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Qing Lin

The Diachrony of Tone Sandhi

Evidence from Southern Min Chinese

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Abstract

This book provides a diachronic account of the final-prominent tone sandhi of Southern Min Chinese (SM), which is known in the field of phonology for its arbitrariness and opacity. Most previous studies on SM tone sandhi adopted a synchronic perspective and concentrated on the phonological alternations between citation tones and sandhi tones. These alternation-based analyses, though succeeded in neatly describing one particular SM dialect's tone sandhi system (mostly that of Taiwanese or Xiamen), failed to identify the nature of SM tone sandhi and to accommodate the diversity of different SM tone sandhi patterns. Besides, the psychological reality of SM tone sandhi alternations has been seriously challenged in the last two decades. Therefore, a new method is needed to shed light on the formation of SM tone sandhi.

In this book, I propose a position-based diachronic approach towards tone sandhi. I argue that SM's sandhi tones (i.e. non-final tones) and citation tones (which is one type of final tones) have been changing along divergent paths. Generally speaking, the change of non-final tones is reductive in nature: it tends to reduce the pitch excursion of contour tones and neutralize tone categories, and it is more prone to contextual effect than final tones do. On the other hand, the change of final tones can be characterized as a series of chain shifts, which is non-reductive in nature. It is this difference in the directions of change that brings about the unnaturalness in the phonology of SM tone sandhi.

To demonstrate the diachronic changes of SM final and non-final tones, 16 SM dialects' disyllabic final-prominent tone sandhi systems are discussed in this book, and ten of them are based on acoustic results drawn from first-hand data. By adopting the position-based diachronic approach, this book provides for the first time an explicit and systematic explanation for the formation of SM tone sandhi patterns and, therefore, advances the understanding of tone sandhi and tonal change in general.

Chapter 1
Introduction

This book investigates the areal variations and the diachronic changes of the final-prominent tone sandhi of Southern Min Chinese (SM hereafter). Its purpose is to provide an adequate explanation for the synchronic patterning of SM tone sandhi by reference to the diachronic changes of tones. It is the first study to systematically explore how tones occurring at different positions change over time, and how these changes shape the synchronic phonology of tone.

In the field of tone phonology, SM's final-prominent tone sandhi processes are notoriously puzzling as they defy general explanation in terms of phonetic, functional or typological laws. Although quite a few proposals have been put forward to formalize some particular SM tone sandhi systems with derivational rules or ranked constraints (e.g., Wang, 1967; Yip, 1980; Barrie, 2006; for reviews, see Yin, 2012), their explanatory power is very limited as they fail to accommodate the diversity of different SM tone sandhi patterns (see Sect. 1.3.1). Besides, the psychological reality of SM tone sandhi alternations has been seriously challenged in the last two decades (see Sect. 1.3.2).

This book attempts to tackle this challenging issue from a different perspective: the diachrony of SM tone sandhi as revealed by synchronic areal variations. I argue that SM tone sandhi is mainly shaped by two regular tonal changes: prosodic-driven tone reduction and non-reductive tonal shift. The former regulates the changes of sandhi tones (i.e. the non-final tones within a SM tone sandhi domain), while the latter dominates the changes of citation tones and final tones. That is to say, tones occurring in different positions are able to change independent from each other, and what's more, the motivations behind their changes can be essentially different.

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This diachronic analysis of SM tone sandhi is based on an extensive investigation of 16 SM dialects' disyllabic tone sandhis. Among these 16 SM dialects, there are 10 dialects whose tone sandhi patterns were described using first-hand acoustic data drawn from field investigations. Their tone sandhi patterns have not yet been phonetically investigated before. Therefore, the current research also contributes to the literature as the first study to acoustically and consistently document the tone sandhi of a wide range of SM varieties.

Regarding the phonological representation of tone, the "Multi-Register and Four-Level" (RL) tone model is used in this book. The RL model incorporates a phonation-based register dimension into to the structure of lexical tone and divides each register into four pitch levels (Zhu, 2006, 2012, 2015). This tone model has been shown to surpass traditional tone models in describing not only the synchronic pattern but also the diachronic evolution of citation tones (e.g., Zhu & Wang, 2012; Zhu, 2014; Zhu & Ruan, 2014; Wang & Zhu, 2015; Zhu, Lin & Pachaiya, 2015; Zhu & Li, 2016). This book extends the application of this model to the domain of tone sandhi.

The remainder of this chapter provides the necessary background information on the issues of Chinese tone sandhi and SM tone sandhi, with emphasis on the theoretical progresses made in the last three decades and their limitations. The objectives and organization of this book are presented at the end.

1.1 What Is "Tone Sandhi"?

The term "sandhi", in its broadest sense, refers to the phonological processes that occasioned by the concatenation of morphemes or words to form larger units of speech (Henning, 1986; Kaisse, 2006).[1] Because of the existence of sandhi, morphemes and words have different phonological realizations in different contexts. Paradigm examples of sandhi include English plural alternation (between/s/,/z/ and/ɪz/) and French *liaison* (Re-syllabification of a usually silent word-final consonant as the onset of the next, vowel-initial word, cf. Nespor & Vogel, 1982, 2007).[2]

In tonal languages, sandhi may happen to lexical tones as well as segments (cf. Yip, 2002; Chen, 2000). In Chinese, tone sandhi is very common and highly diverse. A considerable amount of work has been done on the tone sandhi of various Chinese dialects (for reviews, see Chen, 1993a, b, 2000, 2001; Li, 2004; Bao, 2011; Zhange, 2014). One of the best-known and best-studied case is the "Third-tone (T3) Sandhi" of

[1]A narrower definition would limit the scope of "sandhi" to phonological processes that occur at morpheme or word boundaries, i.e. the junctures of the resulting combination (Henning, 1986; Kaisse, 2006). However, such a definition does not fit into the usage of 'tone sandhi' in Chinese phonology in many cases. More importantly, a broader definition would help us to gain a better understanding of the nature of sandhi phenomenon (cf. Henning, 1986, Chen, 2000, 2001: F37).

[2]Sandhi processes that occur between morphemes are more often termed as "morphophonology", and those occur between words are discussed under the rubrics of "post-lexical phonology" (Kiparsky, 1982), "phonology-syntax interface" (Kaisse, 1985; Selkirk, 1986) and "phrasal phonology" (cf. Kager & Zonneveld, 1999).

Standard Mandarin, in which a low dipping tone /213/ is realized as a rising tone /35/ when followed by another /213/, as illustrated by the examples given below. The tone values are noted with numbers according to the five-point scale (Chao, 1930), with 1 representing the lowest pitch and 5 the highest. Contour tones are denoted by number concatenations.

(1)	a.	213	213	>	**35** 213
		雨	伞		雨 伞
		yu	san		yu-san
		“rain”	“umbrella”		“umbrella”
	b.	213	213	>	**35** 213
		买	伞		买 伞
		mai	san		mai san
		“buy”	“umbrella”		“buy umbrella”

As a result of tone sandhi, a tone-carrying syllable has different tonal targets when uttered in different contexts. As a common practice, the tone value appears when the syllable is pronounced in isolation is called its “citation tone”, while the one appears only in connected speech is called its “sandhi tone” (cf. Yue-Hashimoto, 1987; Chen, 2000, 2001: 49).

Research on Chinese tone sandhi mainly focuses on two issues: the domain of tone sandhi application, and the tonal alternation involved in tone sandhi. In the last few decades, great advances have been made in our understanding of these two aspects of tone sandhi. The following section is a brief description of two most recent approaches to tone sandhi. The first one—the prosodic approach to tone sandhi—deals with the question of domain formation, while the second one—the phonetic approach to tone sandhi—is primarily concerned with the question of tonal alternation.

1.2 Recent Approaches to Tone Sandhi

1.2.1 Tone Sandhi as an Embodiment of Prosodic Structure

Since the late 20 century, sandhi processes (both segmental and tonal) have become a topic of particular interest in the field of phonology and morphosyntax-phonology interface, because they provide substantial evidence in support of the existence of a prosodic structure as an autonomous module in the grammar of language (Nespor & Vogel, 1982, 2007; Selkirk, 1986, 2001; Kager & Zonneveld, 1999).

Sandhi changes apply within a certain domain. Interestingly, there are many cases in which the formation of sandhi domain cannot be adequately predicted solely on the basis of syntactic constituency. Instead, it is found to be a confluence of multiple factors such as syntactic structure, semantic relations, pragmatic considerations, and phonological grounds (Nespor & Vogel, 1982, 2007; Kager & Zonneveld, 1999; Chen, 2000, 2001; Simpson, 2014). Take for example the Mandarin T3 sandhi:

(2)	a.	T3	T3	T3	T3		
		(**35**	213)	(**35**	213)		
		wo	[xiang	[mai	san]]		
		我	想	买	伞		
		I	want to	buy	umbrella		
	b.	T3	T3	T3	T3	T3	Shih (1997)
		(**35**	213)	(213)	(**35**	213)	
		(**35**	**35**	213)	(**35**	213)	
		老	李	买	好	酒	
		[lao	li]	[mai	[hao	jiu]]	
		old	Li	buy	good	wine	

In the above examples, parentheses indicate the domains of tone sandhi while square brackets indicate syntactic structuring. In (2)a, the four-syllable sentence is phrased into two T3 sandhi groups, and the phrasing does not mirror the underlying syntactic constituency exactly. In (2)b, the sentence can be phrased into (at least) two different ways according to different speech styles and information conditions. Roughly speaking, the first type of sandhi grouping occurs in slow and careful speech, and the second one is more commonly seen in normal and casual speech (for more discussions on T3 sandhi domain, see Shih, 1997; Chen, 2000, 2001: 364–402; Simpson, 2014).

In order to explain the idiosyncrasies and variations of sandhi domain formation, Nespor and Vogel (1982, 2007) formulated a hypothesis that sandhi domains are actually governed by **prosodic structure**, and the non-isomorphism between sandhi domain and syntactic constituency is a reflection of the non-isomorphism between prosodic constituency and syntactic constituency.

Prosodic structure specifies the phrasal organization of an utterance (i.e., how a sentence is segmented into appropriate chunks that are used by listeners and speakers for language processing)[3] and the relative prominence of each constituent in the utterance. Formally, it consists of a set of "prosodic units" (abstract constituents used in phonological segmentation) and a "Prosodic Hierarchy" to organize the prosodic units into a hierarchical structure (for reviews of phonological theories of prosody,

[3]Even in silent reading or in linguistic thought process, sentences are organized prosodically (Fougeron, 1999).

see Kager & Zonneveld, 1999; Fox, 2002: 330–365; Selkirk, 2011). The existence of such an autonomous prosodic structure can be demonstrated by the patterning of typical prosodic features such as accent, intonation, rhythm and pause, as well as the fine-grained phonological/phonetic modifications of segment articulation and phonation (Beckman & Pierrehumbert, 1986; Fougeron, 1999; Fox, 2002; Keating, 2006; Wagner & Watson, 2010; Cho, 2016).[4] According to Nespor and Vogel (1982, 2007), phonological sandhi changes are also one of the consequences of prosodic structuring.

This prosodic view towards sandhi soon gained ascendancy in the study of Chinese tone sandhi, especially in that of Mandarin and Shanghainese (Shih, 1986, 1997; Chen, 1990 2000, 2001; Selkirk & Shen, 1990; Duanmu, 1993, 2005; Yip, 2002; Simpson, 2014; Zhang, 2016; among many others). Take again the example of Mandarin T3 sandhi, a currently widely recognized conclusion is that T3 sandhi applies obligatorily within a "foot"—a prosodic unit which is ideally comprised of two syllables—and optionally in other larger prosodic units (Shih, 1986, 1997; Chen, 2000, 2001: 364–430[5]; Wang, 2008: 138–146; Duanmu, 2005; Kuang & Wang, 2006). Given this, the question of T3 sandhi domain formation is now often treated as a question of Mandarin foot formation.

Though details may vary, all prosodic approaches to tone sandhi postulated a direct and rigid correspondence between tone sandhi application and prosodic phrasing. However, in the last two decades, careful phonetic studies on tone sandhi have suggested that this might not be the case or at least not entirely the case. In fact, there are important differences between automatic tonal variation driven by spontaneous prosodic phrasing, and categorical tone sandhi that has already been phonologized and conventionalized and thus are less sensitive to pure prosodic forces. In other words, tone sandhi is related to prosody only through phonologization.[6]

1.2.2 Tone Sandhi as Phonologized Tonal Variation

In every utterance, with or without sandhi, prosodic structuring exerts significant influence on the phonetic realization of tones. In the domain of speech articulation, prosody specifies the timing and articulatory strength of each syllable, and the tonal contour of each syllable varies accordingly (Xu, 2001; Shih, 2005; Xu & Wang, 2009; see also Fougeron, 1999; Wagner & Watson, 2010; Cho, 2016). Generally

[4]Languages may differ in their selection of prosodic units as well as the prosodic cues used for prosodic units (Fox, 2002; Jun, 2005, 2014; Fletcher, 2010; Wagner & Watson, 2010).

[5]Chen (2000) opposed using the term "foot" to denote the domain of T3 sandhi, and he put forward a new prosodic unit called "minimal rhythmic unit (MRU)" to do so. But the idea that T3 sandhi domain can be described by an abstract prosodic unit didn't change.

[6]The process by which a universal phonetic tendency becomes a sound change and is incorporated into a language-specific phonological system in called phonologization (Bybee, 2015: 49, see also Hyman, 1976; Kirchner, 2012; Yu, 2013).

speaking, stressed syllables[7] and syllables occurring at the edges of certain prosodic unit are phonetically “strong” (or “prominent”), as they are produced with longer duration and/or stronger articulation than other syllables within the same prosodic unit (Fougeron, 1999; Keating, 2006; Fletcher, 2010; Wagner & Watson, 2010; Cho, 2016). As a consequence, sounds that are not stressed or not at prosodic boundaries are more likely to undershoot their phonological targets and undergo coarticulation. The so-called “T2 sandhi” of Mandarin, whereby a high-rising T2 [35] surfaces, or appears to surface as a T1 [55] when preceded by T1 or T2 and followed by any tone, is exactly such a prosodic-driven phonetic process. This is demonstrated by the observations made by Shih and Sproat (1992), Shih (2005) and Xu and Wang (2009), who showed that T2 sandhi is more obvious in prosodically weak positions, and the extent of T2 change is negatively related to syllable duration.

Positional phonetic asymmetry triggered by prosodic phrasing is quite probably an universal phenomenon, and the phonologization of such phonetic asymmetry is also widely attested across world languages (cf. Hyman, 1977; Fougeron, 1999; Zhang, 2001; Peng et al., 2005; Barnes, 2006; Keating, 2006; Cho, 2016). The genesis of lexical stress, segmental positional allophones and positional neutralization, can all be traced back to the prosodically-induced phonetic asymmetries (Hyman, 1977; Fougeron, 1999; Barnes, 2006).

Therefore, it should not be surprising that phonological tone patterns may emerge from prosodically-induced tonal variation. For instance, typological surveys across world’s tone languages have noted that word-final or phrase-final syllables are more hospitable to contour tones than non-final syllable(s) (Zhang, 2001). This positional asymmetry of lexical tone is grounded in the well-known prosodic effect of “final lengthening” (a.k.a. pre-boundary lengthening), where a syllable, and in particular the rhyme portion of a syllable tends to be longer in domain-final positions than when the same syllable is uttered in non-final positions (Zhang, 2001; Fletcher, 2010). Given a complex tone like falling-rising or rising-falling, the extra duration gives the final syllables an advantage to fulfill the intense tonal movement, whereas non-final syllables are prone to have more truncated or simplified realizations of the same tone target owing to their shorter durations (Zhang, 2001; Xu, 2004; more discussions in Sect. 2.3.1). This might serve as a phonetic motivation for “final prominent” (or “right prominent”, “last syllable dominant”) tone sandhi like the Half T3 sandhi of Standard Mandarin, whereby the dipping contour of T3 is reduced into its falling portion/21/ when followed any tone other than T3 (Xu, 2004; Zhang, 2007). Compared to T2 sandhi, Half T3 sandhi is no longer a pure automatic phonetic process, because the rising portion of T3 /213/ does not appear in non-final positions even given enough duration (Xu, 2004). Thus we can say that Half T3 sandhi is a phonologized tone sandhi.

As for the T3 sandhi of Mandarin, its relation with prosodically-induced tonal variation is less straightforward, because another tonal change—the neutralization between sandhi T3 and T2—ensued. According to Myers and Tsay (2003)’s review of experimental research on T3 sandhi, native speakers of Beijing Mandarin apply

[7] Including lexical, phrasal, and pragmatic stressed syllables.

T3 sandhi by phonetically modifying T3 so that it sounds similar to but not the same as T2,[8] whereas speakers of other varieties of Mandarin (including Taiwan Mandarin) categorically replace T3 with T2 (see also Yuan & Chen, 2014). For Beijing Mandarin speakers, the difference between sandhi T3 and T2 is smaller when the T3 sandhi applies within a foot than when it applies across foot boundary (Kuang & Wang, 2006; Wang, Yu, & Wu, 2016). For Mandarin speakers in general, the difference between sandhi T3 and T2 is smaller in less frequent words than that observed in highly frequent words (Yuan & Chen, 2014). These results lead to a conjecture that Mandarin T3 sandhi is originally a prosodic-driven tonal change, subjected to contour-simplification and coarticulatory effect (low tone dissimilation more specifically), resulting in a sandhi tone that could roughly be transcribed as [^{3}24] (cf. Yuan & Chen, 2014; Wang, Yu, & Wu, 2016). Then the neutralization between this sandhi T3 and T2 /35/ occurs gradually (the development of this neutralization is different between native Beijing Mandarin speakers and other speakers of Mandarin).

Unfortunately, although there were quite a few studies working on the phonetic motivations of tone sandhi, few studies have articulated the process how automatic tonal variation become phonologized and restricted to certain domains. Bybee (2001: 167–188) provided an insightful discussion on one of the best-studied cases of segmental sandhi—French liaison. She pointed out that construction or phrase frequency plays a major role in the establishment, maintenance, and loss of French liaison. Thus, the application rate of French liaison is higher not only in syntactic constituencies that have "tighter cohesion"—which is simply the reflection of high frequency of co-occurrence, but also in stretches of speech that are often used together but do not correspond to traditional constituents (ibid.). Similar to French liaison, Chinese tone sandhi also shows a preference for "tighter syntactic structures" and fixed phrases, in which tone sandhi is often said to apply obligatorily and be able to take in more syllables (e.g., Hirayama, 1975/2005; Chen, 1993a, b; Shih, 1997). Therefore, it seems that frequency of co-occurrence may also play a role in tone sandhi domain formation. It remains to be seen whether this hypothesis stands up to scrutiny, and how it influences the development of tone sandhi.

Introducing a phonologization perspective into the study of tone sandhi provides valuable insights into the phonetic underpinning of tone sandhi, and it also helps make sense of some important typological generalizations of Chinese tone sandhi (more discussions in Chap. 2). Nevertheless, it is surely beyond doubt that prosodically-induced tonal variations is not the only force that shapes Chinese tone phonology. Tone sandhi rooted in prosodic factors should be more or less phonetically transparent, as in the cases of Mandarin Half T3 sandhi and T3 sandhi. Yet phonetically unexpected tone sandhi patterns are ubiquitous in Chinese. Although Chinese tone sandhi often involves contour simplification, assimilation/dissimilation, and contrast neutralization in non-prominent positions, there are too many counter examples that defy these generalizations (Yue-Hashimoto, 1987; Chen, 2000, 2001; Zhang, 2014). Researchers often blame this predicament on overlaid tonal changes. To quote Chen

[8] The average F_0 of sandhi T3 is significantly lower than that of T2, and the slope of sandhi T3 is flatter than that of T2 (Myers & Tsay, 2003).

