Yangping Tone in Zhangzhou: Beyond the Convention

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Abstract

This study examines the encoding of Yangping tone in three different linguistic contexts in Zhangzhou Southern Min, a Sinitic dialect spoken in south Fujian province of mainland China. The scientifically-acoustically normalized F0 result, based on21 native speakers' utterances, falsifies those auditory-based prior studies that document this tone with competing transcriptions. Its F0 contour is changed to be categorically different from corresponding citation form at the non-right-most position, demonstrating the right-dominance of tone sandhi system in this dialect. In the meanwhile, the F0 contour at the right-most position is not exactly the same as its citation value. Instead, it presents variation resulting from its phonetic sensitivity to occurring environments, reflecting the carry-over effect of tonal co-articulation, and the position-final declining effect, while questioning the conventional default-principle on the specification of sandhi dominancy in Sinitic languages. This exploration addresses existing inconsistency and inadequacy in prior studies, while substantially advances our knowledge of tonal phonetics and phonology in this dialect. It also contributes vital linguistic data to the typology of tone and tone sandhi as an important language phenomenon in Asian languages, while enlightening the discussion on how human beings model different variants in their mental grammar, while decode the complexity in their language practice.

Keywords: Yangping Tone, Acoustics, Citation, Phrase-initial, Phrase-final, Zhangzhou.

1. INTRODUCTION

Tonal languages occupy about 50% (Hyman 2011) or as much as 60%-70% (Yip 2002) of the world's spoken languages, which are largely concentrated in Sub-Saharan Africa, East and Southeast Asia, and South Central Mexico (Hyman 2011; Yip 2003; Pike 1948) and partly exist in Amazonia and New Guinea (Donohue 2005). The change of tonal pitch is conventionally expected to change either lexical meanings or grammatical information, or both in those so-called tonal languages. Prior to phonological analysis and acoustic processing, an auditory transcription is necessary to capture contrastive distinction and represent the range of allophonic variation among tones. In Asian tonal languages, Chao (1930)'s notional system has been most widely adopted to characterize pitch contrast, which divides a speaker's pitch range into four equal parts and labels the five boundaries with the integers 1 through 5 to represent low, mid-low, medium, mid-high, and high pitch, respectively. For example, level tones are transcribed by two instances of the same number (e.g., [22] or [55]); falling and rising tones are separately noted using increasing and decreasing numbers (e.g., [51] or [35]). When required, a third number is included to denote the turning point of a complex contour, such as the dipping tone in Mandarin is transcribed as [214].

However, it is common to see in the literature that different descriptions and analyses are posited for phonologically identical tones spoken within the same community. For example, tone 2 in Zhangzhou Southern Min, which can be referred to as Yangping tone in terms of Middle Chinese tonal category, have been transcribed in several different ways. These include [212] (Dong 1959), [13] (Lin 1992; FJG 1998; Yang 2008), [12] (Ma 1994), and [23] (Gao 1999), and [22] (Huang 2018; 2020), covering dipping, rising and level contour shapes. The reason for such a variation is

unclear. One may ascribe it to the between-speaker variation, but also can treat it as the consequence of different transcriptional skills in applying Chao's model in real-world utterances. Nevertheless, the inducing inconsistency and inadequacy of tonal notations makes existing work unreliable to truly represent the language being concerned and unavoidably can create confusion for theoretical modeling. For example, this tone 2 in Zhangzhou correspondingly can be modeled in three ways, including [-upper, LL], [-upper, HLH], and [-upper, LH].

Driven by such an intriguing tonal phenomenon, this study incorporates field linguistics, acoustic phonetics, and statistic testing to investigate the encoding of Yangping tone (tone 2) in order to derive a picture as to how it is realized in utterances and how native speaker structures the variants. The exploration is based on the empirical data from 21 native speakers of Zhangzhou Southern Min, and systematically examines how this Yangping tone is realized across three different linguistic contexts that include citation, phrase-initial, and phrase-final. The normalization approach is conducted to reduce speaker-dependent variation, while the technique of pairwise t-test is employed to examine whether its F0 realization may be affected by surrounding tones in a statistically significant way in constructions beyond monosyllables. The research design ensures this study to be solidly grounded in quantifiable phonetic reality and achieve a higher level of generalization and interpretation. The description directly supersedes existing inconsistency and inadequacy of prior studies, while substantially advances and stretches our knowledge of tonal phonetics and phonology in this dialect. It contributes vital linguistic data to the typology of tone and tone sandhi as an important language phenomenon in Asian languages, while shedding important light on the discussion of how human beings model different variants in their mental grammar and decode the complexity in their language practice.

