痴 [ts^{h}i^{33}]	350 365	2034 2126	2720 2779	3587 4134
	區 [k^{h}i^{33}]	335 330	2259 2315	2630 2833	3954 3911
	飛 [fi^{33}]	341 382	2140 2089	2600 2648	3881 3834
	碑 [pi^{33}]	338 329	2195 2180	2887 2707	4014 3889
	詩 [si^{33}]	318 330	2091 1908	2734 2612	3837 4039
	Mean	**342**	**2134**	**2715**	**3908**
[u]	蘇 [su^{33}]	379 397	854 810	2581 2486	3751 3810
	粗 [ts^{h}u^{33}]	362 405	877 815	2534 2520	3770 3950
	箍 [k^{h}u^{33}]	382 386	683 710	2850 2589	3897 4124
	夫 [fu^{33}]	430 364	727 647	2560 2937	4017 4191
	埔 [pu^{33}]	399 399	758 718	2917 2670	3625 3822
	Mean	**390**	**760**	**2664**	**3896**
[o]	波 [po^{33}]	511 452	824 776	2862 2662	3852 3676
	梳 [so^{33}]	522 520	900 893	2780 2701	3614 3661
	賀 [ho^{55}]	543 516	773 623	3032 2947	3405 3402
	初 [ts^{h}o^{33}]	506 574	916 916	2770 2783	3745 3619
	課 [k^{h}o^{22}]	560 503	799 731	2728 2783	3458 3750
	Mean	**521**	**815**	**2805**	**3618**
[a]	車 [ts^{h}a^{33}]	887 922	1370 1361	2700 2976	3737 3864
	爸 [pa^{33}]	821 807	1289 1335	2524 2568	3591 3721
	誇 [k^{h}a^{33}]	930 862	1379 1330	2846 2590	3704 3799
	花 [fa^{33}]	887 897	1311 1338	2587 2722	3316 3672
	沙 [sa^{33}]	851 832	1358 1340	2536 2497	3780 3449
	Mean	**870**	**1341**	**2655**	**3663**

Vowels	Test CVN Syllables	F_1	F_2	F_3	F_4
[i]	先 [sin^{33}]	389 430	1719 1716	2475 2391	3812 3707
	軒 [hin^{33}]	407 425	2157 2098	2537 2328	2760 3813
	健 [k^{h}in^{55}]	427 448	2021 2151	2318 2617	3581 3817
	千 [ts^{h}in^{33}]	393 404	1906 1813	2591 2504	3811 3547
	辮 [pin^{33}]	395 407	1981 1933	2498 2369	3862 3749
	Mean	**413**	**1950**	**2463**	**2349**
[u]	換 [wun33]	507 418	853 718	2582 2422	3544 3539
	歡 [fun33]	474 520	788 898	2323 2307	3591 3593
	般 [pun33]	425 451	754 842	2259 2308	3655 3521
	看 [khun22]	490 499	920 860	2400 2543	3708 3482
	安 [un33]	463 416	759 716	2551 2583	3476 3662
	Mean	**466**	**811**	**2428**	**3577**
[o]	鵬 [poŋ^{21}]	484 471	821 737	2630 2647	3896 3797
	充 [soŋ^{33}]	458 505	924 949	2389 2405	3359 3629
	胸 [hoŋ^{33}]	492 562	807 883	2355 2542	3528 3508
	鬆 [ts^{h}oŋ^{33}]	519 495	1045 996	2447 2441	511 509
	共 [k^{h}oŋ^{55}]	511 509	880 893	2537 2347	3647 3581
	Mean	**501**	**894**	**2474**	**3629**
[ɔ]	糠 [hɔŋ^{33}]	702 707	960 1070	2902 2597	3359 3467
	商 [sɔŋ^{33}]	645 634	1127 1169	2536 2532	3651 3557
	康 [k^{h}ɔŋ^{33}]	696 699	1109 1042	2587 2517	3590 3453
	幫 [pɔŋ^{33}]	583 644	1005 1064	2578 2649	3500 3470
	倉 [ts^{h}ɔŋ^{33}]	670 642	1163 1126	2361 2350	3334 3407
	Mean	**662**	**1084**	**2561**	**3479**
[ɐ]	身 [sɐn^{33}]	655 685	1389 1349	2447 2362	4237 3286
	賓 [pɐn^{33}]	705 691	1164 1352	2573 2535	3690 3770
	昆 [k^{h}ɐn^{33}]	760 808	1422 1291	2235 2361	3526 3521
	親 [ts^{h}ɐn^{33}]	728 724	1488 1490	2397 2353	3677 3536
	分 [fɐn^{33}]	694 625	1197 1166	2443 2160	3413 3506
	Mean	**708**	**1331**	**2386**	**3616**