(2000: 42), "whatever phonetic or functional motivation there might have been has been wiped out by succeeding waves of changes". However, one might wonder, what change can dramatically shape the system of tone without leaving a trace of its phonetic or functional motivation?

Southern Min's final prominent tone sandhi—the subject of the current research—is a paradigm example of phonetically "unnatural" tone sandhi. The next section gives an introduction of Southern Min tone and tone sandhi, especially the characteristics that pose great challenges for the existing approaches to tone sandhi.

1.3 Problems Surrounding Southern Min Tone Sandhi

The interests and discussions around Southern Min (hereafter SM) tone sandhi were mainly aroused by the **Tone Circle** (Bodman, 1955: 41, cited in Yin, 2012) attested in two SM varieties—Mainstream Taiwanese and the closely related dialect of Xiamen (historically known as Amoy). This section begins with a presentation of the tone pattern of Xiamen, and then elaborates on three key issues surrounding SM Tone Circle: (a) the nature of SM tone sandhi alternation; (b) the nature of SM tone sandhi domain; and (c) the underestimated dialectal variation of SM tone sandhi.

1.3.1 Xiamen Tone Pattern

As the tones of other Chinese dialects, SM tones are typically associated with individual syllables. Every syllable—whether it is a free morpheme or not—in an utterance is lexically specified for a tone category (Li, 1962; Cheng, 1968).

Xiamen dialect has 8 tone categories, including one neutral tone that occurs with light syllables, and 7 others occurring with full syllables (Luo, 1956; Dong, 1959; Li, 1962). Neutral tone is beyond the scope of this book, and not particularly relevant to the theme we are focusing on. Thus the following discussion only concerns full-syllable tones.

The 7-tone system of Xiamen can largely be traced back to Middle Chinese (as reflected in the dictionary *Qieyun* (AD 601)), which has 4 tone categories called *Ping*, *Shang*, *Qu* and *Ru* respectively. Each Middle Chinese (henceforth MC) tone split into 2 subcategories conditioned by the phonation registers of syllables, traditionally termed as *yin* and *yang* (Thurgood, 2007; Zhu, 2014). This split gave rise to an 8-tone system, which can be regarded as the common point of origin from which the varieties of modern SM have evolved (Hirayama, 1975/2005; Handel, 2003). In the dialect of Xiamen, *Yang-shang* merged with *Yang-qu*, yielding a 7-tone system (Luo, 1956: 125–127). Table 1.1 gives a schematic summary of the correspondence between the tone categories of MC, proto-SM, and modern Xiamen.

The notation of Xiamen tone categories includes numbers 1, 2, 3, 4 indicating the MC tone origins, and small letters "a" and "b" for subcategories originally condi-

Table 1.1 Xiamen tone categories

MC	Ping		Shang		Qu		Ru	
Proto-SM	Yin-ping	Yang-ping	Yin-shang	Yang-shang	Yang-qu	Yin-qu	Yin-ru	Yang-ru
Xiamen	1a	1b	2a	2b, 3b		3a	4a	4b

tioned by phonation registers. The *Ru* categories (4a and 4b) are short tones occurring with syllables ending in stop consonant (a.k.a. "checked" syllables), all others are long tones occurring with other types of syllable (a.k.a. "smooth" syllables).[9]

What makes Xiamen tone special is that each tone category of Xiamen has (at least) two positionally conditioned allotones. One occurs at citation or domain final positions (leaving for the moment undefined what this domain is), the other occurs at non-final positions (Dong, 1959; Li, 1962).

Table 1.2 demonstrates the citation/final form and non-final form of each tone category with examples from Chen (2000: 43) and Li (1962), both used the five-point scale of Chao (1930) to transcribe tone values, with underlining to indicate short duration. For ease of reference, the final form of a tone category is hereafter referred to as the "final tone (**FT**)", and the non-final form of a tone category is referred to as the "non-final tone (**NFT**)". In previous SM literature, FT and NFT are often called "citation tone" and "sandhi tone", or "juncture tone" and "context tone", respectively. The new terminology used here highlights the positional conditions of SM tone sandhi. Relatedly, the abbreviation for the citation form of a tone category is "**CT**".

Phonological analyses of Xiamen tone sandhi generally assume that the alternations between FTs and NFTs are categorical and "structure-preserving" (i.e. the alternations do not create new non-lexical tones, cf. Myers & Tsay, 2008). Note that NFTs form a subset of FTs, as the NFT of 1a and 1b neutralize. For this reason, FTs are usually taken as the underlying forms, and the NFTs as derived from the corresponding FTs through phonological processes (e.g. Cheng, 1968; Yip, 1980; Hsieh, 2005; Barrie, 2006). Accordingly, the FT-NFT alternations of the long tones can be summarized with a pendulum shaped Tone Circle (first put forward by Bodman, 1955, cited in Yin, 2012), as illustrated in Fig. 1.1. The Tone Circle of Mainstream Taiwanese is also shown below.

Tone Circle provides a neat way to present the mapping relations between FTs and NFTs in Xiamen and Taiwan. However, the phonetic and phonological motivations underlying these alternations are unclear. Tone Circle involves highly unnatural sandhi rules (the tone sandhi of T3a: 21 > 53 or 51, for instance), and the circularity itself poses a significant problem for phonological analysis (Barrie, 2006; Yin, 2012).

A number of attempts have been made to formalize Tone Circle with feature-exchange rules or autosegmental processes (e.g., Wang, 1967; Yip, 1980; for reviews, see Yin, 2012), but these proposals were criticized for relying on either arbitrary rules

[9]The syllable structure of Xiamen is CGVX, or [initial [onglide [nucleus + coda]]. Only nasals, glides and the stops [p t k ʔ] can occur as codas (Chen, 1987).

Table 1.2 Tone values of Xiamen tone categories (The "." marks the boundary between two syllables)

Tone category	CT/FT	Example	NFT	Example	Tone Sandhi rule
1a	44	p^{h}aŋ 44 芳 "fragrant"	22	p^{h}aŋ 22. tsui 53 芳水 "perfume"	44 > 22/__X #
1b	24	we 24 鞋 "shoes"	22	we 22. tua 21 鞋带 "shoe laces"	24 > 22/__X #
2a	53	hai 53 海 "ocean"	44	hai 44. kĩ 24 海墘 "ocean front"	53 > 44/__X #
3a	21	ts^{h}u 21 厝 "house"	53	ts^{h}u 53. tiŋ 53 厝顶 "roof"	21 > 53/__X #
2b, 3b	22	pĩ 22 病 "sick"	21	pĩ 21. laŋ 24 病人 "patient"	22 > 21/__X #
4a[a]	$\underline{32}$	ts^{h}it $\underline{32}$ 七 "seven"	4	ts^{h}it 4. tiũ 44 七条 "seven pieces"	$\underline{32}$ > 4/__X #
		t^{h}iʔ $\underline{32}$ 铁 "iron"	53	t^{h}i 54. tiŋ 44 铁钉 "iron nail"	$\underline{32}$ > 53/__X #
4b	4	peʔ 4 白 "white"	$\underline{32}$	peʔ $\underline{32}$. kim 44 白金 "platinum"	4 > $\underline{32}$/__X #

[a]T4a has two nonfinal forms, [4] and [53], depending on whether the checked syllable ends in –p, −t, −k or in −ʔ (Li, 1962)

Xiamen					Taiwan				
/44/	→	/22/	←	/24/	/55/	→	/33/	←	/24/
↑		↓			↑		↓		
/53/	←	/21/			/51/	←	/21/		

Fig. 1.1 Xiamen tone circle [Left] and Taiwanese tone circle (adapted from Myers & Tsay, 2008) [Right]

or subjective tonal representations, and the conundrum of underlying motivations remained unsolved (Schuh, 1978; Tsay & Myers, 1996; Hsieh, 2005; Yin, 2012).

Circular alternation is considered to be not analyzable in classical OT, yet several proposals have been put forward under extended versions of OT, using new family of constraints such as anti-faithfulness constraints and contrast preservation constraints (Hsieh, 2005; Barrie, 2006; Thomas, 2008). These proposals all took the structure-preserving feature of Xiamen/Taiwanese tone sandhi for granted, assuming that candidates of NFTs include only the tones of FTs. However, structure-preserving is hardly a common trait of SM tone sandhi. Many SM varieties have NFTs which do not occur in FTs (see the tone sandhi of Coastal Taiwanese in Hsieh (2005) for example; for more examples, see Chaps. 4 and 5). In addition, the OT-based proposals pay particular attention to the absence of rising tone in NFT position and treated it as the trigger (or one of the triggers) of Xiamen/Taiwanese tone sandhi. However, in many other SM varieties, rising tone can occur in NFT position even when there is no corresponding rising tone in their FTs. Therefore, OT analyses fail to accommodate the diversity of different SM tone sandhi patterns (see also Chen, 2000, 2001: 38–49).

In sum, previous analyses of SM tone sandhi focus mainly on the synchronic alternations between FTs and NFTs, but their expositions are unsatisfactory because of the lack of generality. In fact, even we limit our scope of discussion to the Tone Circle of Xiamen/Taiwanese, a simple alternation-based perspective is insufficient as it cannot adequately reflect speakers' knowledge about Xiamen/Taiwanese tone sandhi. Evidence from psycholinguistic studies is reviewed in the following subsection.

1.3.2 The Nature of SM Tone Sandhi

There are two different standpoints regarding the nature of the alternations between FTs and NFTs: one is grammar-based, the other is lexicon-based. Grammar-based theories view a FT-NFT alternation as a derivational process, distinguishing underlying tones and surface tones, or input tones and output tones. Grammar-based analysis has been the common practice in the field of Chinese tone sandhi, and SM tone sandhi is no exception. However, a great weight of evidence has been built up against this conception.

Hsieh (1970, as cited in Chen, Myers, & Tsay, 2010) first questioned the psychological reality of SM tone sandhi derivation. He tested the ability of Taiwanese speakers to apply tone sandhi in nonce disyllables. His results showed that: (1) only disyllables comprised by actually occurring morphemes received 100% correct tone productions, whereas other types of nonce forms showed only 10–30% accuracy rates; (2) most of the incorrect responses were due to the non-application of tone sandhi, that is, speakers produced the FT form in non-final position. These two findings were largely replicated by subsequent experiments (Hsieh, 1976; Wang, 1993; Zhang, Lai, & Sailor, 2007, 2009; Chen et al. 2010. The last reference offered a review chapter of research on Taiwanese tone sandhi productivity).

In order to accommodate these results (and given the fact that the overwhelmingly majority of Taiwanese morphemes are monosyllabic), some researchers proposed that FT syllables and NFT syllables are both listed in the lexicon of Taiwanese speakers. In other words, every monosyllabic morpheme in Taiwanese has (at least) two allomorphs, one showing up in citation/final position, and the other showing up in non-final position, both are stored in the lexicon of Taiwanese speakers. Therefore, Taiwanese tone sandhi should be viewed as a process of choosing between two lexicalized allomorphs (Hsieh, 1970, as cited in Chen et al., 2010; Hsieh, 1976; Tsay & Myers, 1996; Tsay, 2002).

Nevertheless, there is also evidence that Taiwanese speakers apply the FT-NFT alternations productively in actual language use. For instance, loanwords into Taiwanese and newly coined lexical items do participate in the Tone Circle (Wang, 1993). So how do Taiwanese speakers extend the tone sandhi pattern to new sequences?

Further experiments revealed that, in Wug-tests, the productivity of Taiwanese tone sandhi is related to 3 factors: First of all, the frequency of tone category. The lowest productivity is always found in the tone category that has the lowest type and token frequencies[10] (T2b3b: 33 > 21), whereas the highest productivity is often found in the tone category that has the highest type and token frequencies (T1a: 55 > 33) (Hsieh, 1976; Chen et al., 2010; Zhang et al., 2009, 2011). Secondly, the amount of prior language experience that a native speaker has also influences the productivity rate, and thus older speakers have significantly higher accuracy rate than younger ones (Chen et al., 2010). Last but not least, if an existing morpheme mainly occurs in citation/final position and rarely occurs in non-final position, speakers tend to make more errors when asked to produce a NFT counterpart in novel phrases, and vice versa (Chen et al., 2010). Such an "allomorph frequency effect" has long been noticed by the field workers of SM, who often encounter difficulty in eliciting the citation form of a morpheme (or syllable)[11] used only in non-final position (cf. Li, 1962; Yue-Hashimoto, 1987).[12]

Taken together, these findings demonstrated that the productivity rate of tone sandhi in Wug words is profoundly influenced by speaker's familiarity with the tested syllables. Therefore, for Taiwanese speakers, applying tone sandhi to new sequence is actually a task of analogy (cf. Bybee, 2010: 57–75). They produce novel NFT/FT syllables by referring to similar NFT/FT syllables that they have stored in their memory, not by activating abstract tone alternation rules or constraints. This psychological unreality of tone sandhi as simple alternation rules seriously undermines the role of synchronic FT-NFT alternations in explaining the formation of SM tone sandhi.

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[10] The type frequency of a tone refers to the number of different syllables that can carry the tone; and the token frequency is the number of occurrences of the tone in the entire corpus (Zhang et al., 2009).

[11] Syllables in monomorphemic polysyllabic words also undergo sandhi (cf. Wang, 1993).

[12] Beside these three factors, Zhang et al. (2009, 2011) contended that phonetic transparency also affect the productivity of Taiwanese tone sandhi, so that speakers showed a tendency against phonetically unmotivated patterns. But conflicting results are found in Chen et al. (2010).

Given that the FT and NFT of the same tone category are associated with different (but related) mental representations in speakers' knowledge, some kind of independence is expected between the FT and NFT of the same tone category. In this book, I provide a new position-based perspective towards SM tone sandhi, sidestepping the question of FT-NFT mapping and dealing with FTs and NFTs separately. I will demonstrate that SM FTs and NFTs can be independent from each other in terms of how they change diachronically, and this independence is a key for understanding the formation and development of SM tone sandhi.

To understand the difference between FT and NFT, first we must know where they occur respectively. The next section summarizes recent developments in the topic of SM tone sandhi domain, which helps us to understand the origin of FT-NFT division.

1.3.3 The Nature of SM Tone Sandhi Group

The stretch of syllables over which SM tone sandhi applies is referred to as a Tone Sandhi Group (TSG). Below are two examples from Chen (1987) demonstrating the phrasing of Xiamen TSG. In these examples, the last syllable within each TSG (that is, the syllable before closing parenthesis, which is shown in bold) carries a FT, other syllables within the same TSG, if any, carry NFTs.[13]

a.	(**tsi**)	(tioʔ	k^hiam-k^hiam-a	**yiŋ**)
	钱	得	俭俭阿	用
	money	must	sparingly	use
	"One must use money wisely."			

b.	(tso	tsit	ts^hut	liok-ja-**p^hĩ**)	(lai	**k^huã**)
	租	一	出	录影片	来	看
	rent	one	Cl	video-movie	to	watch
	"Rent a video movie to watch"					

Since SM tone sandhi is positionally conditioned, it seems apparent that SM tone sandhi serves a demarcative function, marking the right-hand boundary of a TSG. But the nature of SM TSG is a controversial and much disputed question.

Compared to the domain formation of Mandarin T3 sandhi, Xiamen tone sandhi grouping is much less sensitive to rhythmic factors and much more compliant with syntactic structures (Chen, 2000, 2001; Duanmu, 2005; Simpson, 2014). It was

[13] This formulation of Xiamen TSG does not consider cases involving neutral tone syllables.

argued that, in normal speech, the right ends of Xiamen TSGs "correspond to the right ends of maximal projections in syntactic representation which are not lexically governed" (Lin, 1994, see also Chen, 2000, 2001: 455–470). This syntactic principle of Xiamen TSG formation is so strict that the size of a TSG can vary from a monosyllabic word to a full sentence with multiple syntactic phrases, without affected by rhythmic factors (Li, 1962; Chen, 1987).

However, SM TSGs still exhibit robust prosodic effects. Firstly, syntactically "flat" structures such as telephone numbers can form multiple TSGs. Besides, in verse recitation, literary readings, and idiomatic expressions, it is very common for rhythmic considerations to override syntactic concerns (Li, 1962; Chen, 2000, 2001: 471–474). Moreover, quite a few phonetic experiments on Taiwanese tone sandhi have shown that, in normal speech, TSG boundary influences articulation just as prosodic boundaries do. Prosodic boundary effects such as final lengthening (Peng, 1997; Pan & Tai, 2006; Wang & Fon, 2012; Guo, 2013) and initial strengthening (Hsu & Jun, 1996; Keating et al., 2003) are also attested on TSG boundary positions. These experiments also found that Taiwanese speakers can distinguish three levels of prosodic units during sentence speech production, i.e., Syllable, TSG, and Intonation Phrase (Guo, 2013). Thus, in terms of phonetic realizations, TSG behaves just like a prosodic unit (Prosodic Phrase specifically), embedded in a prosodic hierarchy.

There is another advantage to view Xiamen and Taiwanese TSG as a prosodic unit. As presented in Fig. 1.1, there are more tonal contrasts in FTs than those in NFTs, and the rising tone /24/ only occurs in FTs. These differences between FTs and NFTs are readily understandable by referring them to the prosodic-driven phonetic asymmetries discussed in Sect. 1.2.2. Owing to the articulatory constraints on the speed of pitch change, a rising tone requires a longer duration than a falling tone of equal pitch excursion (Xu & Sun, 2002; Xu, 2004). Given that final syllables of TSG exhibit final lengthening effect, it seems quite reasonable that the rising tone /24/ only occurs in TSG final position (cf. Barrie, 2006; Zhang et al., 2009).

Taken together the syntactic and the prosodic characteristics of SM TSG, and in light of the phonologization hypothesis of tone sandhi discussed in Sect. 1.2.2, it seems possible that a TSG boundary is a conventionalized prosodic boundary. Syntactic constituency provides a constant and stable basis for prosodic phrasing, and hence the right ends of XPs are probably the places where perceptible prosodic boundaries most frequently occur (cf. Duanmu, 2005; Zhang et al., 2011).[14] Accordingly, prosodic-driven tonal variations are more likely to be phonologized in these places. Once phonologized, the differences between the FT and the NFT of the same tone category cease to be phonetic and prosodic-driven in nature, and TSG is no longer a prosodic unit in terms of speech planning and processing, but TSG phrasing and spontaneous prosodic phrasing still often coincide.

[14]It should be noted that the syntactic conditions of TSG vary across different SM dialects. For instance, singular personal pronouns as sentence subject normally do not form a TSG by themselves in Xiamen and Taiwanese (cf. Li, 1962), but in the dialect of Shantou—another variety of SM, they usually form a TSG by themselves in the same sentences. Dialectal variation as such may provide important information about the development of SM tone sandhi. So far, however, there has been little discussion about the dialectal variation in SM TSG formation.

1.3.4 *Problems Raised by Recent Findings*

Two crucial conclusions can be drawn from the studies reviewed above. Firstly, the abstract FT-NFT alternations do not play a central role in actual SM tone sandhi processing. In fact, the FT and NFT of the same tone category are at least semi-independent categories in speakers' knowledge. Secondly, the domain of SM tone sandhi, i.e. TSG, probably originated from spontaneous prosodic phrasing as other tone sandhi systems did, but it has developed into a highly conventionalized structure.

These new understandings of SM tone sandhi lead to new questions about the patterning of SM tone sandhi:

i. If SM FTs and NFTs are not governed by abstract tonal alternation rules/constraints, how should we explain their differences and relations, and what governs the patterning of SM FTs and NFTs?
ii. If SM TSGs originate from spontaneous prosodic phrasing, we would expect that SM tone sandhis also originates from prosodic-driven tonal variations (as discussed in Sect. 1.2.2). However, it is known that many SM tone sandhis are not phonetically transparent. So what obliterates the parallelism between SM tone sandhi and phonetically tonal variation and causes the phonological unnaturalness of SM tone sandhi?