2. Research Material

2.1 Zhangzhou Speech

Zhangzhou 漳州, romanised differently as Chiang Chiu or Changchow, is a prefecture-level city situated in the south Fujian province of Mainland China, with the latitude and longitude coordinates at 24.5130° N, 117.6471° E. The language spoken by native people is predominantly Southern Min, known as Hokkien for its colloquial pronunciation for Fujian, and referred to as Zhangzhou speech in this study. This speech is mutually intelligible with Southern Min varieties of Quanzhou, Xiamen and Taiwan; but it is entirely unintelligible with other Chinese dialects (e.g., Mandarin, Hakka, Cantonese, Wu, Xiang, and Gan). Mandarin, as the official language of China, is used on public occasions. Hakka, a Sinitic language, is also found but only spoken by a relatively small population living in western mountainous areas that border a major Hakka-speaking city of Longyan (ZZG 1999).

Certain regional variation can be observed in the sound system, in particular the tonal system, among its eleven administrative areas (Ma 1994; Yang 2008). For example, the pitch of tone 7 (Yangru in terms of middle Chinese tonal category) varies from a short high contour [4] in Longhai, a mid-level contour [33] in Changtai, a low rising contour [13] in Dongshan and Zhao'an, and a convex contour of either [121] or [131] elsewhere (Yang 2008). The study thus restricts the research locality to the urban districts of Xiangcheng and Longwen, which is conventionally considered to be historically-socially-culturally-linguistically-and-geographically representative of Zhangzhou (ZZG 1999). This selecting ensures the derived tonal patterns truly reflect the central tendency of this dialect as an independent variety, while maximally minimizing the regional variation.

2.2 Corpus

The data used in this study are obtained by the author on a formal field trip in Zhangzhou in 2015. Twenty-one native speakers (9 males and 12 females) from the urban districts of Longwen and Xiangcheng are selected based on a set of strict criteria including intellectual curiosity, physical condition, age, birthplace, language environment at home, occupation, education, and competence in other languages. The average age for male speakers is 56.5 and 50 for females.

The corpus incorporates about 160 monosyllabic tokens, as illustrated in Table 1, and about 192 disyllabic tokens (=12 samples * 8 combinations * 2 contexts), as illustrated in Table 2. Tokens contain comparable numbers of syllable onsets with different manners and places of articulation and vowels of varying height and frontness. They are written in simplified Chinese characters and presented via Powerpoint, with one slide for one token, to ensure the utterance could be elicited in a clear and unexaggerated voice, along with well-controlled intensity and speech rate. They are recorded in Zhangzhou Hotel from individual speakers in Praat via a professional cardioid condenser microphone at a sampling frequency of 44100 Hz.

TABLE 1: Examples of Zhangzhou citation tones.

MC		Pitch	Example1	Example2
1	Yinpi	[35]	kɔ 'mushroom'	tɐŋ 'east'
2	Yang	[22]	kɔ 'glue'	tɐŋ 'copper'
3	Shan	[51]	kɔ 'drum'	tɐŋ 'to wait'
4	Yinqu	[41]	kɔ 'look after'	tɐŋ 'frozen'
5	Yang	[33]	ɦɔ 'rain'	tɐŋ 'heavy'
6	Yinru	[41]	kɔk 'country'	tɐp 'answer'
7	Yang	[221]	tɔk 'poison'	tsɐp 'ten'
8	Yang	[22]	kɔ̃ 'snore'	tsi 'tongue'

TABLE 2: Examples of Yangping tone in phrase-initial and phrase-final contexts.