Vowels	Test CVN Syllables	F_1	F_2	F_3	F_4
[a]	班 [pan^{33}]	825 805	1222 1205	2566 2324	3522 3706
	框 [k^{h}aŋ^{33}]	872 861	1365 1409	2408 2285	3650 3813
	山 [san^{33}]	843 720	1448 1374	2443 2484	3842 3457
	餐 [ts^{h}an^{33}]	903 871	1411 1339	2518 2496	3718 3360
	慳 [han^{33}]	973 784	1430 1418	2275 1895	2940 2754
	Mean	**846**	**1362**	**2369**	**2476**

Vowels	Test CVS Syllables	F_1	F_2	F_3	F_4
[i]	血 [hit^{3}]	415 444 474 453 434	2109 2013 2104 2097 1881	2299 2314 2459 2508 2284	3755 3575 3753 3319 3650
	切 [ts^{h}it^{3}]	467 466 459 451 480	1805 1967 1808 1774 1782	2289 2566 2336 2285 2333	3381 3241 3594 3550 3505
	缺 [k^{h}it^{3}]	416 455 455 451 480	2390 2269 2051 2060 1900	2390 2269 2269 2358 2132	3822 3655 3655 3483 3602
	必 [pit^{3}]	469 416 411 421 395	1920 1991 1972 2047 2038	2504 2485 2351 2408 2432	3662 3849 3799 3710 3709
	舌 [sit^{3}]	458 488 459 484 452	1608 1605 1598 1574 1471	2323 2220 2338 2303 2344	3726 3619 3669 3634 3675
	Mean	**450**	**1885**	**2349**	**3623**

Vowels	Test CVS Syllables	F_1	F_2	F_3	F_4
[u]	活 [wut^5]	470 496 543 545 505	752 813 988 985 917	2534 2658 2421 3541 2530	3560 3489 3653 4573 3539
	撥 [p^{h}ut^3]	456 460 487 467 463	815 772 789 788 764	2365 2357 2301 2211 2161	3515 3532 3443 3450 3395
	豁 [k^{h}ut^3]	510 486 470 469 432	859 972 762 804 784	2296 2173 2295 2234 2092	3442 3513 3435 3403 3458
	闊 [fut^3]	514 456 461 488 490	729 873 821 809 787	2354 2585 2502 2477 2431	3441 3436 3398 3381 3355
	Mean	**483**	**829**	**2426**	**3521**
[o]	哭 [hok^3]	512 500 490 593 614	791 851 825 804 910	2723 2601 2584 2547 2436	3975 3618 3911 3704 3471
	曲 [k^{h}ok^3]	578 554 535 525 556	751 844 869 776 891	2601 2499 2359 2456 2359	3474 3501 3590 3502 3573
	仆 [p^{h}ok^3]	512 529 585 529 531	897 924 901 890 912	2511 2540 2608 2587 2618	3545 3535 3663 3508 3814
	速 [ts^{h}ok^3]	526 567 510 484 499	1012 958 1065 1037 927	2306 2554 2354 2248 2413	3696 3530 3746 3774 3563
	叔 [sok^3]	544 510 518 593 528	934 911 989 862 1006	2399 2183 2250 2395 2251	3582 3689 3631 3603 3599
	Mean	**537**	**901**	**2455**	**3616**