This book attempts to answer these two questions by adopting a diachronic perspective, more specifically, a diachronic perspective which takes into account not only the interaction between FTs and NFTs, but also the separate changes of FTs and NFTs.

So far, little is known about the diachrony of SM tone sandhi. In fact, few studies have adopted a diachronic approach towards any tone sandhi system in a systematic way, the exception being Qian (1988). This is because comparable data on the areal variation of tone sandhi patterns are extremly limited.

1.3.5 *The Tone Sandhi Patterns of Other Southern Min Dialects*

In contrast to the considerable amount of work done on Xiamen and Taiwanese tone sandhi, other varieties of SM received only sporadic attention in the tonological literature (but see Chen (2010) for a typological research of the synchronic tone sandhi rules of SM). Generally speaking, the tone sandhi patterns of most SM dialects are essentially similar. They are, or originally were: (1) final-prominent (or right-prominent, which means the last syllable within a TSG keeps the citation tone); (2) positionally conditioned and

Table 1.3 The tone sandhi patterns of Jieyang and Quanzhou (adapted from Chen 2000/2001:46)

<table>
<tr><th colspan="3">Jieyang</th><th colspan="3">Quanzhou</th></tr>
<tr><th>MC Tone Category</th><th>NFT</th><th>FT</th><th>MC Tone Category</th><th>NFT</th><th>FT</th></tr>
<tr><td>1a</td><td>33</td><td>44</td><td>1a</td><td>44</td><td>44</td></tr>
<tr><td>2a</td><td>35</td><td>42</td><td>2a</td><td>35</td><td>55</td></tr>
<tr><td>3a</td><td>31</td><td>313</td><td>3a</td><td>55</td><td rowspan="2">31</td></tr>
<tr><td>3b</td><td rowspan="3">11</td><td>22</td><td>3b</td><td rowspan="3">11</td></tr>
<tr><td>2b</td><td>13</td><td>2b</td><td>22</td></tr>
<tr><td>1b</td><td>55</td><td>1b</td><td>24</td></tr>
</table>

The "Jieyang" dialect here denotes the Kedong variety of the Jieyang dialect (Dong, 1960). Its tone sandhi system is very different from the one spoken in the administrative center of the Jieyang city—the one that will be presented in Chap. 4

context-insensitive.[15] The "structure-preserving" or "circular" property of Xiamen/Taiwanese tone sandhi is not a common trait of the tone sandhi of SM dialects.

Chen (2000: 38–49) pointed out that, when dealing with dialectal variation, a paradigmatic diachronic approach towards SM tone sandhi makes much more sense and faces much fewer problems than traditional grammar-based analyses do. He demonstrated this point using data from Jieyang, Xiamen, Longxi (a.k.a. Zhangzhou), and Quanzhou. See, for example, the comparison between Jieyang and Quanzhou below (Table 1.3).

By referring to the Middle Chinese (MC) tone categories, the similarity between the NFTs of Jieyang and Quanzhou is apparent—all b-register (or *Yang* register) long tones are neutralized into one tone category. However, it is extremely difficult, if not impossible, to explain why the set of /22, 13, 51/ in Jieyang and the set of /24, 22, 31/ in Quanzhou are neutralized into /11/.

Furthermore, regarding the FTs, Quanzhou has merged 3a and 3b (which is a very common tonal change in the history of Chinese) while Jieyang keeps this contrast intact. Note that Quanzhou merged different tone categories in different positions, and the mergers overlap on 3b. This makes the task of designating underlying forms a tricky issue (which is a very common problem in Chinese tone sandhi analysis, cf. Yue-Hashimoto, 1987; Chen, 1993).

The observations of Chen (2000: 38–49) are very insightful, but unfortunately there are no further studies that explore the diachronic aspect of SM tone sandhi. One reason for this is the lack of reliable and comparable data sources. Except for Taiwanese, the descriptions of SM tone sandhis were mostly based on aural impressions rather than instrumental analyses. The impressionistic transcription of tone is notoriously difficult, as attested by the ubiquitous discrepancies in tonal transcriptions among different sources of a single dialect, and the situation is even worse when it comes to the transcription of tone sandhi (Chen, 2000: 17–19; Bao,

[15] Some SM dialects have context-sensitive tone sandhis (cf. Chen, 2010), but these context-sensitive tone sandhis probably appeared after the context-insensitive ones.

2011; Donohue, 2013; Zhang, 2014). As a consequence, it is difficult to draw tenable conclusions regarding the changes of tone values. This enormous gap of controlled phonetic descriptions of different SM dialects must be filled if we want to improve the diachronic approach to tone sandhi.

1.4 Research Goals

The present study sets out to investigate the mechanisms and principles that govern the evolution of tone sandhi. It is devoted specifically to SM's final prominent tone sandhi, focusing on the question of how the current tone sandhi patterns of SM come into being.

To attain this goal, I conducted a cross-dialect acoustic survey on the disyllabic tone sandhi of different SM varieties. Several aural descriptions made by seasoned dialectologists will also be used when relevant. I do not intend a comprehensive typological census of the tone sandhi patterns of SM. Instead, the selection of SM varieties is biased towards those which show clear relations to the tone pattern of Xiamen/Taiwanese. So that it would be easier to infer the path of tonal changes from dialectal variations.

Unlike previous research on SM tone sandhi, which pay particular attention to FT-NFT mappings, I investigate the change of FTs and NFTs separately. The idea that tones occurring in different positions may change independently is not new in the study of tone, but a systematic understanding of how exactly these tones change and what are the differences between them is still lacking. This book helps to fill this research gap.

To summarize, the goals of this book are threefold:

(a) To provide acoustically-based documentation of a number of tone sandhi systems of different SM varieties;
(b) To explain the patterning of SM tone sandhi by referring to the diachronic developments that SM tones have undergone, and to identify the general rules of these developments;
(c) To enrich our understanding of how tone evolves in connected speech.

1.5 Outline of the Book

The rest of this book is organized as follows.

Chapter 2 provides a theoretical framework for understanding the distinction between the change of domain-final tones and that of non-final tones. First of all, I introduce the model used in this book for transcribing and characterizing tones.

Then I review the latest research on the change of citation tones,[16] which reveals that non-reductive chain shift is the most common type of citation tone change. After that, I review studies concerning the typological and phonetic differences between tones occurring on domain-final and non-final positions, from which I infer that the regular change of non-final tones should include contour reduction and contrast neutralization. Based on the above observations, I predict that, in SM, the change of CT and FT follows the pattern of non-reductive chain shift, while the change of NFT follows the rule of tone reduction.

Chapter 3 through Chap. 5 is a detailed investigation of the disyllabic tone sandhi of 16 SM dialects, including 6 Chao-Shan varieties and 10 Zhang-Quan varieties. Chapter 3 begins with a brief introduction to the SM dialects discussed in this book, and then introduces the tone experiments conducted to elicit the acoustics of the tone sandhi of 6 Chao-Shan varieties and 4 Zhang-Quan varieties. The procedures and methods used in the tone experiments are described, including a new F_0 normalization method that I devised especially for final-prominent tone sandhi systems.

Chapter 4 presents the results of the tone experiments of the 6 Chao-Shan varieties, and discusses the diachronic tonal changes revealed by the synchronic variations of these 6 Chao-Shan varieties. As the 6 Chao-Shan varieties do not differ markedly in their CTs/FTs, the focus of this chapter is how NFTs change. It is shown that the results are consistent with the predictions made in Chap. 2.

Chapter 5 discusses the diachronic tonal changes that the 10 Zhang-Quan varieties have undergone, based on a series of careful comparisons of various Zhang-Quan tone sandhi patterns. The changes of CTs, FTs, and NFTs are dealt with separately. Firstly, a common NFT pattern across different SM subgroups is identified, which strongly indicates that there is a common mechanism of NFT change underlying different SM varieties, and that NFT change is independent from FT change. Then I examine 7 Zhangzhou varieties to further explore on how exactly NFTs and FTs/CTs change independently. The results are also largely consistent with the predictions made in Chap. 2.

In Chap. 6, I present my conclusions together with a discussion on the formation of Tone Circle. Their implications for our understanding of tone sandhi and tonal change in general are disccused. Several crucial yet unsolved questions are also put forward for further research.

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[16] This book concerns only the long tones (i.e., tones carried by unchecked syllables), because the evolution of short tones (i.e., tones carried by checked syllables) is influenced by the obstruent syllable coda, which is beyond the scope of the current study.

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Chapter 2
A Position-Based Diachronic Perspective to Tone Sandhi

This chapter establishes a basic understanding of how tones occurring in domain-final and non-final positions change diachronically and what are the differences between them.

This chapter is divided into 4 parts. In Sect. 2.1, I introduce the "Multi-Register and Four-Level" (RL) model used in this book for transcribing and characterizing tones at the phonological level.

In Sect. 2.2, I review the latest research findings on the change of citation tones. It is shown that contrast-preserving chain shift is the most common type of the change of modal voice citation tones, and that the shift of citation tones is bidirectional and non-reductive.

In Sect. 2.3, I make several inferences on how tone changes diachronically in non-final positions, based on observations drawn by studies concerning the typological and phonetic differences between tones occurring in domain-final and non-final positions. I argue that non-final tones should be prone to prosodic-driven tone reduction, which reduces the complexity of tonal contour and the number of tonal contrasts.

Section 2.4 is a summary of the issues discussed in this chapter. Predictions about the development of SM's final-prominent tone sandhi are made based on the conclusions drawn in this chapter.

2.1 A General Tone Model

To understand how tone changes, first we need to know how to characterize different tones.

In the field of tone phonology, there have been many prior attempts to formalize the features and organization of tone in the past five decades, most of which were formulated under the framework of Autosegmental Phonology (Goldsmith, 1976). But none of these proposals became widely accepted (for reviews, see Duanmu, 2000; Fox, 2002: 200–241; Zhang, 2014). The traditional five-point scale of Chao (1930) is still the most-used method for transcribing tones in practice.

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Previous tone models are unsatisfactory for two main reasons. First of all, a lexical tone in East/Southeast Asia is very often a complex of other features besides pitch—such as duration and phonation type (Thurgood, 2002; Zhu, 2009, 2012b; Donohue, 2012; Michaud, 2012). However, at the time when these tone models were formulated, research on the linguistic status of phonation and its interaction with pitch was still in its infancy. Consequently, previous tone models either did not take phonation type into account or failed to provide an empirically valid way to characterize the relationship between pitch and phonation.

Secondly, with rare exceptions, previous tone models were built on impressionistic descriptions of tone and tone sandhi, whose precision and credibility varies considerably. Besides, it is not uncommon that a phonological analyst arbitrarily reinterpreted a tone value reported in the literature according to a particular theoretical bent (Zhang, 2014). Therefore, tone analyses concerning the subtle nuances of different tones are often inconclusive and unconvincing.

The current research adopts a more recent model—the "Multi-Register and Four-Level" (RL) model—to represent tones. RL model was first suggested by Zhu (1995, as cited in Zhu, 2005) to transcribe Shanghai tones, and in recent years it has been continuously improved and developed by Zhu and his colleagues to attempt a universally applicable tone model (Zhu & Wu, 2007; Zhang & Zhu, 2011; Zhu, 2012a; Zhu, Zhang, & Yi, 2012; Zhu & Ruan, 2014; Wang & Zhu, 2015; Zhu, Lin, & Pachaiya, 2015; among others). The following is a brief description of the RL model based on the latest account given in Zhu (2014, 2015). But note that two minor modifications are made here regarding the "Height" and "Contour" of the "Pitch" dimension.

RL model characterizes a lexical tone in terms of three dimensions: Register (Rg), Length (Leng), and Pitch (P), as illustrated in Fig. 2.1. Register is defined by linguistically meaningful phonation types and has a maximum of three levels—Upper (U), Modal (M), and Lower (L). Phonetically the number of phonation types is way more than three, no matter what kind of classification one has in mind (see, for example, Gordon & Ladefoged, 2001; Keating et al., 2011; Zhu, 2012a). But if we consider solely their influence on pitch and their phonological roles in tone typology, three registers are enough to accommodate various situations of pitch-phonation interaction. Roughly speaking, tones produced with distinctive creaky voice or breathy voice (including week breathy, i.e. slack voice) are put in the Lower Register; and those produced with distinctive falsetto voice (including weak falsetto, i.e. fortis voice) are put in the Upper Register. The Modal Register is for tones produced with modal voice and those accompanied by incidental non-modal voice. Since the SM tones discussed in this book do not contrast in phonation type, the Register dimension is not particularly relevant to the current study.[1] The interested reader is referred to Zhu (2012a, 2014, 2015) for details.

[1]Note all SM tones are modal register tones. It has been found that in the Jinghai variety of SM old speakers produced T2a with fortis voice (Zhang, 2015), and thus should be put in the upper register. In addition, in the Chaozhou variety of SM, creaky voice occurs in syllables traditionally described as ended with glottal stop (Shen & Lin, 2016), and thus should be put in the lower register.

Tone	Register		Upper / Modal / Lower
	Length		Long / Mid-short / Short
	Pitch	Height	High / Mid / Low / Bottom
		Contour	Falling / Level / Rising / Dipping

Fig. 2.1 The maximum structure of tone. Adapted from Zhu (2015)

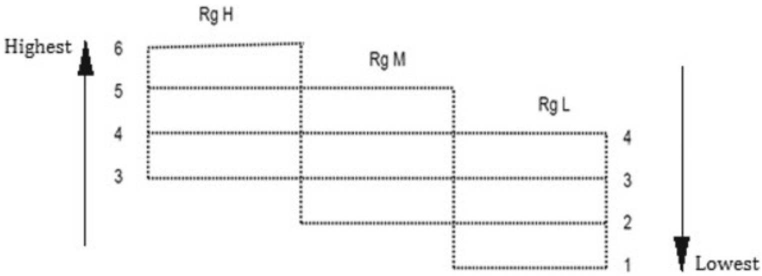


Fig. 2.2 Schematic representation of "Register-Height" interaction. Adapted from Zhu (2012a)

The Length dimension has a maximum of three levels: Long, mid-short, and short. Empirically, the ratio of the duration of short tone, mid-short tone, and long tone is approximately 1:2:3 when the tones are uttered in citation. In Chinese, long tone is the most common type and can be regarded as the unmarked form of lexical tones. Short tones normally occur in checked syllables, while mid-short tones can occur in both checked syllables (cf. Zhu et al., 2008, 2016) and smooth syllables. Dialects that contrast mid-short falling with long falling in smooth syllables have been found independently in several Chinese dialects (Zhu, 2012b). In this book, a new case of this kind of tonal contrast is identified in the dialect of Nanjing (Sect. 5.2.5).

The Pitch dimension has two subdimentions: Height (Ht) and Contour (Cnt). Height has a maximum of four levels, which means a tone inventory can have at most four tones contrasting only in Height within each register as shown in Fig. 2.2. The pitch range of the Lower register is one notch lower than that of the Modal register owing to the existence of breathy/creaky voice, and the pitch range of the Upper register is one notch higher than that of the Modal register owing to the existence of falsetto voice. Therefore, a phonation-complex tone system can distinguish up to 6 levels of Height, whereas a simple modal voice tone system has 4 at most, numbered from 2 to 4. In Zhu (2014, 2015) the four levels of Height are labeled with numbers "4", "3", "2", "1". In this work I change them into "high", "mid", "low", and "bottom" respectively to avoid confusion between levels of Height and the actual values of tone.

Different levels of Height can combine with different types of Contour to form different tones. But not all combinations are attested in actual tone languages (Zhu, 2012b, 2014; Zhu et al., 2012). In a broad classification, the Contour dimension has 4 major types: level, falling, rising, and dipping. In Zhu (2014, 2015), there is one more major contour type: pure-low, denoting a low tone without contouricity specification. But in this book I remove this pure-low type from the list for reasons given below.

A tone is expected to exhibit considerable phonetic variation conditioned by factors such as neighboring tones, prosodic positions, and the time and effort allotted to the tone (Xu, 2001, 2006). For instance, a straight high falling tone is often realiszed as [52] when produced before pause, but [53] when produced in connected speech. A circumflex high falling tone can be realized as [553], [453], [552], or [452] in different circumstances. Most notably, the bottom level tone/22/ is seldom implemented with a level F_0 contour, first because there is always a natural fall at the beginning (the same also occurs to low rising tone/24/) and frequently a natural bounce off the bottom at the end. In addition, speakers often produce the bottom level tone/22/ with varying degrees of creaky or breathy voice to strengthen its lowest-ness, giving rise to an extremely unstable and sometimes even unmeasurable F_0 contour (for examples, see Zhu, 2012b). For this reason, in the original RL model /22/ was treated as a tone without contour specification and was termed as a "pure-low" tone (Zhu, 2012a, b, 2014). Here I choose to attribute the wide variation of /22/ to pure phonetic reasons and treat it as a simple level tone at the phonological level. The "level" contour here implies that the target of this tone is an overall lowest-ness.

2.2 How Do Citation Tones Change?

The current study only concerns the natural diachronic change of modal-register long tones. The change of non-modal tones is not relevant to the issues under study, because the SM long tones discussed in this work are all modal-register tones. The change of short tones is also set aside because of two reasons: one is that the change of short tones is expected to be very different from that of long tones, owing to their short duration and the fact that they are frequently non-modal (Zhu et al. 2008); the other is that the short tones of SM show extremely complicated regional and speaker variation, as many SM dialects are currently in the process of lengthening their short tones (Li, 1962; Pan et al., 2011), and thus it seems that a sociolinguistically oriented survey or a corpus-based investigation would be more informative about the change of SM short tones.

There are not many works addressing the natural change of modal-register long tones. The overwhelming majority of existing studies on tone evolution dealt with the problem of tonogenesis, i.e. the historical origin of tone, which focused primarily on the interaction between pitch and other linguistic elements such as consonants and non-modal phonations (e.g.Hombert, Ohala, & Ewan, 1979; Thurgood, 2002; Kingston, 2011). In previous literature, the phrase "tone change" was used almost exclusively to refer to synchronic tonal alternations instead of diachronic tonal developments.

In what follows, I review what is known about the diachronic change of citation tones. Studies have shown that, it is very common that a tone's change is pushed

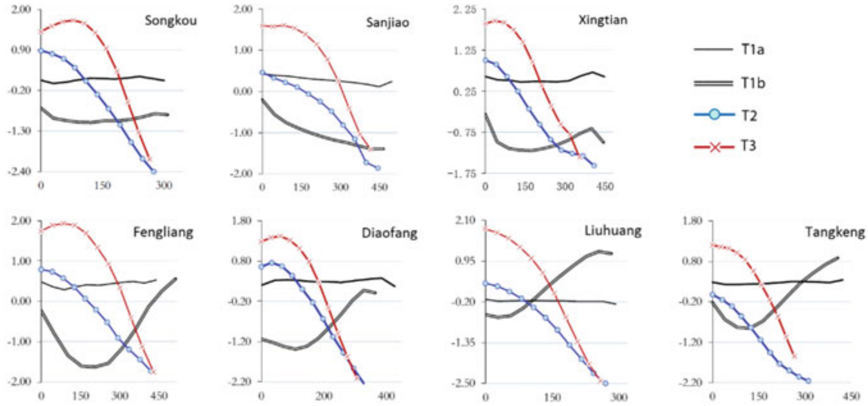


Fig. 2.3 The unchecked citation tones of 7 Meizhou Hakka varieties. Adapted from Zhu and Li (2016)

by another tonal change to maintain or enhance perceptual contrast, or dragged by a conspicuous gap in the tone space to restore system balance. Generally speaking, in citational position, tonal chain shift takes place much more frequently than tone merge (or neutralization if the tonal contrast is maintained in other positions) does. Examples are given in the following sections.