Phrase-initial example		Phrase-final example	
2+1	tɛ.hwɐ 'camellia'	1+2	tsʰɛ̃.tɛ 'raw tea'
2+2	tɛ.ɗɐw 'tea house'	2+2	ʔɐŋ.tɛ 'black tea'
2+3	tɛ.ɓi 'dried tea'	3+2	tsɐ.tɛ 'morning tea'
2+4	tɛ.tjɐm 'tea store'	4+2	swɛ̃.tɛ 'unpacked tea'
2+5	tɛ.tsʰju 'tea tree'	5+2	ʔjɔŋ.tɛ 'have tea'
2+6	tɛ.sik 'tea colour'	6+2	sip.tɛ 'moisten tea'
2+7	tɛ.sit 'tea dessert'	7+2	sik.tɛ 'colorful tea'
2+8	tɛ.ɦjə 'tea leaf'	8+2	pɛ.tɛ 'Bai tea'

2.3 Acoustic Processing

Tonal F0 and duration, two main acoustic correlates of tone, are extracted in Praat. The rhyme portion incorporating all syllable segments except onset is considered as the tonally relevant duration (Huang 2018; 2020). The onset of tonal duration is set at the glottal pulse, where the amplitude of air pressure fluctuation begins to increase; the periodicity of speech wave vibration appears regular, and the formant patterns are stable and identifiable. Contrastively, the offset is set at the point where the periodicity of the waveform becomes irregular, and the formant patterns in the spectrograms ceases to be visible. Figure1 illustrates how the tonally relevant duration is determined (Huang 2022).

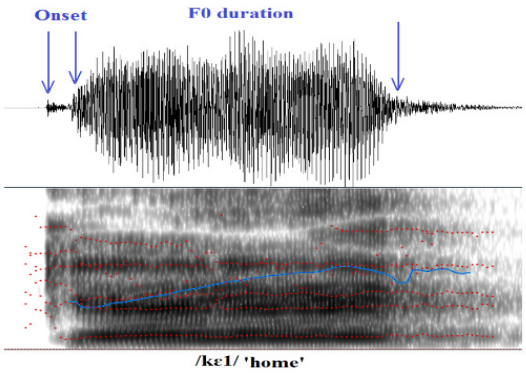

FIGURE 1: Praat labeled monosyllabic example /kɛ1/ 'home' (WYF, male).

2.4 Normalization

The acoustic signals are highly variable that carry both linguistic content and extra-linguistic information, such as speakers' socio cultural background, pragmatic intent, vocal tract anatomy, and physiology (Rose 2016; Huang et al., 2016). Processes of normalization are thus conducted to reduce indexical variances and to derive a linguistically phonetic representation of this variety. These include the z-score approach as in formula (1) for F0 values and the absolute representation as in formula (2) for duration values (Huang et al., 2016; Huang 2018; 2022).

$$Z_i=(X_i-m)/s \quad (1)$$

$$D_{norm}=(D/D_{mean})*100 \quad (2)$$

In (1), separately, the parameters m and s stand for the raw mean F0 value and the standard deviation estimated from all sampling F0 values for all tokens of all tones from a given speaker. Xi is an observed F0 value at a given sampling point, while Zi is its corresponding normalized value derived as a distance from the mean F0 value, corresponding to the speakers' neutral pitch. In (2), Dmean represents the mean raw duration value estimated from the average duration of all tokens in all tones from individual speakers. D is the duration observed for a given tone, while its corresponding normalized value Dnorm is expressed as a percentage of the average duration of all tones from the speaker being considered.

2.5 Statistical Testing

This study employs the pairwise t-test by effect sizes (Huang 2022) to examine whether the realization of Yangping tone is affected by its surrounding tones in disyllabic constructions in a statistically significant way. The application of this approach requests exhaustive comparisons of all possible pairs, assuming all paired differences are independently and normally distributed. For example, examining whether the offset of Yangping tone is affected by its subsequent tones requires comparing 28 (8*7/2) paired normalized F0 differences at the 100% sampling point. Figure 2illustrates the pairwise t testing on F0 offsets of tone 2 across eight following tones.