Vowels	Test CVS Syllables	F_1	F_2	F_3	F_4
[ɔ]	確 [$k^hɔk^3$]	694 680 662 655 673	969 996 973 960 950	2616 2352 2438 2410 2467	3422 3389 3352 3346 3317
	着 [$ts^hɔk^3$]	716 772 668 672 683	1064 1121 1101 1130 1097	3238 2931 2508 2641 3113	3683 3376 3461 3479 3571
	博 [$pɔk^3$]	636 651 630 629 626	961 946 944 932 981	2683 2645 2472 2422 2471	3437 3419 3477 3433 3305
	學 [$hɔk^5$]	758 677 706 719 703	1038 968 1064 1055 1076	3094 2437 2580 3154 2582	3588 3373 3479 3665 3418
	索 [$sɔk^3$]	613 649 631 644 665	1062 1060 1010 1061 1098	2415 2223 2225 2265 2307	3560 3483 3509 3474 3436
	Mean	**672**	**1025**	**2588**	**3458**
[ɐ]	咳 [$k^hɐt^3$]	804 774 757 774 761	1360 1334 1378 1416 1383	2283 2270 2171 2161 2232	3563 3447 3744 3794 3547
	失 [$sɐt^3$]	648 728 678 687 716	1260 1364 1343 1355 1326	2141 2226 2262 2205 2219	3697 3415 3387 3479 3451
	筆 [$pɐt^3$]	736 759 675 711 708	1300 1313 1148 1141 1197	2141 2075 2073 2229 2093	3298 3640 3580 3387 3443
	七 [$ts^hɐt^3$]	695 688 712 667 680	1353 1307 1359 1396 1380	2329 2317 2379 2258 2280	3694 3666 3754 3616 3667
	忽 [$fɐt^3$]	698 695 681 643 648	1079 1133 1045 1045 1165	2279 2277 2305 2087 2069	3420 3349 3298 3379 3572
	Mean	**709**	**1275**	**2214**	**3531**

Vowels	Test CVS Syllables	F_1	F_2	F_3	F_4
[a]	乞 [hat^3]	917 939 919 900 894	1259 1261 1318 1285 1240	2774 2838 3127 2976 2866	3416 3353 3877 3880 3811
	卡 [k^{h}ak^3]	933 862 838 881 859	1381 1318 1330 1364 1356	2631 2327 2361 2421 2401	4091 3232 3523 3527 3610
	八 [pat^3]	881 881 851 867 868	1255 1262 1266 1228 1235	2773 2885 2867 2879 2888	3667 3744 3759 3811 3696
	擦 [ts^{h}at^3]	824 846 862 864 834	1361 1363 1320 1331 1296	2416 2410 2662 2412 2547	3576 3663 3703 3656 3623
	殺 [sat^3]	813 838 797 851 825	1385 1401 1351 1388 1372	2323 2191 2311 2414 2448	3587 3495 3756 3785 3710
	Mean	**866**	**1317**	**2606**	**3662**

Appendix B: Formant frequency values ($F_1F_2F_3F_4$ in Hz) of the diphthongs in Taipung