2.2.1 One Tone's Shift

The first example of citation tone shift comes from Meizhou 梅州 Hakka (Zhu & Li, 2016). Figure 2.3 presents the normalized pitch curves (in logarithmic Z-score, plotted against average duration; each curve is an average of about 20 tokens produced by eight speakers) of the citational long tones of seven Meizhou Hakka varieties.[2] In terms of phonological toneme, T1a, T2 and T3 are basically the same across all 7 varieties: T1a is a mid level tone/44/, T2 is a mid falling tone/42/ (with slight variations in the onset), and T3 is a high falling tone/52/. T1b, however, has an array of different realizations. In Songkou 松口 it is a low level/33/, in Sanjiao 三角 it is a low falling/32/, in Xingtian 兴田 it is a bottom level/22/, in Fengliang 丰良 it is a front dipping/324/, in Diaofang 刁坊 it is a mid rising/24/, in Liuhuang 留隍 and Tangkeng 汤坑 it is a high rising/35/.

These regional varieties of T1b can easily be lined up to form a continuum, which probably represents different stages of a gradual tonal change as illustrated below:

[2]Besides long tones, these Meizhou dialects each have 2 short tones, which are not shown in the figure.

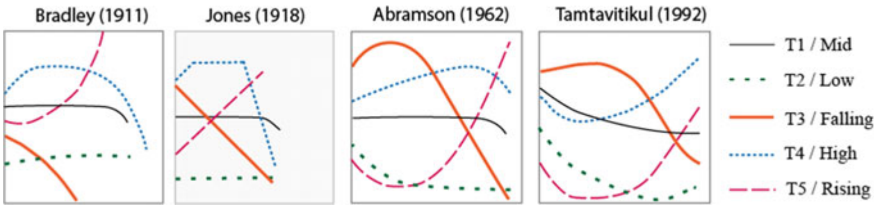


Fig. 2.4 Four representative stages of the development of Standard Thai tones. Adapted from Zhu et al. (2015)

(1) The gradual change of T1b in 7 Meizhou Hakka varieties

/33/ - /32/ - /22/ - /324/ - /24/ - /35/

The direction of this change is undetermined. But it seems reasonable to consider/33/ as the starting point, because in the tone system of Songkou 松口 T1b/33/ differs from T1a/44/ by only one level of Height, whereas in other varieties T1b is more distinct from other tones. Besides, it is likely that the utter absence of rising tone in the earlier systems, as in Songkou 松口, Sanjiao 三角 and Xingtian 兴田, allows T1b to expand its variants in the direction of this huge gap and change its center of gravity gradually. In this sense, the change of T1b is comparable to the "drag" part of a drag chain.

Some clearer examples of tonal chain shifts are given in the next subsection.

2.2.2 *Chain Shift*

The change of the tones of Standard Thai over the past century is a perfect example of tonal chain shift. Acoustic examinations of the citation tones of Standard Thai started as early as 1911 (Bradley 1911, cited in Zhu et al., 2015), and since then many works have been done to replicate the tone experiment. Zhu et al. (2015) gathered together the descriptive and experimental literature on Standard Thai tones, and found that all of the long tones, except the mid-level tone T1, have undergone a series of changes over the past century. Figure 2.4 presents three representative acoustic results measured in 1911, 1962 and 1992 respectively, and one auditory-based depiction of the pitch contours of Standard Thai tones made in 1918. The tones are named by numbers as well as the conventional terms used by contemporary Thai phonologists. Zhu et al. (2015) also replicated the tone experiment and the results are similar to that of Tamtavitikul (1992, cited in Zhu et al., 2015).

It is evident from Fig. 2.4 that every tone in Standard Thai, except T1, has undergone dramatic changes, but the contrastive relationships among the 5 tones are unchanged. Figure 2.5 is a schematic diagram of the tonal changes that Standard Thai has undergone. The tones are transcribed with the RL model. The arrows indicate the direction of change.

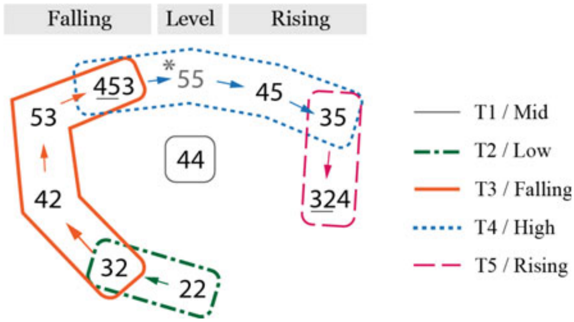


Fig. 2.5 Developments of Thai tones. Based on the descriptions of Zhu et al. (2015)

According to Jones (1918, cited in Zhu et al., 2015)'s depiction, the first significant change that happened after Bradley (1911, cited in Zhu et al., 2015) was probably the raising of the low falling tone T3, and then successive changes ensued. As T3 became higher, it pushed the high circumflex tone T4 to become a simple rising tone, which further pushed the high rising tone T5 to lowered itself. At the same time, the gap left by T3 drew the bottom level (or low level) tone T2 to become a low falling tone. To sum up, the long tones of Standard Thai have undergone two connected push chains and one drag chain.

It is generally believed that there is no tone sandhi in Standard Thai (Potisuk, Gandour, & Haroer, 1996; Tingsabadh & Deeprasert, 1997), which means, in Standard Thai, the tonal chain shifts have been applied to all relevant tone-carrying syllables across different contexts. Such "no sandhi" tone system is generally considered to be the initial form of tonal languages (e.g. Hirayama, 1975/2005, 1998; Qian, 1988).

This is not always the case though. A diachronic tonal change attested in citational position does not necessarily entail the same change in other positions. Hirayama (1998) provides a pertinent example from several northern Mandarin dialects spoken in the Shandong province of China.

According to Hirayama (1998), in many Shandong dialects, the citation tones have undergone a series of circular chain shifts, but the tones followed by neutral tone did not change synchronously, resulting in a set of pre-neutral allotones and allomorphs.[3] In other words, the pre-neutral tones are more conservative than the citation tones, and thus they preserve the earlier values of the tone categories. More interestingly, the Shandong dialects given in Hirayama (1998) share a very similar citation tone inventory, but their pre-neutral tone inventories could be classified into two types—the Weicheng (潍城) type and the Dezhou (德州) type.[4] These two types of pre-neutral tone systems were regarded as two stages of the circular chain shifts that the citation tones have gone through, as illustrated in Fig. 2.6. The tone values are

[3]This is because in natural speech the neutral tone syllable and the preceding syllable are tightly combined together as a cohesive structure, and this structure gains some extent of autonomy from the component morphemes, enabling it to resist change (Hirayama, 1998. See also Bybee, 2001: 167–188).

[4]Some trivial differences on the transcriptions are ignored here for expository simplicity.

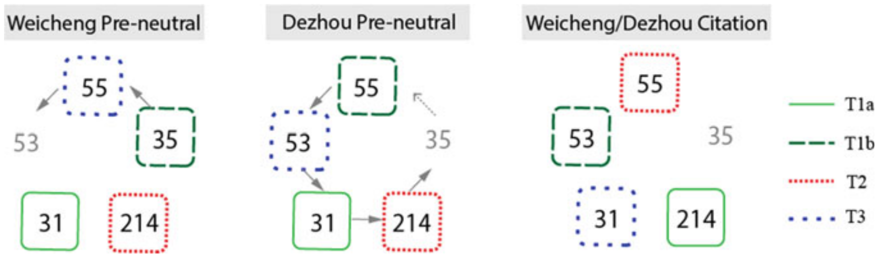


Fig. 2.6 Circular chain shifts attested in Shandong. Based on the descriptions of Hirayama (1998)

copied from Hirayama (1998), which were noted according to the five-point scale. The arrows indicate the direction of later change.

In the above case of Shandong, the changes of citation tones leave their traces in the pre-neutral positions. This makes the internal reconstruction method successful in recovering the past of citation tones. Hirayama (1975/2005, 1996/2005) applied the same method to **Xiamen** tone sandhi, asserting that Xiamen NFTs and FTs are descended from the same tone inventory of ancient Xiamen, and that NFTs are more conservative than FTs. Therefore, the synchronic alternation from a NFT to the corresponding FT is actually a reflection of a historical tonal change.

This account of Xiamen tone sandhi has several obvious drawbacks. First of all, it cannot explain the neutralization of T1a and T1b in NFTs, which did not happen in FTs. Secondly, according to the author's own account, the assumption that NFTs predate FTs is not applicable to other closely cognate SM dialects such as Jingjiang (晋江) and Jieyang (揭阳) (Hirayama, 1975/2005). Third, the author failed to provide a compatible explanation for the conservativeness of SM NFTs and the patterns of SM tone change. In Hirayama (1975/2005), the change of T2a from /55/ to /53/ was taken as the initial impetus of the changes of SM tones. The author attributed the occurrence of this change to articulatory factor that a high level tone is hard to maintain perfectly when uttered at the end of a phrase, because at the end of a phrase the vocal folds are relaxed and the subglottal pressure is reduced. This change initiated a series of chain shifts of FTs (the change of T1b not included) as illustrated in lower half of Fig. 2.7. The NFTs are not subjected to phrase-final reduction, and therefore the chain shifts did not occur or they occured with a lag. In Hirayama (1996/2005), however, the author changed the original value of T2a from /55/ to /35/, in order to accommodate the fact that in many other SM dialects the NFT of T2a is /35/ and to conform to the hypothesis that SM NFTs and FTs are changed in the same direction. As a result, the reason why NFTs are more conservative than FTs provided in Hirayama (1975/2005) was in fact brushed aside. To put it in a nutshell, seeing SM's NFTs simply as the relics of FT changes cannot provide a consistent explanation for the tone sandhi patterns of Xiamen and the diversity of SM tone sandhi patterns.

It should be noted that there is a fundamental difference between Shandong pre-neutral tones and SM NFTs. In a sequence of "full syllable + light syllable", obviously

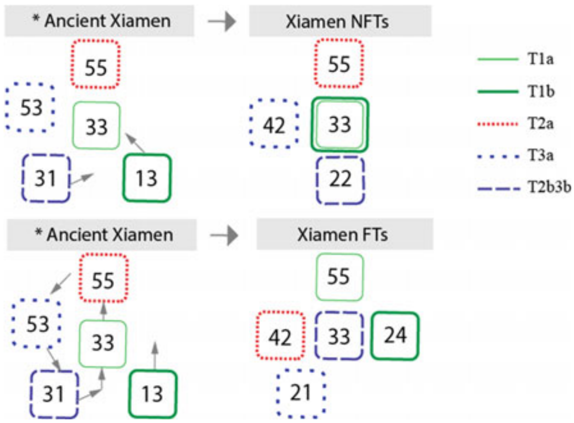


Fig. 2.7 Diachronic changes of Xiamen tones proposed by Hirayama (1975/2005). The tone values are copied from Hirayama, (1975/2005), which is noted according to the five-point scale

the former syllable is more prominent than the latter one, and thus it is reasonable to compare the behavior of pre-neutral tones to that of citation tones.[5] In a SM TSG, however, NFT is the less prominent one (cf. Sect. 1.3.3). Therefore, it should not be surprising that the change of NFTs and the change of FTs differ not only in speed.

This section established one major type of citation tone change: chain shift.[6] Interestingly, if we compare the direction of change of Standard Thai with that of Shangdong or Meizhou Hakka, it can be seen that the change of citation tone is not unidirectional. More importantly, in a citation tone shift, a level tone can readily become a contour tone, and a simple falling/rising can readily become a circumflex/dipping tone, indicating that the change of citation tones can head towards tones with higher complexity.

2.3 How Do Non-final Tones Change?

In the previous session, we've seen that a diachronic tonal change attested in citational position does not necessarily entail the same change in other positions. However, to my knowledge, no research has been done to seriously address the question of how non-final tones or sandhi tones change diachronically and what is its relationship with citation tone change and synchronic tone sandhi. The only well-established concept about sandhi tone change is that it can be independent from citation tone change, as sandhi tones and citation tones can be radically different in terms of their tonal values and what tone categories they neutralize (cf. Yue-Hashimoto, 1987, Chen, 1993).

[5]Incidentally, the pre-neutral tones of SM also have the same values as the citation tones (Chen & Li, 2008).

[6]There are also cases in which no obvious motivation can be identified. For instance, why is the T3 of Standard Thai raised into a high falling? The answer remains unkown.

Nevertheless, we can gain valuable insights from the study of tone sandhi typology, as long as we acknowledge that the typological differences between sandhi tones and citation tones are closely related to the differences between how sandhi tones change and how citation tones change. In addition, under the hypothesis that tone sandhi are originated from prosodic-driven tonal variation (as explained in Sects. 1.2.2 and 1.3.3), I believe that the observations drawn from the prosody-phonetics interface and the prosodic-driven phonetic variation of tone would shed important light on the evolution of sandhi tones.

2.3.1 Typological Asymmetries Between Final and Non-final Tones

It is well-known that SM tone sandhi patterns are “final-prominent” (or “right-prominent”, “last syllable dominant”, see Sect. 1.3.2), as it is the last syllable in a TSG that basically retains the values of citation tones. This phonological division between prominent and non-prominent tone has important typological implications.

2.3.1.1 Asymmetry in Contour Tone Distribution

Yue-Hashimoto (1987) conducted a study on the tone sandhi of 83 Chinese dialects, and she noted that in final-prominent tone sandhis the non-final tones often take the forms of level, falling, and neutral tones. She interpreted this phenomenon as the result of a general tendency to ease articulation in the middle of a speech flow.

Similarly, in an extensive survey of 187 tonal languages across the world, Zhang (2001: 95–107) observed that the distribution of contour tone favors domain-final syllables over non-final syllables, and he generalized this distributional asymmetry with an implication hierarchy: all else being equal, if non-final syllables in a prosodic domain can carry contours, the final syllable of the same prosodic domain can carry contours with equal or greater tonal complexity (this is true regardless of what type of tone sandhi the language has). Zhang (ibid.) attributed this advantage of final syllable for contour tone bearing to the prosodic effect of final lengthening.

Turning to a diachronic perspective, accordingly, it is very likely that in a final-prominent tone sandhi system the non-final tones are more prone to contour simplification than the final tones are.

Notice that, if viewed from the perspective of phonological tone alternation, this “asymmetry of contour tone distribution” is often violated. For example, in the case of Quanzhou discussed in Chen (2000: 46, see Table 1.3), T2a’s FT is a level tone/55/, while its NFT is a rising tone/35/. Thus, T2a’s NFT is more complex than its FT in terms of tonal contour. According to the research of Yue-Hashimoto (1987) on 283 disyllabic tone sandhi alternations gathered from 71 Chinese dialects (Wu dialects, which are the stronghold of the left-prominent tone sandhi, were excluded here), Wuyi tone sandhi:

<table>
<tr><th>σ_1 \ σ_2</th><th>24</th><th>213</th><th>53</th><th>31</th><th>55</th><th>13</th></tr>
<tr><td>24</td><td colspan="6" rowspan="3">$55\text{-}T_{\sigma 2}$</td></tr>
<tr><td>213</td></tr>
<tr><td>53</td></tr>
<tr><td>31</td><td colspan="6" rowspan="3">$11\text{-}T_{\sigma 2}$</td></tr>
<tr><td>55</td></tr>
<tr><td>13</td></tr>
</table>

Zhangping tone sandhi:

<table>
<tr><th>σ_1 \ σ_2</th><th>24</th><th>11</th><th>53</th><th>31</th><th>21</th></tr>
<tr><td>24</td><td colspan="3" rowspan="3">$33\text{-}T_{\sigma 2}$</td><td colspan="2" rowspan="3">$55\text{-}T_{\sigma 2}$</td></tr>
<tr><td>11</td></tr>
<tr><td>21</td></tr>
<tr><td>31</td><td colspan="5" rowspan="2">$21\text{-}T_{\sigma 2}$</td></tr>
<tr><td>53</td></tr>
</table>

Fig. 2.8 The disyllable tone sandhi of Wuyi (Southern Wu) [Left]; and the disyllabic tone sandhi of Zhangping (Southern Min) [Right]. Both adapted from Zhang (2007)

there were 27 cases of level tones going to falling tones, 32 cases of falling or level tones going to rising tones, and 3 cases of simple tones (level, falling, or rising) going into complex tones (dipping or circumflex). Together they accounted for 21.9% of the total number of tone sandhi, which is not a trivial number.

However, it would be hasty to conclude that final tones may undergo contour simplification before non-final tones do. I will demonstrate in Chap. 5 that such simple-to-complex tonal alternations could be the result of the diachronic shifts of final tones, which are not reduction-oriented.

2.3.1.2 Asymmetry in Tonal Neutralization

In a later study focusing on Chinese tone sandhi, Zhang (2007) indicated another typological characteristic of final-prominent tone sandhi: it often involves paradigmatic neutralization of the non-final tones.[7] That is to say, in a language with final-prominent tone sandhi, non-final syllables tend to have fewer tonal contrasts than final syllables do. Many SM varieties such as the dialect of Xiamen and Quanzhou conform to this general pattern, as described in Sects. 1.3.3 and 1.3.4. Two more extreme examples from Zhang (2007) are given below.

The final-prominent tone sandhi of Wuyi has 6 long FTs and only 2 long NFTs (both are level tones). The final-prominent tone sandhi of Zhangping, which is a SM variety, has 5 long FTs and only 3 long NFTs (2 of them are level tones).

Turning to a diachronic perspective, accordingly, it is very likely that in a final-prominent tone sandhi system the non-final tones are more liable to contrast neutralization than the final tones are.

Nevertheless, things would get tricky if a tone sandhi system involves non-neutralizing context-conditioned tone sandhis. Try compare the tone sandhi of Zhangping given in Fig. 2.8 (right) with the tone sandhi of Anbu (Table 2.1), a SM variety spoken in the Guangdong province, which will be presented with more details in Chap. 4.

In the tone sandhi of Anbu, T1a, T2b, T3b, and T4b each has only one NFT realization, while T1b, T2a, T3a, and T4a each has two or three context-dependent NFT realizations. More importantly, the split NFTs do not neutralize with each

[7] Here I treat "default insertion" as an extreme example of paradigmatic neutralization.

Table 2.1 Anbu's disyllabic tone sandhi

NFT	FT							
	1b/ 55/	4b/ 54/	2a/ 42/	1a/ 44/	2b/ 35/	3b/ 33/	4a/ 32/	3a/ 22/
1b	23+__			33+__				
2a	35+__		35+32	34+__				
3a	54+__		54+32	43+__				
4a	54+__		54+32	43+__				
1a	44+__							
2b	32+__							
3b								
4b	32+__							

other as in the case of the tone sandhi of Zhangping. These NFT allotones occur in complementary contexts and therefore are not minimally contrastive. However, clearly they are not phonetic variants. The conditions of the splits of NFT 2a, 3a, and 4a are not at all phonetically transparent (see the example of NFT 2a given below. The conditions of the splits of NFT 3a and NFT 4a are the same).

(1) The split of NFT 2a

NFT 2a	>/35/ before/55/,/54/, and/32/
	>/34/ before/44/,/35/,/33/,/32/,/23/

If we accept these context-conditioned allotones as categorized tones, then in this tone system the number of NFTs (11) exceeds the number of FTs (9).

In Chap. 4 we will see more cases of this kind of non-neutralizing context-conditioned tone sandhi. I will report how this kind of tone sandhi develops from context-free tone sandhi, and demonstrate that although these tonal splits increase the number of NFTs, they are still reductive in nature—the result of the splits are a series of less-complex tones. Therefore, from a diachronic point of view, they cannot be counted as couterexamples to the typological asymmetry in tonal neutralization between non-final tones and final tones.

All in all, typological studies concerning final-prominent tone sandhi have revealed a licensing asymmetry between non-final tones and final tones: non-final tones have a weaker licensing capacity in general, because typologically they tend to have lower contour complexity and less number of contrasts than final tones do.