	2+1	2+2	2+3	2+4	2+5	2+6	2+7
2+2	< 2e-16	-	-	-	-	-	-
2+3	1.00000	< 2e-16	-	-	-	-	-
2+4	0.00011	5.7e-08	0.00231	-	-	-	-
2+5	1.00000	< 2e-16	1.00000	0.00171	-	-	-
2+6	0.77501	3.0e-11	1.00000	1.00000	1.00000	-	-
2+7	< 2e-16	0.00016	< 2e-16	< 2e-16	< 2e-16	< 2e-16	-
2+8	2.1e-11	1.00000	5.3e-10	0.00075	3.9e-10	3.3e-06	0.02278

FIGURE 2: Pairwise t-test of normalized F0 offsets of Yangping tone 2 across following tones.

During the pairwise t-test, the Bonferroni correction is performed to control for a type I error and ensure significance (Levshina 2015). The corrected alpha number is calculated by dividing the critical P value of 0.05 by the number of comparisons under consideration. For example, in this tone 2 case, the corrected alpha was 0.00186 (= 0.05/28). If the calculated t value was less than the corrected alpha, then the paired difference was considered to be statistically significant, and vice versa. The pairwise t-testing results are visualized using hierarchical clustering algorithms. The threshold is consistently selected at 1 to determine the distance for significance. The statistical testing enables this study to use objective and scientific pattern to encode the nature of Yangping tone, which helps it achieve a higher level of generalization and explanation.

3. ZHANGZHOU CITATION TONES

The urban area of Zhangzhou city has received extensive impressionistic documentations (Dong 1959; Lin 1992; Ma 1994; FJG 1998; ZZG 1999; Gao 1999; Zhou 2006; Chen 2007; Yang 2008; Guo 2014) and some acoustic descriptions (Huang et al., 2016; Huang 2018; 2020; 2022a; 2022b) on its monosyllabic citation tones. However, all the work before Huang (Huang 2018; 2020)'s initiative identify a seven-way tonal contrast with their pitch transcriptions not only differing among themselves but considerably differing from Huang's studies. For example, tone 1 has been transcribed varying from [24], [44], [45] to [35]; while tone 2 has been transcribed in five different ways, including [212], [13], [12], [23], and [22]. The descriptions are summarized in Table 3, where I, II, III, and IV separately correspond to the Middle Chinese (MC) tonal categories of Ping, Shang, Qu, and Ru, while a and b separately represent Yin, and Yang registers which are related to the voicing status of historical syllable onsets.

TABLE 3: Previous transcriptions of Zhangzhou tones.

Author	T1 Ia	T2 Ib	T3 II	T4 IIIa	T5 IIIb	T6 IVa	T7 IVb	T8 IVb
Dong	24	212	53	32	33	32	13	*
Lin	44	13	53	21	22	32	12	*
Ma	44	12	53	21	22	32	121	*
FJG	44	13	53	21	22	32	121	*
ZJG	44	13	53	21	22	32	121	*
Gao	45	23	53	21	33	21	121	*
Zhou	44	13	53	21	22	32	121	*
Chen	44	13	53	21	22	32	121	*
Yang	44	13	53	21	22	32	121	*
Guo	44	13	53	21	22	31	121	*
Huang et al.	35	22	51	41	33	41	221	*
Huang	35	22	51	41	33	41	221	22

The reason as to why variations exist in those auditorily-based documentations is unclear, but one may ascribe it to either between-speaker or between-transcriber differences. However, such

inconsistency not only can lead people to question the accuracy and reliability of existing work but can dampen our understanding of the nature of speech sounds in this dialect. Huang advocates an eight-way tonal contrast and a multidimensional framework for Zhangzhou tonal realization. The newly posited tone 8 emerges from those syllables that are historically assumed to end in a glottal stop but synchronically become open syllables, which render their manifestations (e.g., F0/pitch, duration, voice quality, and syllable structure) to differ from those obstruent-ending syllables. As an extension to explore the nature of Zhangzhou tones, this study adopts the eight-tone proposal. Figure 3 presents the normalized F0 patterns of individual citation tones, which are derived from normalizing monosyllabic utterances from 21 speakers, representing the central tendency of Zhangzhou speech as an independent variety.