Diphthongs	Test CV Syllables	1st vowel				2nd vowel			
		F_1	F_2	F_3	F_4	F_1	F_2	F_3	F_4
[ia]	啤 [pia^{55}]	437	2012	2450	3774	797	1442	2317	3655
		450	1990	2650	3871	818	1527	2383	3809
		430	1948	2725	3913	859	1523	2375	3776
	'his/her' [k^{h}ia^{33}]	556	1972	2340	3783	793	1557	2444	3683
		564	1943	2294	3831	827	1553	2364	3730
		533	1892	2274	3828	771	1415	2416	3755
	啡 [fia^{55}]	440	1977	2485	3907	827	1573	2311	3764
		438	1980	2423	3941	815	1511	2305	3822
		539	1992	2456	3909	806	1460	2101	3664
	些 [sia^{33}]	434	1865	2631	3874	827	1508	2376	3668
		408	1785	2603	3897	718	1523	2410	3745
		405	1842	2728	4026	782	1418	2483	3684
	謝 [ts^{h}ia^{55}]	515	1998	2460	3823	745	1483	2261	3685
		498	1927	2383	3792	798	1439	2495	3778
		427	1977	2800	3976	860	1489	2510	3734
	Mean	**472**	**1940**	**2513**	**3876**	**803**	**1495**	**2370**	**3730**
[io]	茄 [k^{h}io^{25}]	419	1504	2305	3975	536	847	3055	3635
		370	1622	2232	3791	553	884	2749	3639
		357	1749	2409	3721	613	947	2823	3521
	靴 [hio^{33}]	434	1689	2074	3711	527	894	2522	3677
		406	1695	2071	3700	500	838	2959	3606
		459	1863	2200	3779	541	886	2599	3564
	Mean	**408**	**1687**	**2215**	**3780**	**545**	**883**	**2785**	**3607**
[oi]	隊 [t^{h}oi^{55}]	494	995	2545	3663	305	2070	2603	4262
		480	919	2729	3658	365	1931	2510	4080
		525	930	2670	3722	368	2035	2651	4045
		515	889	2738	3796	366	2037	2596	3660
		527	982	2710	3784	391	2054	2554	3995
	劾 [k^{h}oi^{55}]	449	876	2467	3520	319	1947	2532	3497
		408	937	2462	4124	361	2033	2562	4151
		512	860	2656	3862	348	2015	2587	4214
		521	877	2640	3825	368	1997	2556	3820
		548	929	2439	3627	416	1963	2590	3956
	開 [foi^{33}]	476	848	2644	3663	347	1980	2460	3590
		476	806	2640	3736	328	2019	2487	3840
		503	823	2700	3650	335	1965	2522	4037
		509	848	2696	3712	323	2014	2602	4159
		499	803	2671	3660	307	2007	2690	4214
	衰 [soi^{33}]	519	1080	2448	3771	362	1915	2367	3387
		502	1085	2350	3779	316	1915	2497	3846
		501	1034	2353	3604	335	1926	2435	3599
		524	1052	2416	3644	385	1920	2505	4359
		510	1122	2334	3682	352	2026	2687	4328
	吹 [ts^{h}oi^{33}]	458	950	2466	3570	315	2031	2524	3669
		463	1093	2418	3541	340	1916	2408	3906
		518	984	2421	3526	340	1983	2440	3455
		523	1044	2532	3528	380	2026	2466	4260
		498	1010	2412	3538	334	2110	2523	4086
	Mean	**498**	**951**	**2542**	**3687**	**348**	**1845**	**2534**	**3937**

Diphthongs	Test CV Syllables	1st vowel				2nd vowel			
		F_1	F_2	F_3	F_4	F_1	F_2	F_3	F_4
[ɐi]	第 [t^hɐi^{55}]	729	1394	2613	3867	359	2069	2761	4314
		750	1334	2663	3764	423	2057	2710	4264
		762	1411	2674	3852	452	2017	2650	4325
		731	1448	2507	3883	347	2169	2638	4363
		775	1460	2491	3817	428	2066	2637	4368
	雞 [kɐi^{33}]	646	1477	2050	3746	387	2163	2721	4105
		643	1456	2192	3665	400	2062	2673	4066
		669	1697	2055	3846	399	2050	2546	3686
		686	1438	2239	3759	462	2011	2532	3920
		630	1546	2063	3762	416	2018	2536	3895
	輝 [fɐi^{33}]	599	1166	2243	3665	343	2097	2586	3967
		556	916	2493	3585	401	1904	2516	3892
		548	950	2392	3592	411	2038	2622	4147
		551	1025	2390	3640	455	2001	2659	4078
		606	1075	2329	3561	439	1991	2609	3818
	西 [sɐi^{33}]	621	1352	2414	4140	419	1918	2585	4076
		638	1377	2401	4311	437	1843	2480	4133
		660	1435	2371	4160	442	1944	2627	4323
		685	1414	2312	3740	451	1925	2562	4089
		615	1386	2476	4299	440	1924	2514	4395
	妻 [ts^{h}ɐi^{33}]	671	1501	2403	3721	376	2101	2656	4250
		652	1537	2323	3670	363	2016	2618	4134
		700	1547	2412	3669	401	2006	2641	3883
		695	1569	2459	3525	386	2074	2688	4088
		685	1545	2376	3651	402	2047	2554	3985
	Mean	**660**	**1378**	**2374**	**3796**	**410**	**2020**	**2613**	**4103**
[ɐu]	豆 [t^hɐu^{55}]	687	1306	2597	3849	376	898	2866	3900
		682	1206	2773	3812	409	741	2758	3675
		796	1277	2665	3770	368	885	2788	4201
		728	1240	2638	3846	376	892	2845	3911
		717	1320	2691	3888	368	846	2738	3941
	鳩 [kɐu^{33}]	570	1195	2210	3816	336	743	2632	3962
		602	1113	2367	3593	336	807	2819	4200
		652	1265	2316	3787	363	745	2786	3961
		690	1189	2467	3650	393	812	2692	3923
		626	1151	2301	3595	422	767	2721	3900
	邱 [hɐu^{33}]	715	1126	2841	3494	354	758	2771	3814
		686	1126	2606	3540	335	800	2904	4078
		724	1211	2704	3664	369	801	2865	3933
		698	1107	2822	3583	355	902	2820	3921
		692	1107	2693	3590	353	842	2831	4022
	修 [sɐu^{33}]	700	1302	2437	3756	390	886	2846	4134
		653	1337	2447	3914	387	922	2631	3871
		714	1345	2445	3744	361	875	2876	3876
		636	1306	2409	3891	369	845	2700	3898
		650	1306	2473	3763	390	917	2647	3932
	抽 [ts^{h}ɐu^{33}]	640	1367	2293	3885	333	809	2774	4128
		647	1364	2462	4244	317	870	2921	4025
		708	1407	2391	3727	379	889	3004	4170
		679	1409	2416	3889	390	826	2816	4025
		651	1393	2377	3812	255	897	2929	3763
	Mean	**678**	**1259**	**2514**	**3764**	**363**	**839**	**2799**	**3967**