This typological asymmetry is well grounded in the prosodically-induced phonetic asymmetries between non-final tones and final tones. In the following subsection, I present a brief review on a well-studied phonetic feature of prosody which exhibits a clear final/non-final division: the final lengthening effect. Then I elaborate on how this prosodic effect affects the realization of tones.

2.3.2 Phonetic Asymmetries Between Final and Non-final Tones

2.3.2.1 Asymmetry in Duration

A considerable number of acoustics and articulatory studies have shown that segments or gestures become temporally longer in the vicinity of prosodic boundaries, and that the magnitude of lengthening increases progressively (for instance, the nucleus of the pre-boundary syllable lengthens more than the syllable onset) and cumulatively (stronger boundaries showing more lengthening) (Edwards, Beckman, & Fletcher, 1991; Fougeron, 1999; Byrd & Saltzman, 2003; Krivokapić, 2007; Fletcher, 2010; Wagner & Watson, 2010; among many others).[8] For listeners and language learners, final lengthening effect functions as an important cue for speech perception (Tyler & Cutler, 2009; Abboub, Nazzi, & Gervain, 2016).

In Chinese, the final lengthening effect is attested in Standard Mandarin (Fon, 2002; Deng, Shi, & Lv, 2007a; Lai et al., 2010; Guo, 2016),[9] Beijing Mandarin (Lin et al., 1984; Zhang, 2001: 102–104, 149–153), Taiwanese Mandarin (Fon, 2002), Cantonese (Lee et al., 2002), and Taiwanese (Peng, 1997; Pan & Tai, 2006; Wang & Fon, 2012; Guo, 2013). Let me expand on the research of Taiwanese.

Peng (1997) conducted a sentence reading experiment to investigate the effect of prosodic position on the tone duration. He found that all of the 4 speakers produced utterance-final tones significantly longer than other non-final tones, and half of the speakers (2 out of 4) produced phrase-final tones longer than phrase-initial and phrase-medial tones. In addition, the durational differences were significant across tone,[10] but the effect is smaller on falling tones (/53/and/31/) than on other tones.

Wang and Fon (2012) performed a corpus study on syllable durations near discourse boundaries. They confirmed that final lengthening exists at clausal boundaries (DBI-0) and sentence boundaries (DBI-1 and DBI-2), and that the effect is progressive, in that syllables in the penultimate position (p-2) were significantly longer than those in the antepenultimate position (p-3), and the final syllables (p-1) were longer than the penultimate syllables (see Fig. 2.9).

[8]The lengthening effect has been observed phrase initially as well, but in general the magnitude of initial lengthening is smaller than that of final lengthening (Edwards et al., 1991; Byrd & Saltzman, 2003; xxx).

[9]In Standard Mandarin, final lengthening is not attested in the disyllabic phonological words spoken in sentence medial position (Deng et al., 2007b, cf. 2007; Lai et al., 2010).

[10]The "tone" here refers to the surface tone value. For instance, the surface tone values of FT 2a and NFT 3a are both/53/, and thus they are the same tone, despite that they belongs to different tone categories etymologically.

Finally, Guo (2013) conducted a corpus study on the syllable duration of the NFTs and FTs spoken before Intonation Phrase (IP) boundary and TSG boundary. FTs occur right before the boundary, while NFTs are at least one syllable away to the right of the boundary. Two conclusions were drawn: First, FTs are longer than NFTs (except for the low falling tone/31/, as FT/31/ and NFT/31/ were not significant different in duration); Second, measurements from an IP boundary are longer than those at a TSG boundary, confirming the cumulative feature of final lengthening (see Fig. 2.10).

In summary, the above research has identified a highly significant final lengthening effect in Taiwanese before IP and other higher prosodic boundaries, and a significant effect before Phonological Phrase (PPh) or TSG boundaries (recall that in Sect. 1.3.3 I suggested considering TSG boundaries as conventionalized prosodic boundaries).

2.3.2.2 Asymmetry in Pitch Contour

Tone bearing ability, especially contour tone bearing ability, is crucially dependent on duration. Articulatorily, a complicated contour tone requires enough duration to implement its complicated pitch change; auditorily, a longer duration enhances the perception of a complicated tonal contour (Zhang, 2001: 33–34). Several studies have reported that the durational constraint exert considerable influence on the phonetic implementation of tone.

According to Xu and Sun (2002) and Xu (2004), the minimum time it takes for a normal speaker to complete a pitch change of 6 semitones is 135 ms if the direction of change is falling, and 142 ms if the direction of change is rising (the range of 6 semitones is the common pitch range for lexical tones such as high falling and high rising, cf. Xu, 2001; Alexander, 2010). For a symmetric down-up or up-down movement the size of 4 semitones, at least 248 ms is needed.

Interestingly, in normal speech the average duration of non-final syllables is generally less than 200 ms, as shown in Figs. 2.9 and 2.10 (see also, Wang, 1994). Therefore, it is articulatorily very difficult, if not impossible, to implement a full-fledged circumflex or dipping tone in non-final positions. This means that circumflex or dipping tones are bound to undergo some extent of reduction in contour shape when produced in non-final positions.

For example, Tingsabadh and Deeprasert (1997) and Morén and Zsiga (2006) both reported that in Standard Thai (see Fig. 2.4) the circumflex falling contour [453] of T3 only occurs when the tone is produced in citation. In connected speech, the falling portion is missing and the tonal contour becomes [455]. The same happens in the case of Gurao 谷饶, a SM dialect spoken in the Guangdong province. My own acoustic measurements on Gurao's citation tone showed that, when produced in isolation, the citation tone T2a of Gurao is about 243 ms long and most of the tokens have a circumflex falling contour [453]. When the same syllable is put in a carrier sentence (preceded by a [44] tone and followed by a [33] tone), T2a is about 200 ms long and it is realized as [455] or [45], as illustrated in Fig. 2.11.

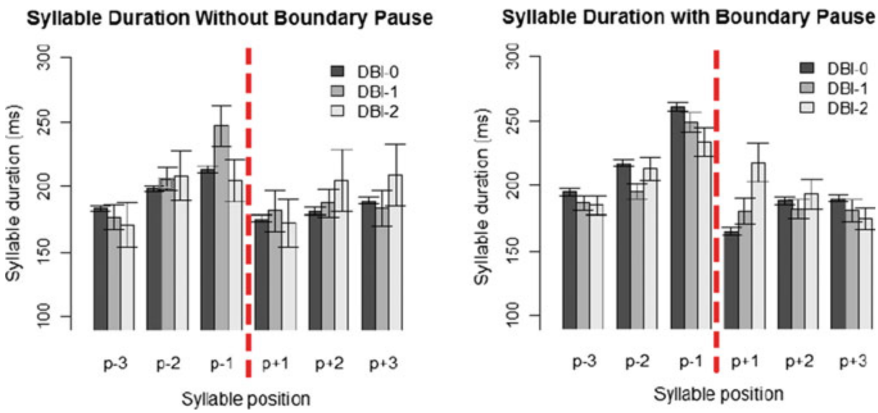


Fig. 2.9 Syllable durations before and after three levels of discourse boundaries, with (left) and without (right) pause. Adapted from Wang and Fon (2012)

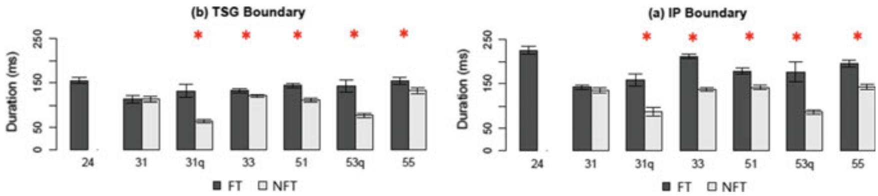
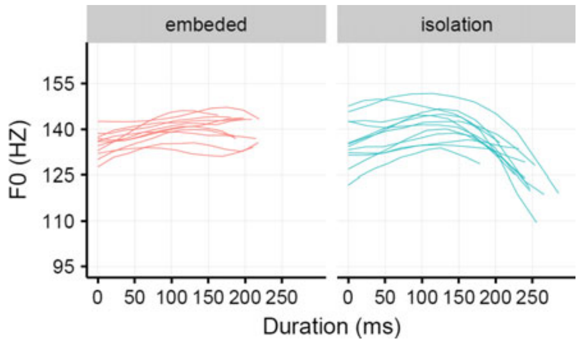


Fig. 2.10 Mean duration of the seven tones at **a** Intonation Phrase boundary; **b** Tone Sandhi Group boundary. Adapted from Guo (2013: 35)

Fig. 2.11 F_0 tracks of CT 2a produced in carrier sentence and in isolation, produced by a male Gurao speaker



This duration-induced tonal variation is easily able to serve as a precursor for a tone sandhi which changes a circumflex or dipping tone into a simple rising, falling, or level tone in non-final positions.

As for rising and falling tones, although there seems to be enough time for them to be effectively implemented even in non-final positions, evidence is mounting that the pitch range of rising and falling tones also varies across prosodic positions.

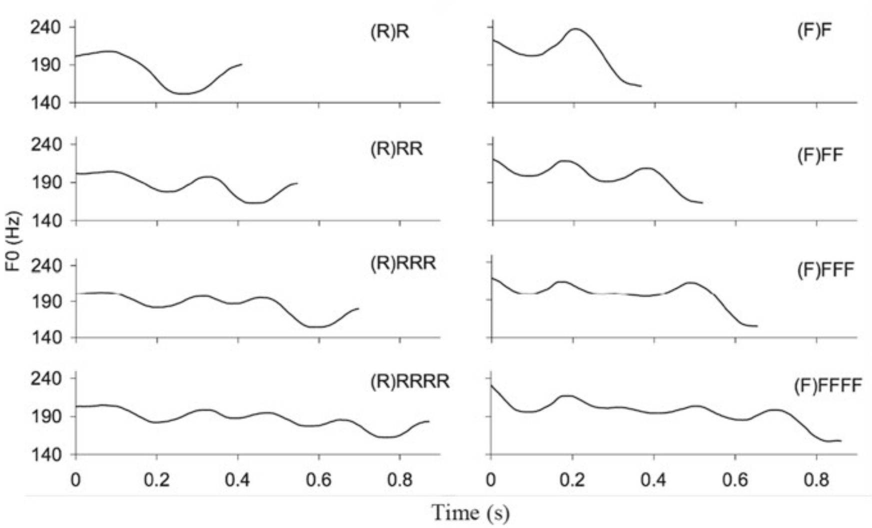


Fig. 2.12 Mean F_0 contours of consecutive rising (R) and falling (F) sequences with varying numbers of syllables said in middle of a carrier. From Xu (2006)

Xu (2006) observed that in Mandarin the magnitude of the F_0 excursion decreases as the numbers of syllables increases, and in each case it is the first and last syllable in the group that are reduced the least (Fig. 2.12). And Xu and Wang (2009) further found that in all multisyllabic sequences the final tone is the longest and has the largest F_0 displacement.

Relatedly, Pan and Tai (2006) reported that Taiwanese's high falling tone at an IP boundary has a greater F_0 range than the same tone occurs before other lower prosodic boundaries.

In addition, in Lee et al. (2002)'s research on Cantonese disyllabic and polysyllabic word, they found that one of their two speakers sometimes produced the rising tones/25/ and/23/ with level contour when they occur on non-word-final syllables.

The above observations indicate that non-final rising/falling tones are likely to have a smaller pitch range than final rising/falling tones do. This position-based tonal variation is easily able to serve as a precursor for a tone sandhi which a tone sandhi which changes a straight rising/falling into a slight rising/falling tone or level tone in non-final positions.

Incidentally, there is another well recognized prosodic effect that marks domain-final positions: the final lowering effect. Final lowering refers to the phenomenon that the F_0 peak in final position is significantly lower than the F_0 peaks in non-final positions, and the degree of lowering is greater than expected from the declination effect alone (Liberman & Pierrehumbert, 1984; Peng, 1997; Yuan & Liberman, 2010; Lai et al., 2014). However, this final lowering effect has been found to be limited to the last prosodic word in an utterance, and thus the F_0 height of the tone occurring in phrase-final position is not as lowered as in utterance-final position (Peng, 1997; Lai et al., 2014). Therefore, final lowering is not considered here as a possible precursor to diachronic tonal change.

This section attempts to shed light on the question of how non-final tones change diachronically by resorting to the typological and phonetic asymmetries between tones occurring in final positions and tones occurring in non-final positions. The typological literature shown that, compared to final tones, non-final tones tent to have lower contour complexity and less contrasts. The phonetic literature shown that, given the same tone, the non-final variants tent to have shorter duration and smaller pitch displacement than the final variants do. Based on these findings, it should be safe to infer that, tones occurring in non-final positions are under greater pressure to reduce their contour complexity and the number of contrast than tones occuring in final positions do.

2.4 Summary

In this chapter, I presented the diachronic, typological, and phonetic evidence from previous literature to show that there are different forces motivating the changes of citation tones and the changes of non-domain-final tones.

Regarding the change of citation tones, studies have revealed that it often takes the form of a chain shift, driven by system-internal pressure. And it is bidirectional, which means it does not imply a reductive direction. SM's CTs are expected to change in the same way. What's more, since SM tone sandhi is final-prominent, i.e. the tone values of FTs are basically the same as the tone values of the corresponding citation tones (see Sect. 1.3.2), the change of CTs and the change of FTs should be by and large synchronous.

As for the change of non-final tones, there is substantial evidence from typological and phonetic studies suggesting that non-final tones should be prone to prosody-driven tone reduction. Phonetic research indicates that, a tone produced in non-final positions tends to have a shorter duration and smaller pitch excursion than the same tone produced in final positions, owing to the prosodic effect of final lengthening. Relatedly, typological research observed that non-final tones tend to have lower contour complexity and less number of contrasts than final tones do. Phonetic tonal variations are the precursors of diachronic tonal change, and typological regularities are the results of recurrent tonal change (Hansson, 2008). Therefore, it is evident that non-final tones are prone to contour reduction and contrast neutralization diachronically. The NFTs of SM are expected to behave the same.

Citation/final tones and non-final tones exist under two completely different prosodic environments. What's more, studies have proven that speakers are able to store both the citation/final and the non-final form of the same morpheme in the lexicon (Sect. 1.3.2). Therefore, it should not be surprising that the development of citation/final tones and non-final tones may be divergent and highly independent from each other. In the following chapters, I present an in-depth investigation of the disyllabic tone sandhi of SM dialects, to see whether the predictions made in this chapter are correct.

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Chapter 3
Experiment Methodologies

This chapter is divided into two sections. Section 3.1 gives a brief introduction to the 16 SM varieties under study. Their dialect backgrounds and geographical locations are presented. 10 out of these 16 dialects are studied using first-hand acoustic data, including 6 Chao-Shan varieties and 4 Zhang-Quan varieties. Section 3.2 describes the tone experiment conducted on these 10 SM varieties. The tone experiment included two parts: a citation tone experiment and a disyllabic tone sandhi experiment. Information about participants, experiment procedures, and the methods used for data analysis are given. In order to better reflect the systematic relationships between NFTs and FTs, a new F0 normalization method, devised especially for final-prominent tone sandhi systems is adopted in this research.

3.1 Southern Min Varieties

Southern Min (SM), as its name indicates, is a branch of the Min dialect.[1] It is spoken by approximate 4 million people, and distributed mainly in the southeast part of Fujian province, southwest part of Guangdong province, and the coastal areas of Taiwan (Li, 1989; Li & Yao, 2008). SM dialect can be further divided into three major subgroups: Zhang-Quan 漳泉, Chao-Shan 潮汕 and Datian 大田 (Li, 1989).[2] Their geographic distributions are shown in Fig. 3.1. The two best known SM varieties, Taiwan and Xiamen, are the representative dialects of the Zhang-Quan subgroup.

[1] According to Li (1989)'s classification, Min dialect has 8 subgroups in total. They are: Southern Min, Puxian, Eastern Min, Northern Min, Central Min, Qiongwen, Leizhou and Shaojiang.

[2] There are several different ways to classify Southern Min (cf. Kurpaska, 2010). But the controversies involved do not affect the discussion here.

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Fig. 3.1 Distribution of Southern Min subgroups. Adapted from Wikipedia (s.v. "Southern Min" 2016) and Language atlas of China:B12 (Chinese Academy of Social Sciences & Australian Academy of the Humanities, 1987)

As mentioned in Sect. 1.3.4, acoustic studies of the tone sandhi of SM varieties are scarce except that of Taiwanese. In order to fill this gap in the literature, I conducted several field investigations between April 2014 and August 2016, collecting first-hand acoustic data of tone and tone sandhi from 21 dialect localities altogether,[3] out of which 10 are presented and discussed in the current research. The tone sandhi patterns of these 10 dialect localities not only show a traceable relation with the tone pattern of Xiamen/Taiwanese, but also present interesting differences from each other.

In addition to these 10 primary sources, secondary sources of 6 dialect localities are also used to enlarge the scope.

Figure 3.2, which is a close-up view of the region inside the dashed rectangle in Fig. 3.1, shows the locations of the dialect localities whose tone sandhi patterns serve as the objects of this research. Two Taiwan SM, Taipei (TP) and Hsinchu (HC), are also included, but their exact locations are not shown in this illustrative map as they are outside mainland China.

[3]A dialect locality is a place where the dialect has been examined (Kurpaska, 2010: 64).

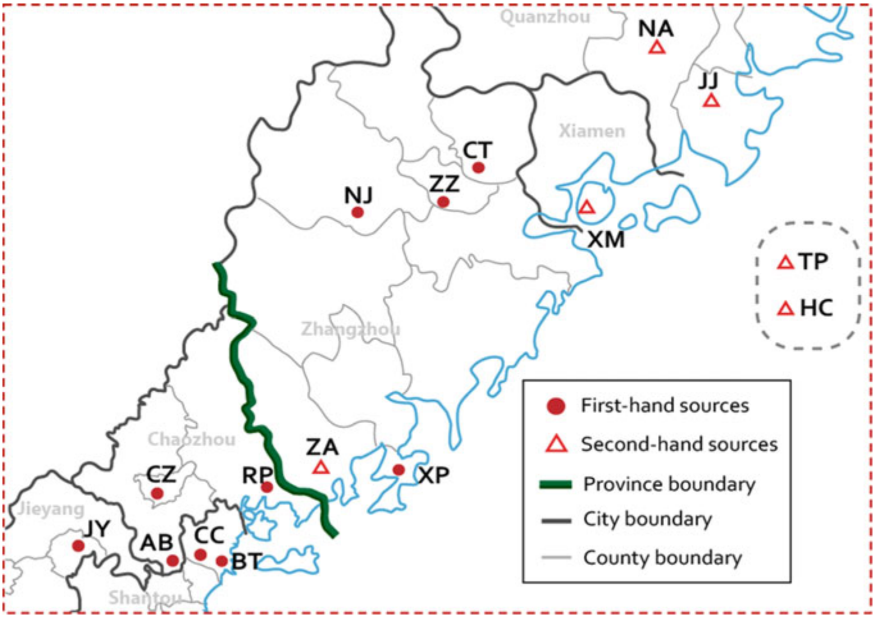

Fig. 3.2 Locations of source dialects

The following Table 3.1 provides more information about the 16 dialect localities, including their language affiliation, administrative affiliation, and the sources of the second-hand data. The dialect localities are ordered in the list according to their geographical locations, from the southwest to the northeast. TP and HC are placed at the bottom of the list. A dash "—" in the third column indicates that this dialect locality is the administrative center of the city and are named after the city's name.

The sources of Taipei and Hsinchu provided ready-made experimental acoustic results on disyllabic tone sandhi, while the source of XM is only a recording made for pedagogical purpose. The recording of XM disyllabic tone sandhi is measured and analyzed by me, using the same method that I used for my first-hand materials. Other secondary sources, including Zhao'an, Nan'an, and Jingjiang, are auditory-based impressionistic descriptions, and therefore they are treated with caution.