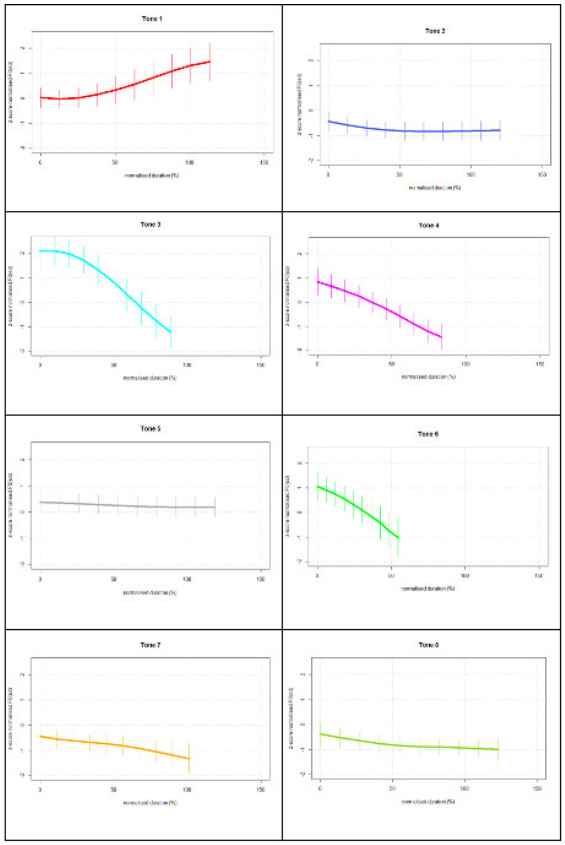

FIGURE 3: Z-score normalized F0 pattern of Zhangzhou tones.

As shown in the figure, the inventory of F0 contour shapes in Zhangzhou consists of a rising (tone 1), three level (tones 2, 5 and 8), three falling (tones 3, 4, and 6), and one level with a final fall (tone 7). Tone 4 and tone 6 both present a mid-high falling contour, but they differ in duration. Tone 8, which is conventionally classified into tone 7, presents a leveling F0 contour in the lower range, contrasting to tone 7 whose duration is shorter and has a depressed F0 contour in the second half because of the larygealisation effect (Huang 2018; 2020). What needs a special attention is that tone 2, also referred to as Yangping tone, presents a low level F0 contour between -1 sd. and 0 s.d., which is similar to that of tone 8. The reason why they are posited as being contrastive is because of their different behaviors in the non-right-most position, referred to as sandhi position: tone 2 shows a mid-level contour while tone 8 presents a mid-falling contour.

Based on the acoustically normalized result on the utterances from 21 speakers, a linguistically phonetic F0 system of Zhangzhou citation tones can be derived using the numeral notation, as summarized in Table 4. As can be seen, this tone 2 (Yangping) is neither a rising contour ([13], [12],

or [23]) nor a dipping contour [212] as transcribed previously. But rather, it is a low-level contour. This scientifically grounded description supersedes existing inconsistency and inadequacy, while provides a framework to investigate how Yangping tone is realized in other linguistic contexts, and how various forms are related to this citation form, and how native speakers structure the variants in their mental grammar.

TABLE 4: F0 system of Zhangzhou citation tones.