Diphthongs	Test CV Syllables	1st vowel				2nd vowel			
		F_1	F_2	F_3	F_4	F_1	F_2	F_3	F_4
[ai]	大 [t^hai^{55}]	875	1296	2539	3609	451	2082	2881	4526
		854	1276	2624	3683	463	2069	2795	4320
		790	1367	2610	3734	493	2030	2828	4679
		808	1172	2656	3727	445	2198	2770	4450
		858	1396	2604	3644	544	1965	2507	4042
	街 [kai^{33}]	828	1385	2182	3801	496	2077	2588	3979
		816	1426	2264	3691	587	1873	2517	3801
		823	1403	2343	3802	546	1865	2579	3899
		829	1391	2275	3614	519	2011	2507	3880
		832	1410	2221	3564	486	2068	2489	3806
	揩 [hai^{33}]	890	1353	2501	3722	497	2031	2552	3977
		894	1291	3004	4088	406	2153	2628	3997
		917	1390	2818	4083	432	2038	2532	3843
		895	1270	2837	3967	464	2177	2679	4090
		919	1289	2922	3714	478	2114	2682	4014
	嘥 [sai^{33}]	859	1483	2305	3622	426	2031	2539	4042
		831	1472	2560	3789	552	1878	2625	3894
		828	1408	2611	3822	586	1965	2691	4400
		873	1393	2546	3691	454	1839	2667	4117
		783	1387	2584	3754	398	1894	2735	4196
	搓 [ts^hai^{33}]	838	1401	2502	3574	367	2153	2748	4074
		803	1369	2564	3701	441	2052	2697	4399
		887	1420	2797	3916	391	2041	2584	4050
		832	1367	2404	3566	485	2028	2652	4072
		809	1353	2490	3640	472	1993	2649	3937
	Mean	**847**	**1367**	**2551**	**3741**	**475**	**2025**	**2645**	**4099**
[au]	滔 [t^hau^{33}]	815	1261	2563	3711	337	807	2931	4087
		812	1301	2842	3754	302	752	2754	4084
		807	1254	2788	3814	319	848	2841	4026
		779	1232	2523	3655	313	910	2758	3753
		801	1236	2638	3720	370	892	2783	3962
	高 [kau^{33}]	771	1287	2406	3630	352	821	2593	3911
		711	1261	2460	3689	513	919	2571	3793
		785	1296	2428	3691	377	804	2670	4124
		745	1288	2405	3665	340	863	2773	3944
		748	1265	2474	3723	363	858	2500	4138
	浩 [hau^{33}]	894	1268	3105	3749	359	841	2270	3846
		865	1221	2895	4215	320	745	2732	3779
		841	1230	2856	3542	379	889	2607	3973
		849	1204	2791	4060	351	874	2721	4096
		847	1226	3073	3860	353	954	2640	3804
	騷 [sau^{33}]	812	1298	2466	3660	323	795	2627	3846
		849	1311	2969	4469	317	828	2669	3883
		848	1347	2805	3695	450	884	2516	3722
		784	1252	2415	3702	345	879	2774	3934
		757	1214	2437	3707	386	900	2769	3928
	操 [ts^hau^{33}]	845	1216	2359	3487	367	875	2575	3984
		789	1267	2547	3523	428	902	2783	4070
		815	1302	2505	3558	434	916	2676	3951
		771	1249	2489	3467	364	877	2713	3922
		754	1210	2397	3515	389	853	2799	3932
	Mean	**804**	**1260**	**2625**	**3730**	**366**	**859**	**2682**	**3940**