As for the 10 first-hand sources, although their tone sandhi patterns have all been reported before by other field workers, the reports were all based on aural impression and varied considerably in completeness and thoroughness (cf. Lin, 1996; Chen, 2010). For the sake of brevity I set aside these previous descriptions. The following discussions of these 10 SM varieties are based solely upon the experimental results draw from the current research.

The remaining part of this chapter introduces the procedures and methods used in the tone experiment to elicit the tone acoustics of the 10 dialect localities.

Table 3.1 Investigated dialects

No.	SM subgroups	Cities	Dialect localities	Sources
1	Chao-Shan	Jieyang 揭阳	— (JY)	
2		Chaozhou 潮州	— (CZ)	
3			Anbu 庵埠 (AB)	
4			Raoping 饶平 (RP)	
5		Shantou 汕头	Chengcheng 澄城 (CC)	
6			Batou 坝头 (BT)	
7	Zhang-Quan	Zhangzhou 漳州	Zhao'an 诏安 (ZA)	Zhang (2016)
8			Xipu 西埔 (XP)	
9			Nanjing 南靖 (NJ)	
10			— (ZZ)	
11			Changtai 长泰 (CT)	
12		Xiamen 厦门	— (XM)	Lin (2015)
13		Quanzhou 泉州	Nan'an 南安 (NA)	Li (2001)
14			Jinjiang 晋江 (JJ)	Li (2001)
15		Taipei 台北	— (TP)	Chen et al. (2010)
16		Hsinchu 新竹	— (HC)	Peng (2011)

3.2 Experiment on Tone Acoustics

3.2.1 Participants

In each selected dialect locality, two or three participants were recruited on-site to take part in the tone experiment. All participants were native speakers of the local SM varieties, born and raised in their hometown and never leave their hometown for more than two years. Most of them also speak Standard Mandarin as a second language. None of them had speech or hearing problems by self-report. The participants were paid for their time.

The participants are all literate and are accustomed to read Chinese characters in SM dialects. But they do not possess conscious knowledge of the phonology of SM. Detail information about the participants of each dialect locality will be given when presenting the experiment results in Chaps. 4 and 5.

Table 3.2 Proto-SM tone categories

	Ping	Shang	Qu	Ru
Yin	1a	2a	3a	4a
Yang	1b	2b	3b	4b

3.2.2 Materials

As mentioned in Sect. 1.3.1, Proto-SM is reconstructed with eight tone categories, two of which—*T4a and *T4b—occur on checked syllables with final stops, as illustrated in Table 3.2. Accordingly, the test materials were compiled on the basis of this 8-tone system.

Two reading lists were used as stimuli in this experiment. One was comprised of monosyllabic words and the other was comprised of disyllabic words or phrases. All stimuli are common words/phrases which can be readily recognized and produced in SM for average SM speakers. Nonsense and uncommon sequences were avoided here because SM speakers have difficulties in applying tone sandhi to unfamiliar collocations (as discussed in Sect. 1.3.2). Efforts have been made to include both high vowels and non-high vowels in each monosyllabic tone category and disyllabic tonal combination, in order to reduce the effects of vowel intrinsic F_0.

The monosyllabic reading list consisted of 80 (8×10) test words. Each tone category had 10 examples. The disyllabic reading list consisted of all 64 (8×8) possible tonal combinations of the 8 lexical tones in SM. Each tonal combination had five examples, making a total of 320 test collocations. These test collocations were grouped into 8 blocks according to the categories of NFTs. That is to say, materials within in the same block had the same NFT on the first syllable, and their FT varied across the 8 tone categories. The full lists of monosyllabic and disyllabic words/phrases are given in Appendix A and B.

3.2.3 Recordings

Recordings for acoustic analysis were taken on-site in quiet hotel rooms, with a digital recorder TASCAM 60 D and a condenser microphone Sennheiser E865 at a sampling rate of 44.1 kHz.

The experiment had two sessions: a monosyllable session and a disyllable session. In the monosyllable session, test words were shown to the participants one by one on a computer screen in a random order, and the participants were asked to read out each word twice, yielding a total of 160 monosyllabic tokens for each participant. In the disyllable session, the test materials were divided into 8 blocks according to the tone category of the first syllable (i.e., the NFT), so that participants were able to finish reading one block in 5 min and to keep a more or less constant pitch range within each block. Participants could take a short break between every two blocks.

The test items were shown to the participants in a similar way as in the monosyllable session. At least 320 disyllabic tokens were elicited from each of the participants. Some participants read the test sequences twice so that there were 640 disyllabic tokens for these participants.

Before the recording started, participants were given enough time to go through the testing materials, making sure that they had no problem in producing the target words/phrases in their vernaculars. The speakers were instructed by the experimenter to read the words and phrases in a normal and fluent speaking style, and to keep the speaking rate constant.

3.2.4 Acoustic Measurements

The sonorant portion of syllable rhyme was taken as the phonetic tone bearing unit (TBU). The boundaries of TBU was hand-labeled in Praat (Boersma, 2001) with the help of the spectrograms and waveforms. The onset and the end of the TBU was set according to the beginning and the ending points of the second formant (F2), and the TBU was labeled for tone position (CT, FT, or NFT), tone category, and segmental composition. Figure 3.3 presents two examples taken from the production of "父" [pe] and "胶水" [ka tsui] by a female speaker CLH of the Raoping dialect, illustrating the segmentation and labeling of monosyllabic and disyllabic tokens respectively.

F_0 values and durations were automatically extracted from the labeled audio files using VoiceSauce (Shue, et al., 2011), a MATLAB-implemented application. F_0 were measured at 11 equidistant sampling points in the TBU and calculated using the STRAIGHT algorithm (Kawahara, Masuda-Katsuse, & de Cheveigné, 1999). In cases where the pitch tracking failed, the circumstances were noted (such as glottalization or breathiness), and these tokens were manually double checked in Praat. Statistical analyses and data visualization were performed using R (R Development Core Team, 2015) and R Studio (RStudio Team, 2015).

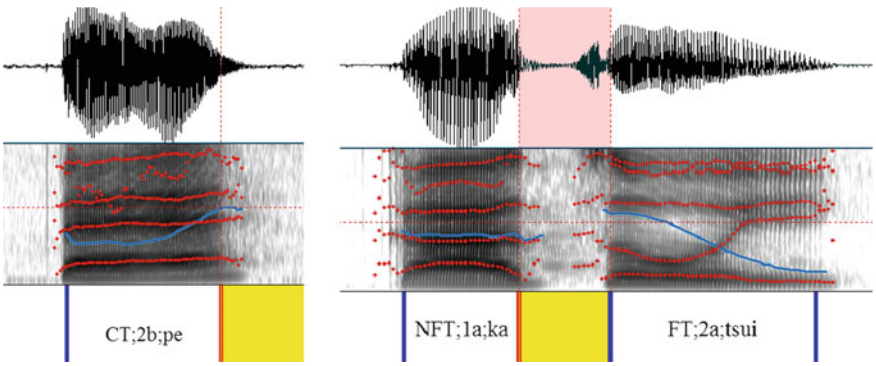

Fig. 3.3 Examples of TBU segmentation and labeling

For the citation tone experiment, mean F_0 values and mean durations for each tone were calculated for each participant. The average F_0 curves (plotted against average duration) of CLH's CTs are given in Fig. 3.4 , based on which a tonal transcription can be done (see next subsection).

As for the disyllabic tone sandhi experiment, first we need to deal with the data of each NFT block. As indicated above, the disyllable session was divided into 8 blocks, and in each block the first syllable carried the same NFT while the second syllable varied across the 8 FTs. The F_0 tracks of the "T1a + __" block, each averaged over five tokens produced by speaker CLH, are given in Fig. 3.5.

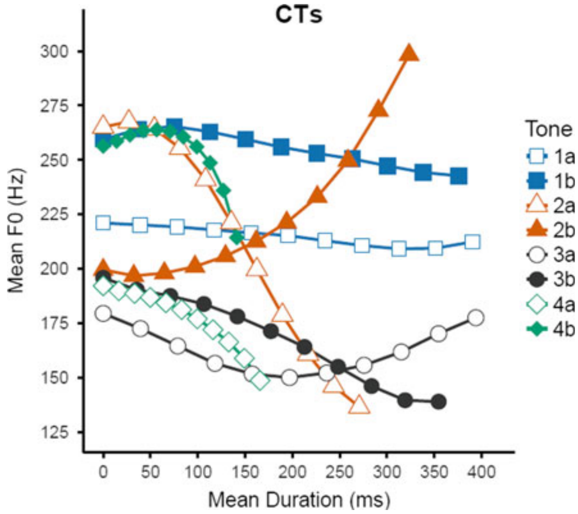

Fig. 3.4 Raoping's CTs, produced by speaker CLH

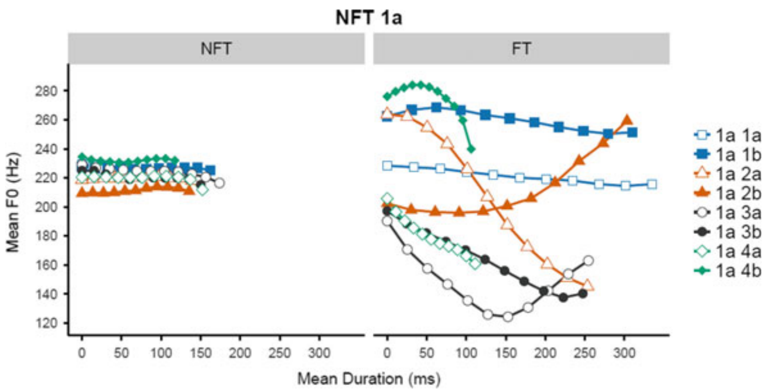

Fig. 3.5 "T1a + __" of Raoping. Produced by speaker CLH

Comparing the above figure with Fig. 3.4, it is clear that in "T1a + __" the FTs are the same as the CTs. As for the NFT, the eight F_0 tracks of NFT 1a make up a bunch of mid level curves. No evident tonal split is attested in this case. The acoustic results of other 7 blocks are given in Fig. 3.6.

From the above graphs, we can see that the FTs remain basically the same across different NFT blocks, but note that the onsets of FTs are significantly influenced by the preceding NFTs, showing an effect of preservatory assimilation (a.k.a. the carryover effect). Similarly, the offsets of some NFTs (NFT 2b for instance) are also influenced by the following FTs. These are gradient phonetic variations. At phonological level, the tone sandhi of Raoping is context-free (in the next chapter I will present more examples of context-free and context-dependent tone sandhi).

To bring the results of different NFT blocks together, an additional normalization procedure is needed. Because the disyllable session as a whole took at least 45 min to finish, it was difficult for untrained speakers to maintain a stable performance throughout such a long time. Although the FT systems across different NFT blocks were basically the same, the exact F_0 ranges of each FT system were not kept constant. Fig. 3.7 shows the distribution of the F_0 values of the long FTs in each NFT block based on the mean F_0 curves of CLH.

In order to eliminate the random fluctuation of pitch change, I choose to normalize the F0 values by converting them to block-specific logarithmic z-scores (LZ). The following subsection describes the method used to normalize the F_0 values and durations of SM tone sandhi.

3.2.5 *Normalization*

LZ normalization expresses a F_0 value in terms of how much it is above or below the average logarithmic F_0 (Zhu, 2005: 50–70, 2010: 286–291). When normalizing citation tones, normally we take the mean F_0 of all tones to calculate the average logarithmic F0. The LZ conversion formula for citation tones is given below:

$$z_i' = \frac{y_i - m_y}{s_y} = \frac{\log_{10} x_i - \frac{1}{n}\sum_{i=1}^{n}\log_{10} x_i}{\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(\log_{10} x_i - \frac{1}{n}\sum_{i=1}^{n}\log_{10} x_i\right)^2}}$$

When normalizing tone sandhi, however, I didn't use the mean F_0 of all tonal combinations to calculate the average logarithmic F_0, although this is a common method in previous tone sandhi studies (see, for example, You & Yang, 2001). Instead, each NFT block was processed individually. Within each NFT block, the average logarithmic F_0 was calculated from the mean F_0 of the long FTs. Put another way, the F_0 values of NFTs and short FTs were excluded when calculating the average logarithmic F_0. Then, this mean log F_0 was used for converting the F_0 values of all

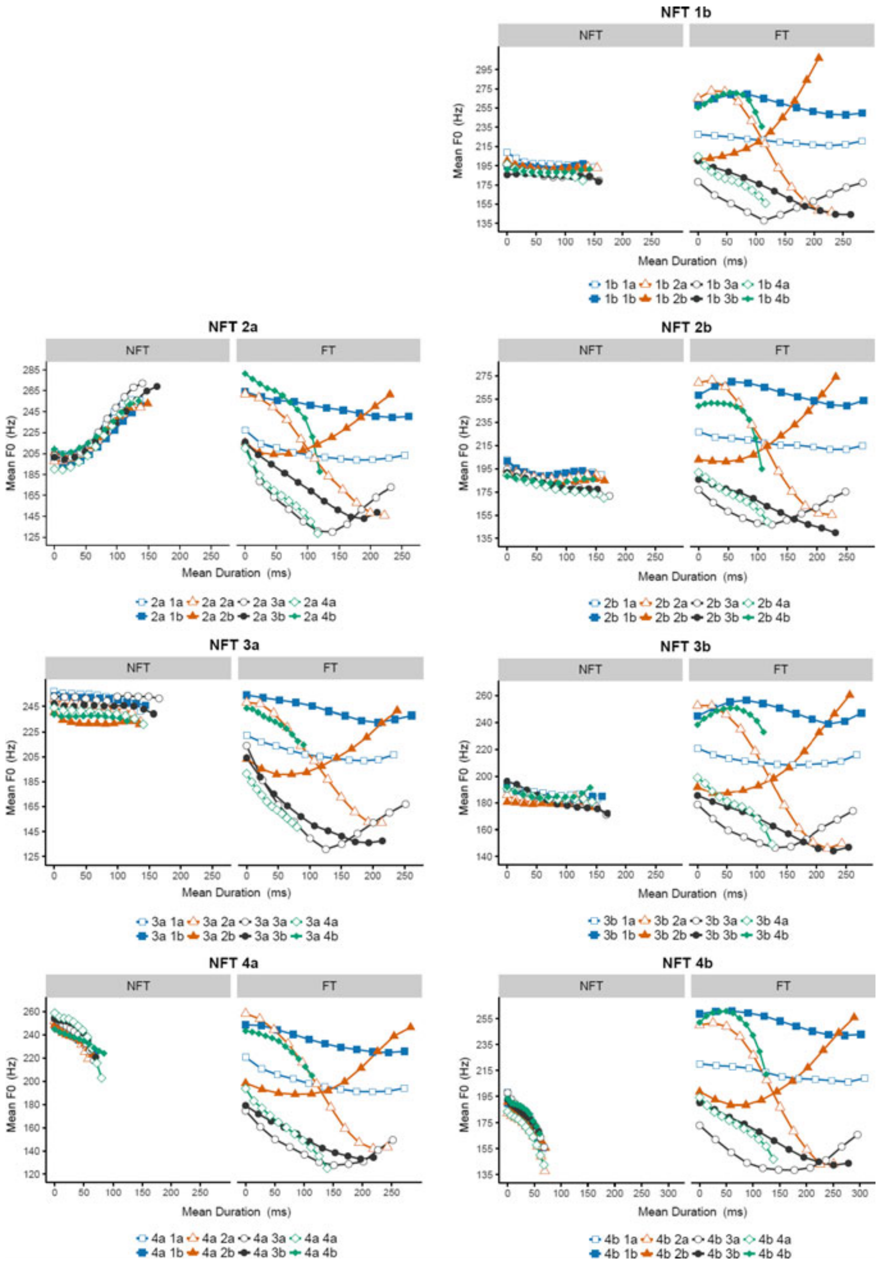

Fig. 3.6 The 8 NFTs, each followed by 8 FTs, of Raoping, produced by speaker CLH

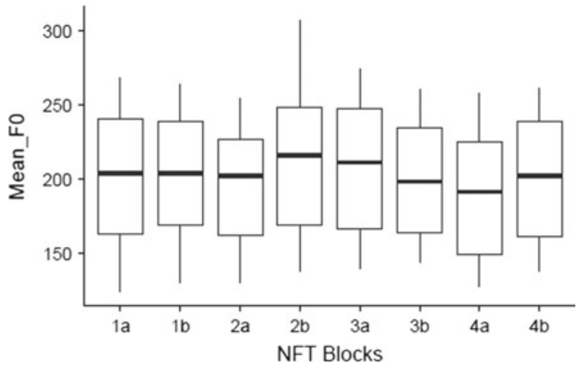

Fig. 3.7 Boxplot comparing the distribution of the F_0 of the FTs across different NFT blocks, produced by the Raoping speaker CLH

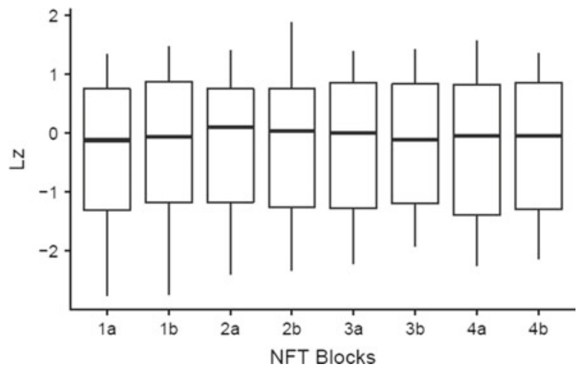

Fig. 3.8 Boxplot comparing the distribution of the LZ scores of the FTs across different NFT blocks, produced by the Raoping speaker CLH

the tones in the block into logarithmic z-scores (LZ). In the same vein, the average duration of the long FTs in a NFT block was used for calculating the relative duration of all the tones in the NFT block.

The effect of this FT-based normalization can be seen in Fig. 3.8. It is clear that after the normalization, the medians and the interquartile ranges (IQR) of the 8 FT blocks are in a better alignment with each other.

A more detailed justification for this FT-based normalization procedure can be found in Lin (2015).

Now, the LZs of different NFT blocks can be pooled together to calculate the average LZ and the average relative duration for each NFT and FT. The mean LZ curves, plotted against mean relative duration, of the NFTs and the FTs produced by the Raoping speaker CLH are given in Fig. 3.9. The result of CTs normalization is also presented here for ease of comparison (short tones were also excluded when normalizing the F_0 and the duration of CTs).

The results show that, in Raoping, NFT 1b, 2b, and 3b neutralize into a low level tone. Participants confirmed that in Raoping, "棋术[ki^{T1b} sut^{T4b}], *chess skill*" and "技术[ki^{T2b}–sut^{T4b}], *technique*" are completely homophonic, "池主[ti^{T1b} tsu^{T2a}], *owner of pond*" and "地主[ti^{T3b} – tsu^{T2a}], landlord" are also completely homophonic.

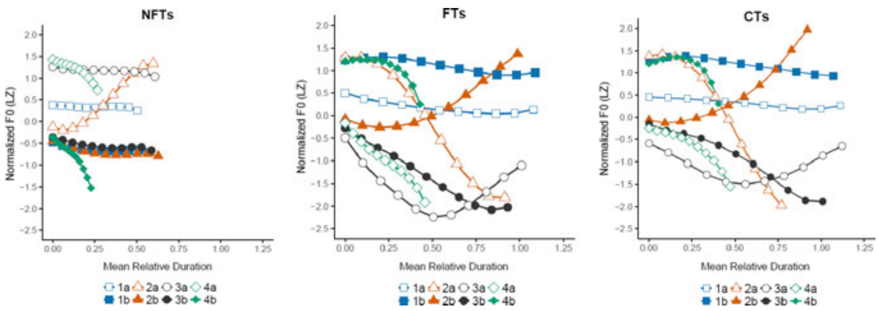

Fig. 3.9 LZ curves of RP NFTs, FTs and CTs, produced by CLH

Table 3.3 Raoping's tones

	1a	2a	3a	1b	2b	3b	4a	4b
NFT	44	35	55	33			54	32
FT/CT	44	53	22	55	35	32	32	54

3.2.6 Notation

As mentioned in Sect. 2.1, this book adopts the "Multi-Register and Four-Level" (RL) tone model to transcribe the values of tones. Therefore, for a tone system without contrastive phonation types, only four levels of pitch height (from 5 to 2) are used. The CTs, FTs, and NFTs of Raoping are transcribed as in Table 3.3.