Citation tone		F0/Pitch contour	Notation
1	Yinping	mid rising	[35]
2	Yangping	mid-low level	[22]
3	Shang	high falling	[51]
4	Yinqu	mid-high falling	[41]
5	Yangqu	mid-level	[33]
6	Yinru	mid-high falling	[41]
7	Yangru	mid-low low level with a final fall	[221]
8	Yangru	mid-low level	[22]

4. YANGPING TONE IN THE PHRASE-INITIAL CONTEXT

Zhangzhou presents a right-dominant tone sandhi system (Huang 2018; 2020; 2022). Tones at the non-right-most position, referred to as sandhi position, are supposed to change their realization phonetically and phonologically, while tones at the non-right-most position maintain their realization categorically similar to their corresponding citation forms. The sandhi domain that motivates tonal alternation to occur is found to be aligned with the boundary of syntactic phrases XP, which range from noun phrases (NP), adjective phrases (AP), verbal phrases (VP) among others (Huang 2018; 2020). Yangping tone (tone 2) is thus expected to change its realization when it occurs at the non-right-most position of any syntactic phrases. However, questions remain to address as to (a) how this Yangping tone (tone 2) is realized as a function of its eight following tones? (b) How does its realization at the sandhi position differ from its citation form? (c) Whether its realization can be affected by the category of following tones; if yes, what may condition the variation. To explore the phonetic nature of this tone at the sandhi context, Figure 4 is plotted to show the normalized F0 patterns of this Yangping tone across eight following tones, while Figure 5 presents the pairwise t-testing results on examining whether the realization can be affected by its following tones.

As indicated in the figures, there are several generalizations that can be made with respect to the sandhi behaviors of this tone. (a) Yangping tone consistently presents a mid-level contour around the mid-point across its eight following tones. This suggests that, its realization is not affected by the category of subsequent tones. Because regardless of whether it is followed by a rising, level, or falling contour, it presents a consistent tendency. (b). Compared with the low level [22] contour in citation, this tone changes its realization to be a mid-level [33] at this phrase-initial context. The leveling contour shapes are similar in both contexts, but their contour heights are different, suggesting the forcing effect of the right-dominant tone sandhi system in this dialect. (c) Statistically, the pairwise t-testing result reveals no significant difference on its onset realization, but its offset presents two different variants, which can be generalized being conditioned by the feature of [low onset]. If its following tone (e.g., tones 2, 7 and 8) is [+low onset], the offset of Yangping tone is supposed to be statistically significantly higher, and vice versa.

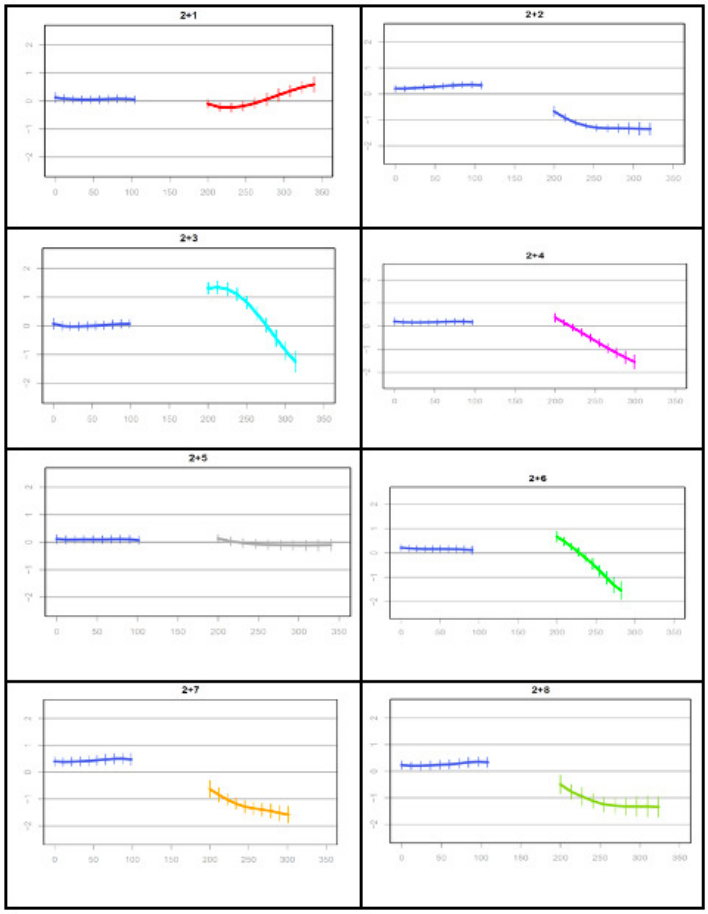

FIGURE 4: Normalized F0 pattern of Zhangzhou Yangping tone across eight following tones.