Diphthongs	Test CVN Syllables	1st vowel				2nd vowel			
		F_1	F_2	F_3	F_4	F_1	F_2	F_3	F_4
[iɛ]	廳 [$t^hiɛŋ^{33}$]	477	2111	2514	3864	660	1719	2201	3591
		436	2083	2502	3970	674	1819	2228	3696
	驚 [$kiɛŋ^{33}$]	398	2073	2286	4027	670	1725	2260	3625
		453	2125	2429	3968	689	1830	2230	3656
	輕 [$hiɛŋ^{33}$]	531	1809	2307	3736	687	1585	2222	3572
		558	2104	2252	3804	723	1634	2264	3526
	腥 [$siɛŋ^{33}$]	426	1690	2680	4016	637	1808	2232	3519
		375	1758	2815	3800	642	1827	2323	3566
	青 [$ts^hiɛŋ^{55}$]	430	2047	2624	3876	679	1595	2274	3615
		392	2023	2626	3783	631	1578	2359	3646
	Mean	**448**	**1982**	**2504**	**3884**	**669**	**1712**	**2259**	**3601**
[iɔ]	薑 [$kiɔŋ^{33}$]	428	1832	2107	3848	563	1190	2245	3628
		395	1767	1949	3899	609	1183	2214	3647
	香 [$hiɔŋ^{33}$]	468	1791	2210	3733	604	1063	2320	3624
		441	1766	2179	3769	566	1115	2253	3628
	箱 [$siɔŋ^{33}$]	378	1695	2518	3685	558	1206	2215	3552
		374	1831	2566	3702	536	1092	2234	3494
	槍 [$ts^hiɔŋ^{33}$]	426	1836	2239	3466	562	1076	2304	3609
		405	1921	2378	3594	596	1209	2299	3538
	Mean	**414**	**1805**	**2268**	**3712**	**574**	**1142**	**2261**	**3590**

Diphthongs	Test CVS Syllables	1st vowel				2nd vowel			
		F_1	F_2	F_3	F_4	F_1	F_2	F_3	F_4
[ia]	踢 [t^hiak^3]	545	1915	2355	3948	842	1565	2175	3711
		537	2126	2687	4070	866	1564	2229	3586
		505	2112	2446	3869	887	1610	2324	3825
		540	1868	2284	3941	768	1538	2284	3651
		501	1854	2266	3887	787	1567	2196	3746
	劇 [k^hiak^3]	508	1871	2257	3746	793	1553	2214	3695
		510	1825	2248	3856	860	1531	2223	3742
		502	1931	2340	4018	840	1651	2297	3720
		523	1908	2240	3822	815	1565	2189	3603
		516	1902	2248	3786	801	1607	2224	3706
	錫 [$siak^3$]	449	1653	2538	3780	732	1554	2072	3470
		418	1665	2577	4075	680	1756	2232	3527
		406	1744	2556	4082	710	1778	2277	3538
		412	1678	2506	4021	713	1543	2136	3487
		436	1601	2509	3812	731	1676	2225	3712
	Mean	**487**	**1844**	**2404**	**3914**	**788**	**1604**	**2220**	**3648**
[iɔ]	腳 [$kiɔk^3$]	409	1719	1925	3862	657	1009	2785	3422
		425	1676	2087	3865	645	1260	2220	3459
		404	1780	1983	3878	656	1146	2548	3426
		389	1703	2199	3985	646	1217	2137	3469
		418	1669	1905	3967	653	1117	2366	3408
	削 [$siɔk^3$]	399	1630	2409	3690	622	1114	2263	3391
		392	1654	2540	3608	637	977	2200	3529
		383	1625	2418	3613	626	1067	2169	3468
		401	1637	2574	3706	630	1028	2245	3587
		396	1671	2390	3581	626	1137	2217	3349
	卓 [$ts^hiɔk^3$]	406	1707	2147	3360	601	1107	2294	3480
		480	1645	1980	3689	640	1187	2487	3386
		438	1669	2120	3689	629	1198	2227	3429
		451	1641	2059	3516	634	1157	2321	3390
		435	1596	2135	3597	646	1179	2238	3471
	Mean	**415**	**1668**	**2191**	**3707**	**637**	**1127**	**2314**	**3444**