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Chapter 4
Tonal Changes in Chao-Shan

This chapter presents the results of the tone experiments of the 6 Chao-Shan varieties, and discusses the diachronic tonal changes that these 6 Chao-Shan varieties have undergone.

Section 4.1 presents the results of the citation tone experiments, which show that the 6 Chao-Shan varieties do not differ markedly in their CTs, and there is no neutralization of tonal contrasts in CTs.

Section 4.2 presents the results of the tone sandhi experiments. The tone sandhi patterns of the 6 Chao-Shan varieties can be divided into two types: context-free tone sandhi (as the tone sandhi of Xiamen/Taiwanese) and context-conditioned tone sandhi (as the T3 sandhi of Mandarin).

Sections 4.3 and 4.4 deal with the changes of FTs and the changes of NFTs respectively. As the 6 Chao-Shan varieties do not differ much in their CTs/FTs, the focus of this chapter is the patterning of NFTs and how NFTs change diachronically. It is found that Chao-Shan's NFTs have undergone three kinds of tonal change: tonal neutralization, context-free tonal shift, and context-conditioned tonal split. I argue that all of the three tonal changes follow the tendency of prosodic-driven tone reduction described in Chap. 2, and therefore they are not essentially different from each other.

The locations of the 6 Chao-Shan varieties under study are shown in Fig. 4.1.

Q. Lin, *The Diachrony of Tone Sandhi*, Frontiers in Chinese Linguistics 6,
https://doi.org/10.1007/978-981-13-1939-6_4

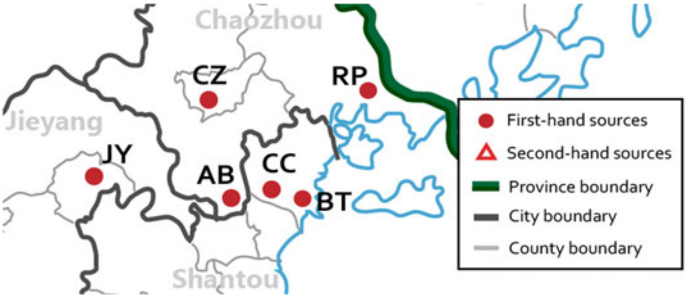

Fig. 4.1 Locations of the 6 Chao-Shan SM varieties under study

4.1 The Citation Tones of 6 Chao-Shan Varieties

The syllable structures of these 6 Chao-Shan varieties are the same: CGVX, or [initial [onglide [nucleus + coda]]]. Only nasals, glides and stops [p t k ʔ] can occur as codas. Phonological differences among these varieties lie mainly in the number and composition of rhymes, which are not large enough to cause any difference to the tonal system. For details on the phonology of these 6 Chao-Shan varieties, see Lin (1996), Lin and Chen (1996).

The following discussion about the tones of these 6 Chao-Shan varieties is based upon the results of my tone production experiments. For expository simplicity, I choose one speaker as the representative for each locality, and his/her acoustic results will be presented in full detail. Other speakers' results will be presented when additional information is needed. Earlier auditory-based transcriptions will not be discussed here, because it is very difficult, if not impossible, to identify the nature of the differences between prior impressionistic transcriptions and the current acoustic results,[1] and they offer no further information about the changes of tones.

Some personal information about the participants of the tone production experiments is given below:

(1) Raoping (RP): 3 speakers took part in the experiment. All of them were born and bred in the Huanggang town (the administrative center) of the Raoping county. The representative speaker is CLH, who was a 56-year-old female at the time of recording.
(2) Batou (BT): 2 speakers took part in the experiment. The representative speaker is WMX, who was a 24-year-old female at the time of recording.
(3) Chengcheng (CC): 2 speakers took part in the experiment. The representative speaker is CMF, who was a 42-year-old female at the time of recording.

[1]It could be owing to speaker variation, historical change, the carefulness of the transcription, or the competence of the transcribers.

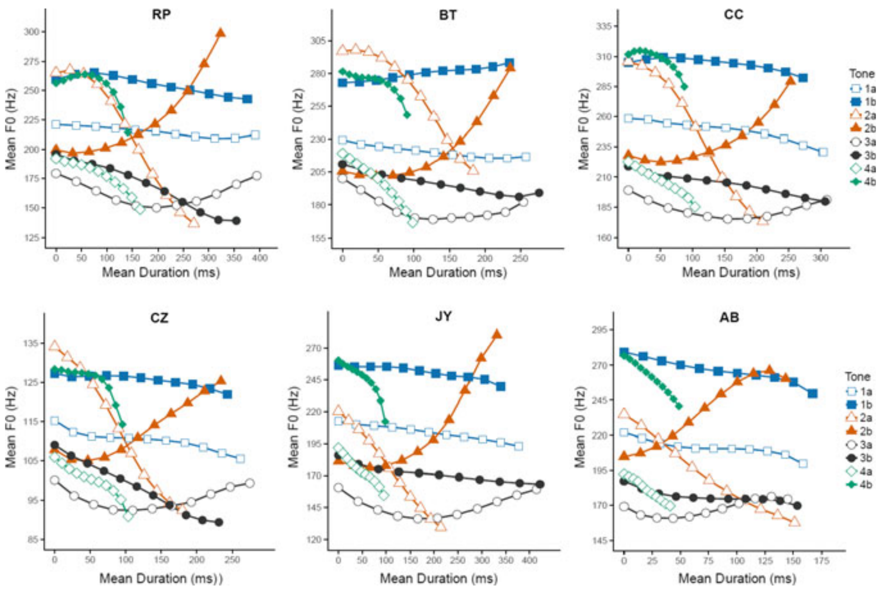

Fig. 4.2 F_0 curves of the CTs of 6 Chao-Shan varieties

(4) Chaozhou (CZ): 3 speakers took part in the experiment. All of them were born and bred in the Xiangqiao district (the administrative center) of the Chaozhou city. The representative speaker is SJQ, who was a 22-year-old male at the time of recording.

(5) Jieyang (JY): 3 speakers took part in the experiment. All of them were born and bred in the Rongcheng district (the administrative center) of the Jieyang city. The representative speaker is LHR, who was a 35-year-old female at the time of recording.

(6) Anbu (AB): 3 speakers took part in the experiment. All of them were born and bred in the Anbu town (the administrative center) of the Anbu county. The representative speaker is LLW, who was a 60-year-old female at the time of recording.

The results of the citation tone experiment are presented in Fig. 4.2.

A quick glance at the above figure reveals that the citation tone system of the 6 dialects are very similar. In each of the varieties, there are a mid level tone T1a /44/ (the slightly falling contour is owing to the declination effect as the words were read in isolation), a high rising tone T2b /35/, a bottom level tone T3a /22/, a high short tone T4b /54/, and a low short tone T4a /32/. T3a /22/ is the lowest tone in CTs and it is often produced with creaky voice, especially in the middle third of the tone, and therefore its F_0 contour is relatively unstable. The degree of creakiness varies from speaker to speaker.

Table 4.1 CTs of 6 Chao-Shan varieties

	1a	2a	3a	1b	2b	3b	4a	4b
RP	44	53	22	55	35	**32**	32	54
BT	44	53	22	55	35	33	32	54
CZ	44	53	22	55	35	**32**	32	54
CC	44	53	22	55	35	33	32	54
JY	44	**42**	22	55	35	33	32	54
AB	44	**42**	22	55	35	33	32	54

T2a is a high falling tone /53/ in Raoping, Batou, Chengcheng, and ChaoZhou; and it is a mid falling tone /42/ in Jieyang and Anbu. T3b is a low falling tone /32/ in Raoping and Chaozhou; and it is a low level tone /33/ in other places. As the variation between high falling and mid falling and the variation between low falling and low level are relatively small, it is possible that we find such variations in one locality if we had a large sample of speakers of this locality.

T1b is a high level tone /55/ in most places, but it is realized with a slightly rising contour in Batou. The other speaker of Batou[2] also produced CT 1b with a slightly rising contour, and such phenomenon does not happen to the speakers of other varieties. It seems possible that the rising feature of T1b is indeed a regional characteristics of Batou, but the range of this rising is so small that it even does not approximate a typical ‘slight rising tone’ /45/. Empirically speaking, for a slight rising tone /45/, we would expect its onset to be near the onset of /44/ (cf. Cun & Zhu, 2013), which is not the case in Batou. Further investigation is needed to determine the status of this rising feature of T1b. For now, the T1b of Batou is treated as a high level tone.

To summarize, the 6 Chao-Shan varieties do not differ markedly in their CTs. Only T2a and T3b show a small extent of variation. The CTs of the 6 Chao-Shan varieties are transcribed as follows (Table 4.1).

Regarding the variation of CT 2a, I suppose that CT 2a was originally a high falling tone /53/ in all these 6 Chao-Shan varieties and later became a mid falling tone /42/ in Jieyang and Anbu, for reasons which will be clarified later. The change of CT 3b (32–33) seems to have no direct causal relationship with the change of CT 2a, and by now we cannot say for certain which value of CT 3b is more recent.

[2]The other speaker of Batou, LY, is also a young female, aged 22 at the time of recording. The two Batou speakers are complete strangers.

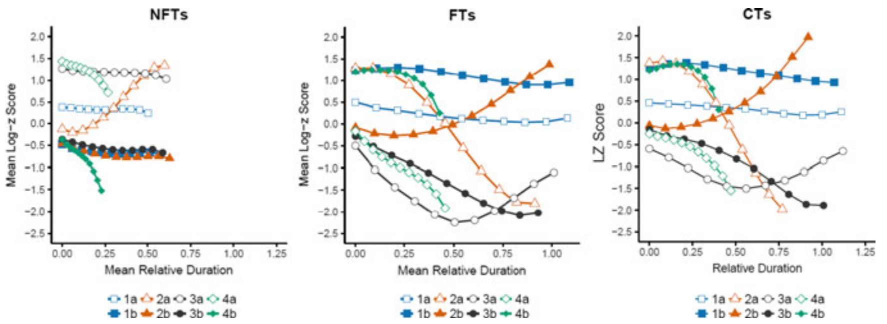

Fig. 4.3 Average LZ curves of the NFTs, FTs and CTs of Raoping, produced by speaker CLH

Table 4.2 Raoping tones

	1a	2a	3a	1b	2b	3b	4a	4b
NFT	44	35	55	33			54	32
FT/CT	44	53	22	55	35	32	32	54

4.2 The Tone Sandhi Patterns of 6 Chao-Shan Varieties

This section reports the results of the disyllabic tone experiments on the 6 Chao-Shan varieties.

4.2.1 Raoping (RP)

The results of the Raoping tone experiment have already been presented in Sects. 3.2.4 and 3.3.5. The average LZ curves of the NFTs, FTs, and CTs are reproduced in Fig. 4.3. The mean duration of the long CTs is 351 ms (SD = 47 ms), and the mean F_0 of the long CTs is 207 Hz (SD = 41 Hz). The mean duration of the long FTs is 258 ms (SD = 29 ms), and the mean F_0 of the long FTs is 200 Hz (SD = 40 Hz).

Based upon the RL model, Raoping tones are transcribed as follows (Table 4.2).

4.2.2 Batou (BT)

The average F_0 curves, plotted against average duration, of the 8 NFT blocks produced by the female Batou speaker WMX are given in Fig. 4.4. This speaker produced FT 3a with intense creaky voice, and thus the F_0 curves of FT 3a do not reflect the actual F_0 measurements. But the measurement of its duration is reliable.

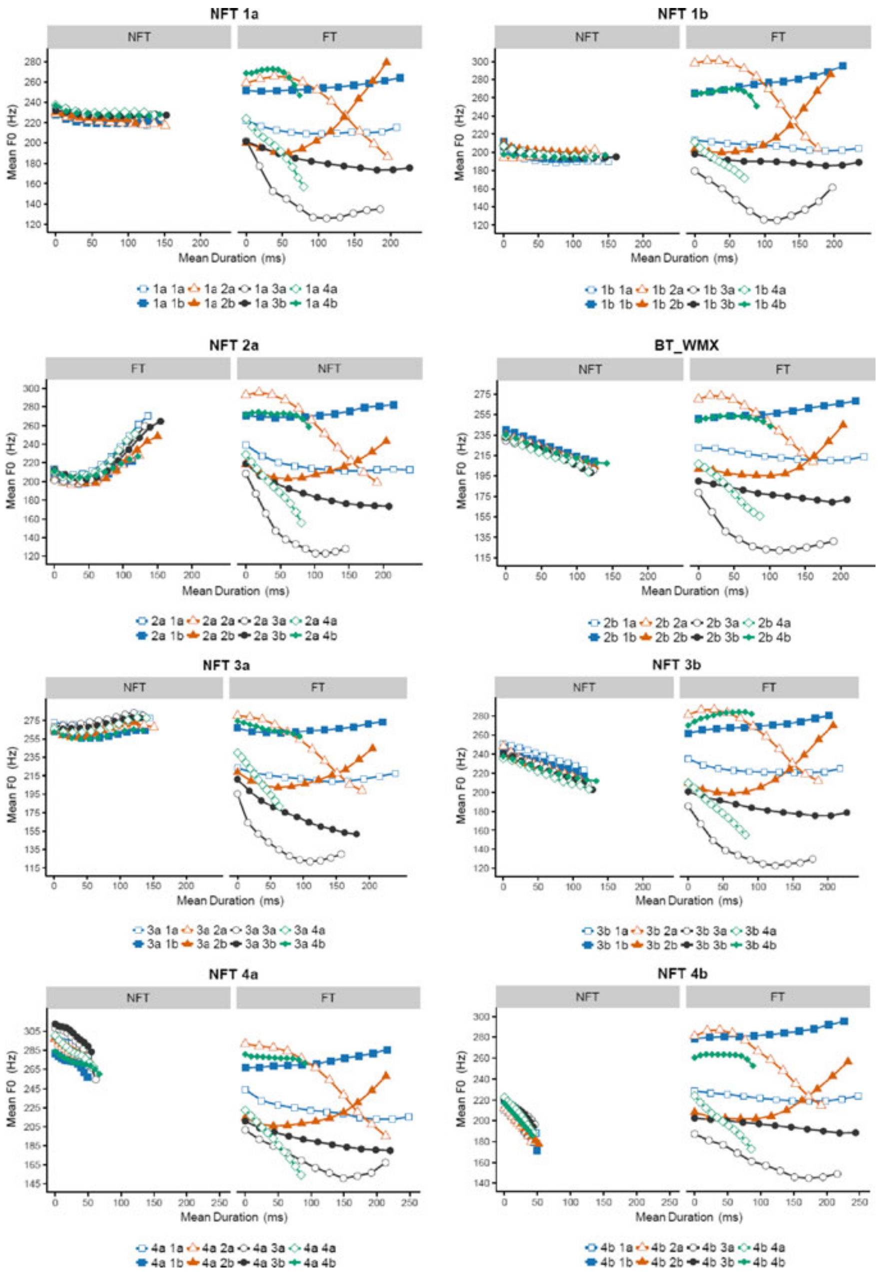

Fig. 4.4 The 8 NFTs, each followed by 8 FTs, of Batou, produced by speaker WMX

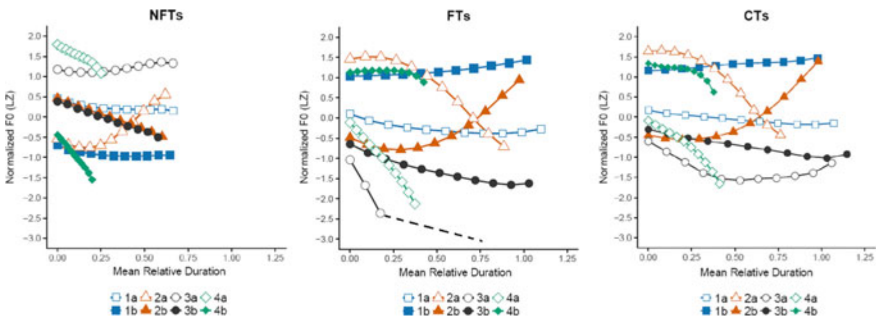

Fig. 4.5 Average LZ curves of the NFTs, FTs, and CTs of Batou, produced by speaker WMX

Table 4.3 Batou's tones

	1a	2a	3a	1b	2b	3b	4a	4b
NFT	44	35	55	33	43		54	32
FT/CT	44	53	22	55	35	33	32	54

Like the tone sandhi of Raoping, Batou's tone sandhi is also context-free, no contextual tonal split is attested, although the effect of tonal coarticulation is obvious in same cases.

Figure 4.5 displays the average LZ curves of the NFTs, FTs, and CTs of Batou from left to right. The mean duration of the long CTs is 245 ms (SD = 33 ms), and the mean F_0 of the long CTs is 226 Hz (SD = 42 Hz). The mean duration of the long FTs is 258 ms (SD = 29 ms), and the mean F_0 of the long FTs is 200 Hz (SD = 40 Hz).

It is evident that, in Batou, FTs and CTs are basically the same. Regarding the NFTs, Batou's NFTs comprise three level tones (NFT 3a, NFT 1a, and NFT 1b), one rising tone (NFT 2a), and two short tones (NFT 4a and NFT 4b). NFT 2b and 3b have neutralized into a mid falling tone, which is different from the tone sandhi of Raoping, where NFT 1b, 2b, and 3b all neutralized into a low level tone.

Based upon the RL model, Batou tones are transcribed as follows (Table 4.3).

4.2.3 Chengcheng (CC)

The average F_0 curves, plotted against average duration, of the 8 NFT blocks produced by the female Chengcheng speaker CMF are given in Fig. 4.6.

Obviously, in Chengcheng the behavior of NFT 2a, 3a and 4a are radically different from other NFTs—they have undergone categorically tonal splits and each has two or three context-conditioned allotones. NFT 2a is a high rising tone when followed by FT 1b, 2a and 4b, and it is a slight mid rising tone when followed by other FTs.