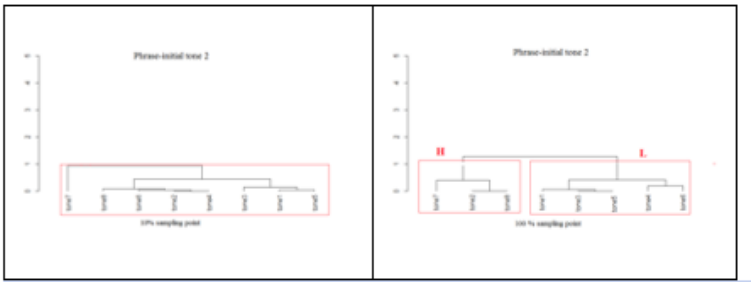

FIGURE 5: Pairwise t-testing result on the realization of tone 2 at 10% (left) and 100% (right) sampling points.

5. YANGPING TONE IN THE PHRASE-FINAL CONTEXT

Under the conventional specification, tones at the dominant position are supposed to maintain their citation forms without change (Zhang 2007; Ballard 1988; Rose 2016). However, given the universal tendency of overlapping articulatory apparatus in speech production (Han & Kim 1974; Shen 1990; Xu 1994; Zhang & Liu 2011), this criterion has turned out to be criticizable. Are the citation forms intactly preserved without any change? Are the forms not affected by surrounding contexts, even at the phonetic level? Questions as such remain to be addressed. This section examines how Yangping tone is realized at the phrase-final context; whether its realization can be affected by

preceding tones, if yes, what may condition the variation. Figure 6 plots the normalized F0 patterns of this Yangping tone as a function of eight preceding tones, while Figure 7 presents the pairwise t-testing result on examining whether there presents statistically-significantly different variation on its realization.

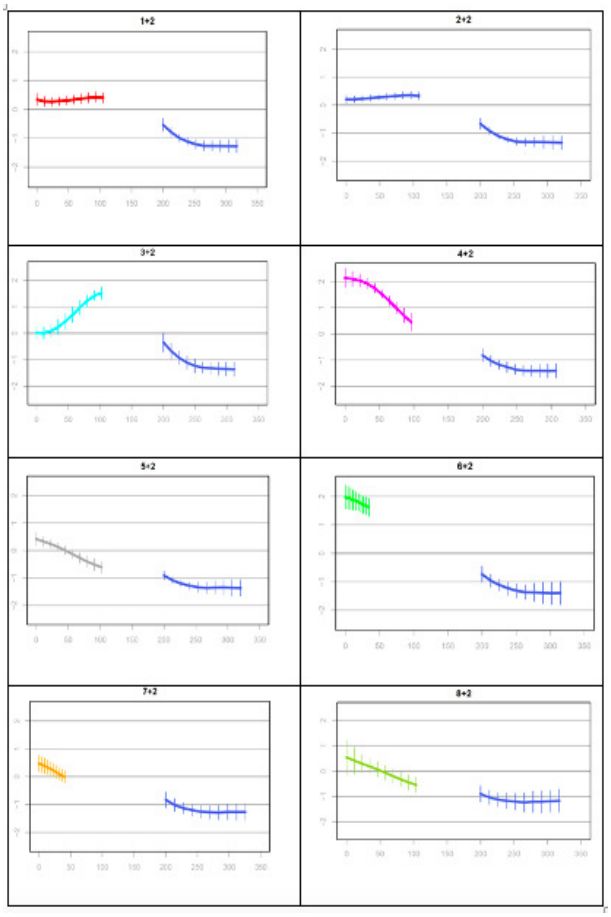

FIGURE 6: Normalized F0 pattern of Yangping tone across eight preceding tones in Zhangzhou.