Appendix C: Fundamental frequency values (F_0 in Hz) of the tones in Taipung

Tones	Test words	11 data points of the pitch contour										
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
[55]	是 [si^{55}]	134	134	134	134	137	137	134	134	134	132	129
		128	128	128	128	128	128	127	126	125	124	124
		134	134	134	133	132	131	131	130	129	129	129
	負 [fu^{55}]	132	132	132	132	132	133	133	133	133	132	132
		127	127	127	128	130	130	130	130	131	131	131
		124	124	125	126	128	129	130	130	129	129	128
	異 [ji^{55}]	130	130	130	130	134	134	134	130	130	129	129
		130	131	133	134	135	136	136	135	133	133	133
		117	116	118	119	120	121	122	122	122	122	121
	步 [p^{h}u^{55}]	131	132	131	134	134	131	130	130	131	131	131
		127	127	127	126	130	127	127	127	125	125	125
		126	126	125	123	122	122	122	122	122	122	122
	射 [sa^{55}]	121	121	121	121	121	122	123	123	123	123	121
		130	130	130	130	130	132	132	130	129	127	125
		135	134	134	135	135	135	137	137	135	135	135
	Mean	**135**	**134**	**134**	**135**	**135**	**135**	**137**	**137**	**135**	**135**	**135**
[33]	詩 [si^{33}]	119	118	118	118	118	115	115	115	115	109	109
		118	117	117	117	117	117	117	115	112	112	111
		122	121	120	119	120	120	120	120	118	115	115
	夫 [fu^{33}]	132	130	129	126	125	125	125	125	124	124	123
		119	117	117	116	114	114	114	113	113	111	109
		118	115	113	111	111	110	109	106	104	104	100
	衣 [ji^{33}]	121	117	113	112	112	112	111	110	109	108	107
		111	111	111	111	112	112	112	112	112	112	111
		115	115	115	115	115	115	115	115	113	113	112
	鋪 [p^{h}u^{33}]	118	118	116	115	115	116	116	116	115	114	114
		119	119	119	119	119	119	117	117	117	117	117
		116	115	114	112	111	111	111	110	109	108	108
	沙 [sa^{33}]	124	122	122	117	116	116	116	114	114	114	113
		115	114	113	112	107	106	106	106	106	106	106
		118	115	115	114	113	112	111	111	110	111	110
	Mean	**119**	**118**	**117**	**116**	**115**	**115**	**114**	**114**	**113**	**112**	**111**
[22]	試 [si^{22}]	98	98	98	99	99	99	99	97	96	96	94
		97	97	97	99	99	99	99	99	99	97	97
		105	105	105	106	106	108	109	109	107	105	104
	富 [fu^{22}]	98	97	97	96	96	96	96	96	95	95	94
		96	94	94	94	94	93	93	93	96	96	96
		99	99	97	97	96	96	96	96	96	97	97
	以 [ji^{22}]	109	107	106	106	109	109	109	108	106	101	101
		109	110	110	111	111	111	111	112	111	110	108
		115	116	118	122	122	122	121	120	120	117	114
	舖 [p^{h}u^{22}]	106	102	102	99	98	98	98	99	99	99	98
		97	99	99	99	99	99	99	99	99	99	99
		100	99	97	95	95	95	97	98	98	98	97
	沙 [sa^{2}]	98	92	88	88	88	88	90	92	92	92	92
		101	98	94	92	92	94	96	96	94	94	96
		92	89	88	88	88	90	90	90	92	92	92
	Mean	**101**	**100**	**99**	**99**	**99**	**100**	**100**	**100**	**100**	**99**	**99**

Tones	Test words	11 data points of the pitch contour										
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
[25]	史 [si^{25}]	97	94	95	99	101	106	108	113	118	121	121
		97	97	98	100	102	104	111	116	124	124	124
		92	93	93	100	104	109	112	117	125	125	125
	府 [fu^{25}]	96	98	100	103	103	108	111	114	117	117	117
		96	98	99	102	107	110	117	119	121	122	122
		99	99	100	102	108	109	116	125	131	131	131
	椅 [ji^{25}]	104	99	96	99	102	104	111	117	123	127	129
		98	96	96	98	98	98	105	110	118	125	127
		97	97	98	100	104	107	113	121	126	127	129
	普 [p^{h}u^{25}]	98	98	98	99	102	104	106	110	117	118	119
		100	101	101	101	103	109	111	116	119	119	120
		105	104	104	103	103	104	108	111	115	118	119
	捨 [sa^{25}]	108	103	103	103	106	108	113	113	118	121	124
		97	95	94	94	94	96	100	103	105	105	106
		93	91	91	91	94	98	100	104	104	109	112
	Mean	**98**	**97**	**98**	**100**	**102**	**105**	**109**	**114**	**119**	**121**	**122**
[21]	時 [si^{21}]	102	102	102	99	98	95	95	90	89	87	85
		103	101	101	101	97	95	93	89	88	86	84
		101	100	99	98	95	93	88	86	82	81	81
	胡 [fu^{21}]	103	101	100	99	96	95	90	87	83	82	80
		99	97	95	93	89	86	82	82	80	77	77
		100	98	95	92	91	87	85	83	77	76	76
	而 [ji^{21}]	102	100	99	99	99	100	97	95	93	88	84
		104	100	96	98	98	96	96	93	89	84	77
		99	97	95	95	95	95	88	86	82	79	77
	葫 [p^{h}u^{21}]	105	103	100	97	92	89	85	84	82	81	80
		103	101	99	95	92	88	87	85	85	84	83
		106	105	103	102	101	99	97	94	92	89	89
	蛇 [sa^{21}]	102	99	99	97	94	91	90	87	86	86	83
		96	94	93	92	90	89	89	86	84	82	81
		93	93	91	90	86	83	83	79	78	78	78
	Mean	**101**	**99**	**98**	**96**	**94**	**92**	**90**	**87**	**85**	**83**	**81**
[5]	食 [sit^{5}]	137	137	137	137	137	136	135	135	134	134	134
		134	134	133	132	132	132	132	132	131	131	130
		132	132	132	132	130	128	127	127	127	126	125
	服 [fuk^{5}]	129	128	128	128	128	128	127	127	126	127	128
		125	125	125	124	124	124	124	124	124	123	124
		139	139	139	139	139	139	138	138	138	138	138
	頁 [jip^{5}]	137	137	137	138	138	138	138	138	138	137	136
		136	136	136	136	135	135	132	131	131	130	129
		140	141	142	142	142	142	143	143	143	143	144
	僕 [p^{h}ok^{5}]	116	116	116	116	116	116	116	116	116	115	115
		115	113	113	113	113	113	113	113	113	113	113
		125	126	127	127	127	127	127	127	127	127	127
	石 [sak^{5}]	123	123	123	123	123	123	122	123	123	122	121
		131	131	131	131	129	127	125	125	126	125	121
		118	117	117	117	117	116	116	116	115	115	116
	Mean	129	129	129	129	129	128	128	127	127	127	127

Tones	Test words	11 data points of the pitch contour										
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
[3]	舌 [sit^{3}]	123	123	123	122	122	122	121	121	121	121	120
		122	122	123	122	122	121	120	120	120	119	117
		125	125	125	124	123	121	121	121	121	121	121
	福 [fuk^{3}]	111	112	112	112	112	112	112	112	112	112	112
		111	110	109	109	108	107	107	106	106	106	105
		123	121	120	121	123	120	120	119	120	120	121
	醃 [jip^{3}]	103	104	104	105	105	105	105	105	105	104	103
		112	113	114	116	118	118	118	117	117	117	113
		108	109	109	111	111	111	111	110	109	108	108
	仆 [p^{h}ok^{3}]	112	112	111	112	111	111	110	110	110	109	109
		108	106	106	106	106	106	106	106	106	106	106
		106	106	105	105	105	105	104	104	104	104	104
	'slice' [sak^{3}]	109	109	108	107	107	107	107	107	105	103	102
		105	105	104	103	103	103	102	101	100	100	98
		106	106	106	105	105	105	105	102	100	97	101
	Mean	**112**	**112**	**112**	**112**	**112**	**112**	**111**	**111**	**110**	**110**	**109**