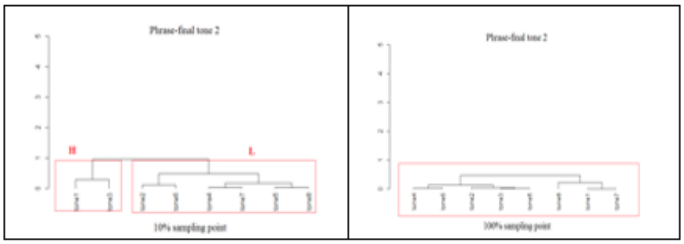

FIGURE 7: Pairwise t-testing result on the realization of tone 2 at 10% (left) and 100% (right) sampling points.

As indicated, several generalizations can also be made as to the realization of this Yangping tone at the phrase-final position. (a) Yangping tone consistently presents a falling tendency with a low-level plateau across different tonal combinations. The manifestation is considerably different from its citation form of a low-level contour, indicating that the citation form is not intactly preserved at the dominant position. (b) Its realization is not affected by the category of its preceding tones, because regardless of whether the preceding tone is rising, level or falling, it shows a consistent tendency in

contour shape. (c) Statistically, there is no significant difference on its offset value across eight tonal combinations, while its onset presents two significantly but marginally different variants. The conditioning factor for the onset variation tends to be tonally relevant. Because the onset is significantly higher after tone 1 than after tone 2, but the two phrase-initial tones have similar realization in both contour height and contour shape. Similarly, the onset is higher after tone 3 than tone 6 while tones 3 and 6 share a similar F0 offset phrase initially. (d) The leveling plateaus between -2 and -1 sd. tends to be one degree lower than its corresponding leveling trend in citation that situates between -1 and 0 s.d. Such a lower leveling may be ascribed to the F0 declining effect of utterance-final position (Pierrehumbert 1989; Rose 2014; Yuan & Liberman 2010).

TABLE 5: F0 of Yangping tone in different contexts.

Tone	Citation	Phrase-initial	Phrase-final
Yangping	[22]	[33]	[211]
		[34] (marked)	[311] (marked)

6. DISCUSSION

This study systematically explore how Yangping tone (tone 2) is realized across three linguistic contexts in Zhangzhou Southern Min based on the utterances from 21 native speakers. The scientifically grounded F0pattern reveals that, in citation, the tone is realized as a low level, noted as [22], rather than a rising ([12], [23], [13]) or a dipping [212] contour as transcribed in most of the prior auditorily-impressionistic documentations. This representation truly reflects the central tendency of this tone in the synchronic speech of Zhangzhou, while superseding existing inconsistency and inadequacy.

In the phrase-initial context, this tone changes its realization to be a mid-level contour [33]; but when occurring before a tone (e.g., tones 2, 7 and 8) that has a lower onset, its offset value appears to be higher, which can be noted as [34]. The two phonetic variants are different from its citation form, reflecting the right-dominant tone sandhi system in this dialect. It also reflects the co-articulatory effect, in particular the preservatory effect, in the production of this tone in the sandhi position. This tone appears to be phonologically inert to the category of its following tones, because regardless of the contour shape of its subsequent tones, it presents a consistent tendency across different tonal combinations.

In the phrase-final context, this tone consistently presents a falling tendency with a low-level plateau. Its onset values present two variants, reflecting the co-articulatory effect, specifically the carry-over effect. The leveling trend is one degree lower than its citation form, indicating the F0 declining effect of utterance-final position. As a whole, assummarized in Table 5, its realization at the dominant position (phrase-final) is not exactly the same as its citation form. This manifestation questions the conventional criterion that considers the citation form to be preserved without change at the dominant position and uses it as a default principle to specify the dominancy of tone sandhi system in Sinitic languages.

This study substantially stretches and advances our knowledge of tonal phonetics and phonology in this study, in particular with respect to how tonal behaviors construct a right-dominant tone sandhi system. It contributes vital linguistic data to the typology of tone as an important phenomenon in Asian languages, while shedding important light on the discussion of how tone sandhi dominancy should be better specified. The exploration of multiple realizations of a single tone also enlightens the discussion on how human beings model different variants in their mental grammar, and decode the complexity in their language practice through their overlapping articulatory apparatus.

7. ACKNOWLEDGE

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