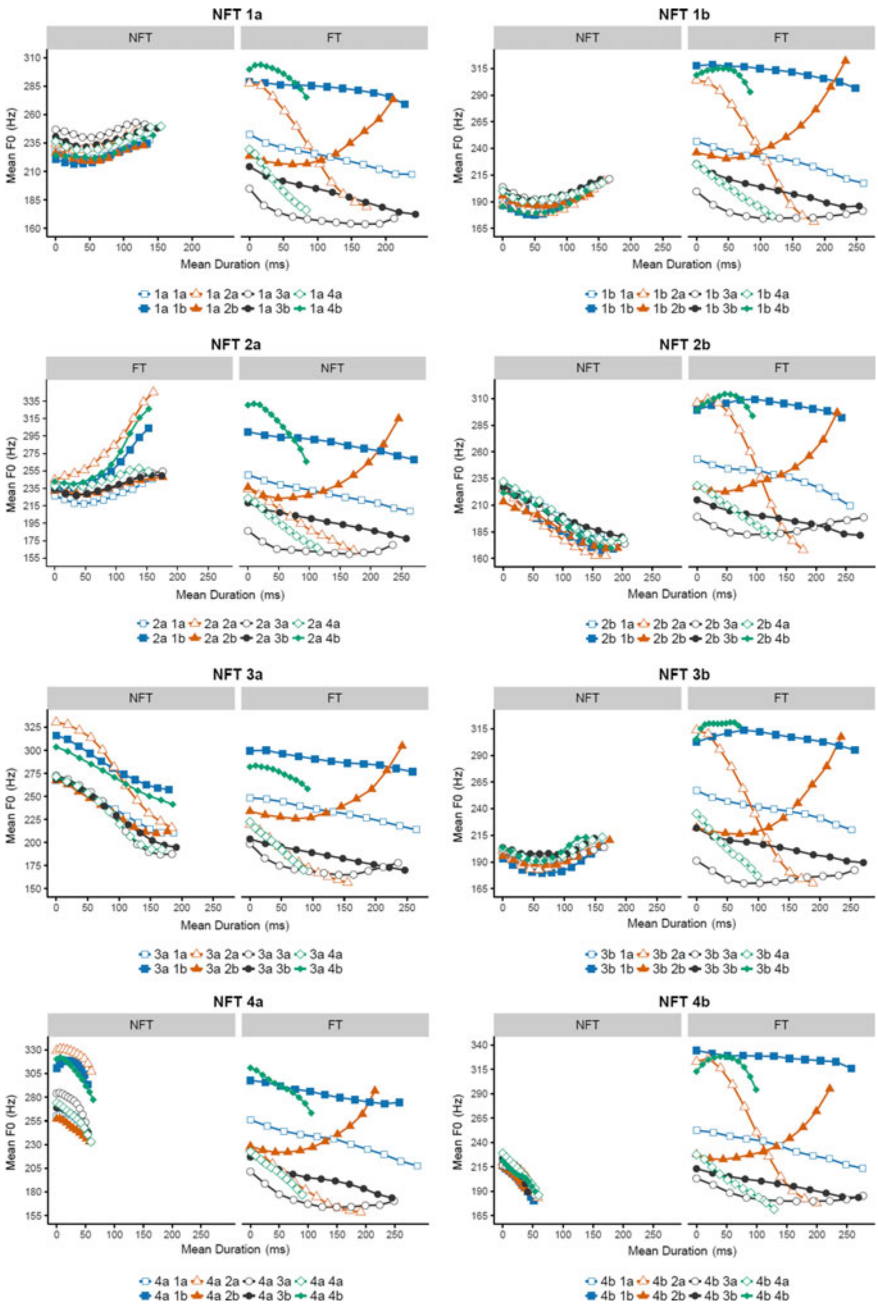

Fig. 4.6 The 8 NFTs, each followed by 8 FTs, of Chengcheng, produced by speaker CMF

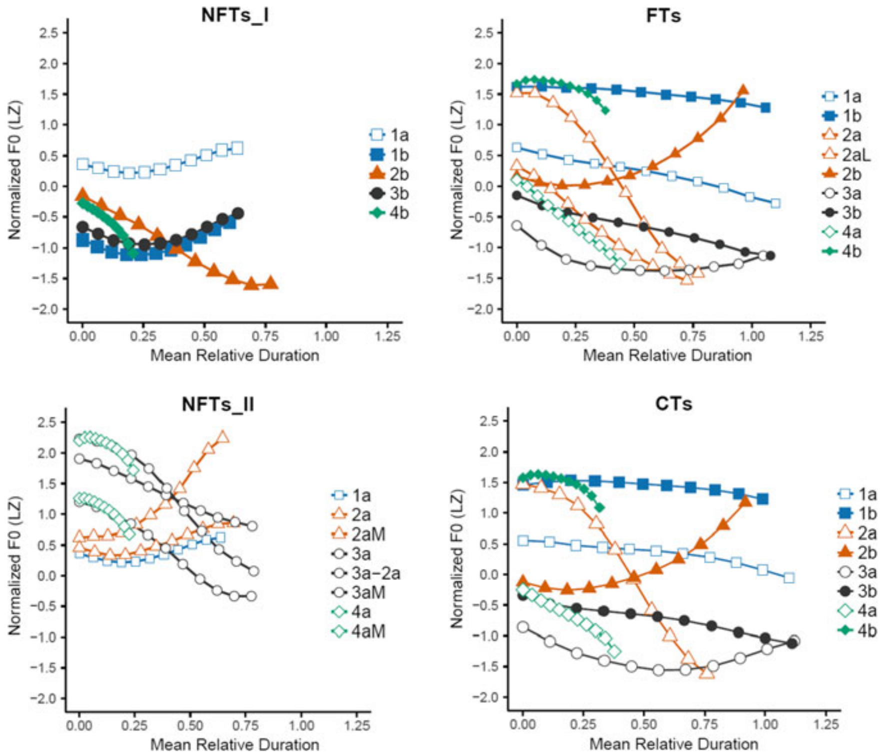

Fig. 4.7 Average LZ curves of the NFTs, FTs and CTs of Chengcheng, produced by speaker CMF

NFT 3a is a high straight falling tone when followed by FT 1b, a high slight falling tone when followed by FT 2a and 4b, and a mid slight falling tone when followed by other FTs. NFT 4a is a high short tone when followed by FT 1b, 2a and 4b, and it is a mid short tone when followed by other FTs.

Furthermore, FT 2a also exhibits contextual tonal split: it is a low falling tone when preceded by NFT 2a, 3a, 4a—the NFTs that exhibit contextual tonal split, and it is a high falling tone when preceded by other NFTs.

Figure 4.7 displays the average LZ curves of the NFTs, FTs, and CTs of Chengcheng. For ease of identification, the NFTs are separated into two groups—the unsplit group (NFTs_I) and the split group (NFTs_II), and they are presented in two separate graphs. NFT 1a is plotted in both graphs for ease of comparison. The mean duration of the long CTs is 276 ms (SD = 39 ms), and the mean F0 of the long CTs is 238 Hz (SD = 44 Hz). The mean duration of the long FTs is 237 ms (SD = 32 ms), and the mean F_0 of the long FTs is 230 Hz (SD = 48 Hz).

We can see that Chengcheng's NFT 1b and 3b have neutralized into a low rising tone. Besides, NFT 1a has become a slight rising tone and neutralized with the lower allotone of NFT 2a.

Table 4.4 Chengcheng's tones

	1a	2a	3a	1b	2b	3b	4a	4b
NFT	34	35/34	54/53/43	23	32	=1b	54/43	32
FT	44	53/32	22	55	35	33	32	54
CT	44	53	22	55	35	33	32	54

Based upon the RL model, Chengcheng tones are transcribed as follows (Table 4.4).

The lower allotone of FT 2a is transcribed here as a low falling tone /32/, but strictly speaking, its onset lies between mid falling /42/ and low falling /32/.

The conditions of the tonal splits are listed below:

(1) The splits of NFT 2a, 3a, and 4a in Chengcheng

NFT 2a	>/35/ before /55/, /54/, and /32/
	>/34/ before /44/, /35/, /33/, /32/, /23/
NFT 4a	>/54/ before /55/, /54/, and /32/
	>/43/ before /44/, /35/, /33/, /32/, /23/
NFT 3a	>/53/ before /32/
	>/54/ before /55/ and /54/
	>/43/ before /44/, /35/, /33/, /32/, /23/

(2) The split of FT 2a in Chengcheng

FT 2a	>/53/ after /34/, /32/, /32/, /23/
	>/32/ after /35/, /53/ and /54/

4.2.4 Chaozhou (CZ)

The average F_0 curves, plotted against average duration, of the 8 NFT blocks produced by the male Chaozhou speaker SJQ are given in Fig. 4.8.

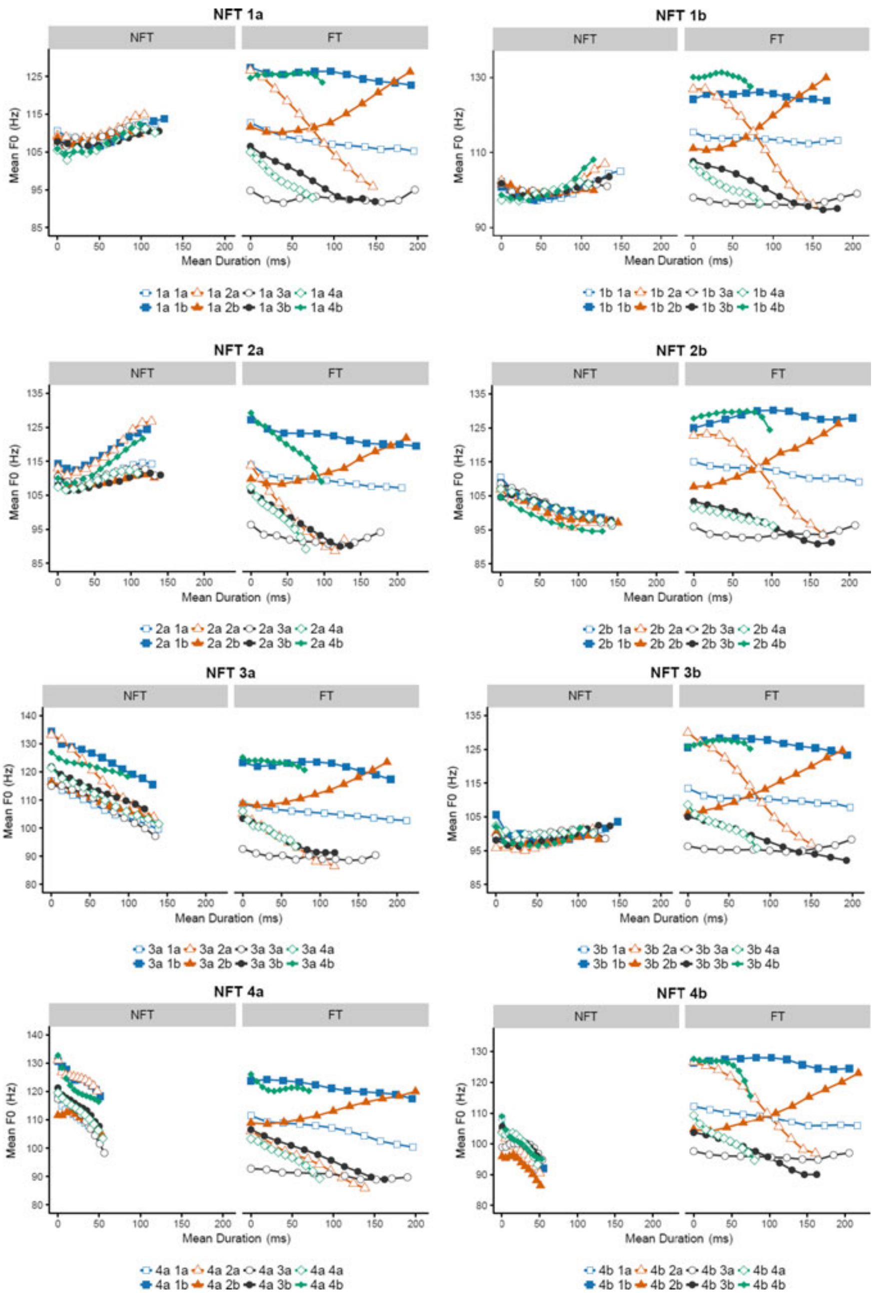

Fig. 4.8 The 8 NFTs, each followed by 8 FTs, of Chaozhou, produced by speaker SJQ

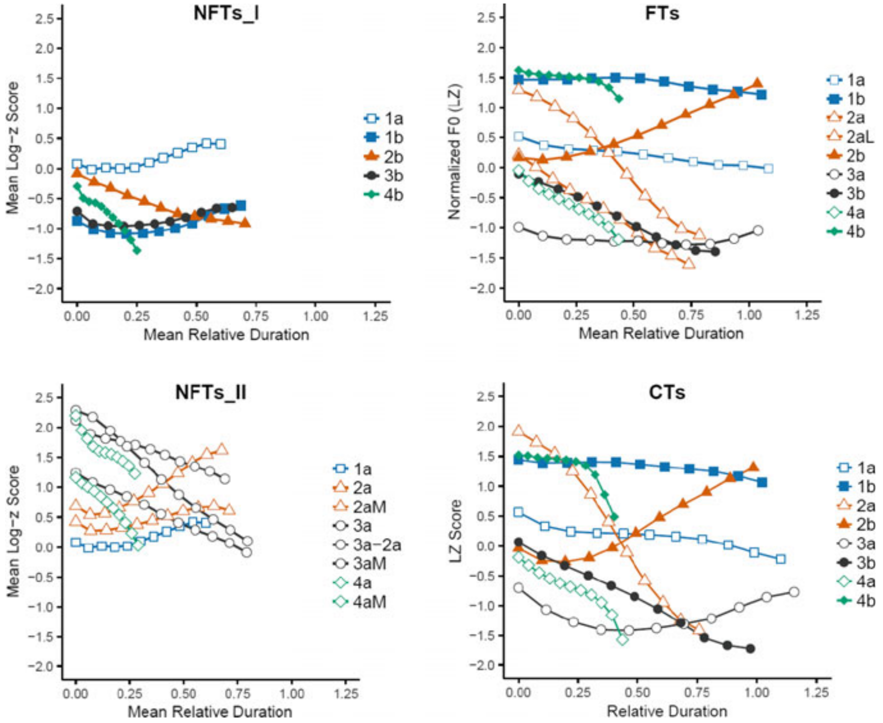

Fig. 4.9 Average LZ curves of the NFTs, FTs, and CTs of Chaozhou, produced by speaker SJQ

The NFTs of Chaozhou are the same as the NFTs of Chengcheng. NFT 2a, 3a and 4a exhibit context-conditioned tonal splits while other NFTs are context-insensitive. FT 2a is a low falling tone when following NFT 2a/3a/4a, and it is a high falling tone when following other NFTs.

But notice that the FT/CT 3b of Chaozhou is a low falling tone, and therefore in terms of pitch contour it is likely that the lower allotone of FT 2a is neutralized with FT 3b.

Figure 4.9 displays the average LZ curves of the NFTs, FTs, and CTs of CZ, plotted against relative duration. The mean duration of the long CTs is 237 ms (SD = 33 ms), and the mean F_0 of the long CTs is 209 Hz (SD = 16 Hz). The mean duration of the long FTs is 180 ms (SD = 28 ms), and the mean F_0 of the long FTs is 108 Hz (SD = 12 Hz).

Based upon the RL model, Chaozhou tones are transcribed as follows (Table 4.5).

The conditions of Chaozhou's tonal splits are the same as those of Chengcheng.

Table 4.5 Chaozhou's tones

	1a	2a	3a	1b	2b	3b	4a	4b
NFT	34	35/34	54/53/43	23	32	=1b	54/43	32
FT	44	53/32	22	55	35	32	32	54
CT	44	53	22	55	35	32	32	54

4.2.5 Jieyang (JY)

The average F_0 curves, plotted against average duration, of the 8 NFT blocks produced by the female Jieyang speaker LHR are given in Fig. 4.10.

Again, the NFT 2a, 3a and 4a of Jieyang exhibit context-conditioned tonal splits while other NFTs are context-insensitive. However, in Jieyang the NFT 1a remains as a mid level tone, and therefore there is no neutralization between NFT 1a and the lower allotone of NFT 2a.

Another thing worth noting is the split of FT 2a. As stated previously, Jieyang's CT 2a has become a mid falling tone /42/. Correspondingly, the higher allotone of FT 2a also became a mid falling tone. In the meanwhile, the lower allotone of FT 2a become even lower—it became a typical low falling tone /32/. The duration of this lower allotone of FT 2a looks very short because it often ended with creaky voice, and the creaky portion is not shown by the pitch tracking. It is possible that, in the production of speaker LHR, the lower allotone of FT 2a has become a Lower register tone.

Figure 4.11 displays the average LZ curves of the NFTs, FTs, and CTs of JY, plotted against relative duration. The mean duration of the long CTs is 349 ms (SD = 76 ms), and the mean F_0 of the long CTs is 192 Hz (SD = 38 Hz). The mean duration of the long FTs is 299 ms (SD = 57 ms), and the mean F_0 of the long FTs is 188 Hz (SD = 38 Hz).

Based upon the RL model, Jieyang tones are transcribed as follows (Table 4.6).

The conditions of Jieyang tonal splits are similar to those of Chengcheng.

4.2.6 Anbu (AB)

The average F_0 curves, plotted against average duration, of the 8 NFT blocks produced by the female Anbu speaker LLW are given in Fig. 4.12.

The acoustic results of Anbu tones reveal two important differences between the tonal splits of Anbu and the above-discussed tonal splits of other Chao-Shan varieties.

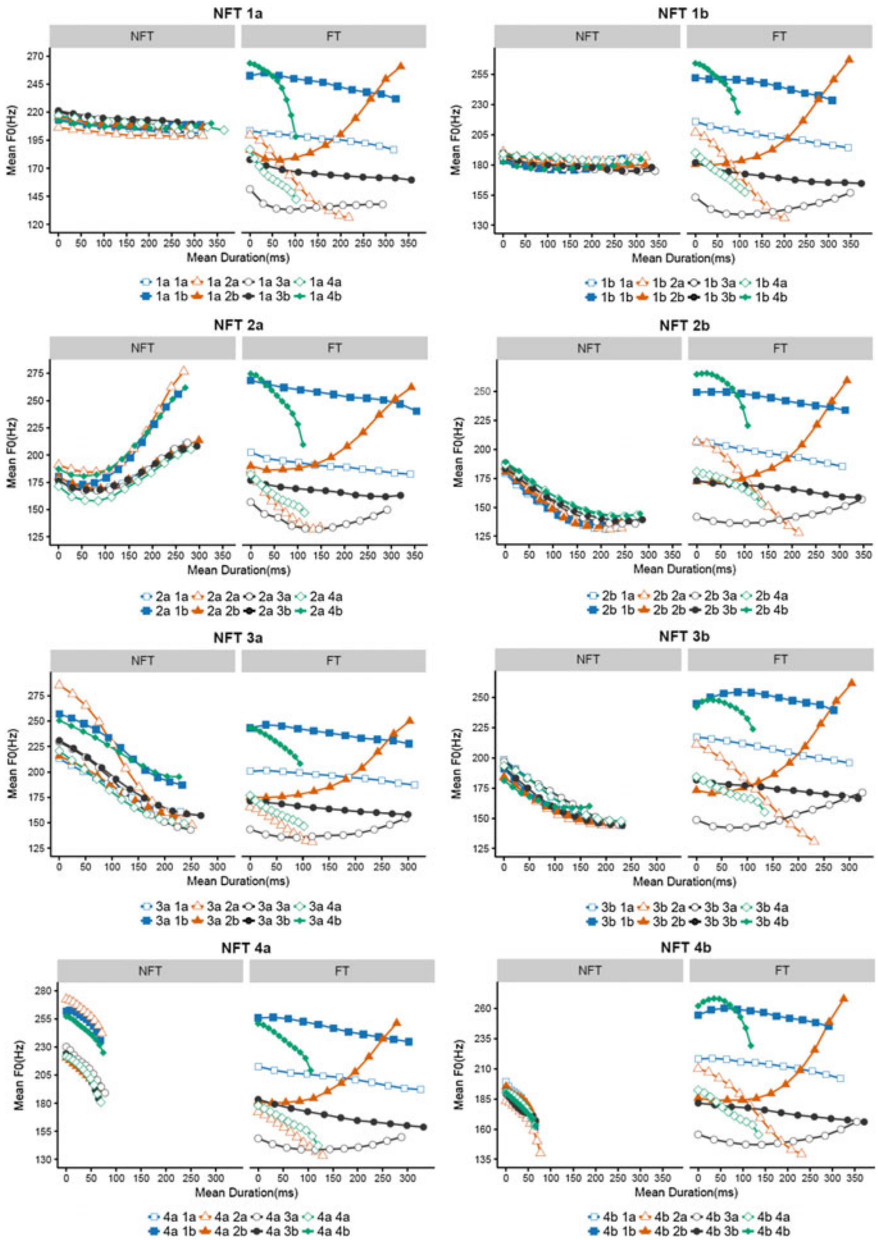

Fig. 4.10 The 8 NFTs, each followed by 8 FTs, of Jieyang, produced by speaker LHR

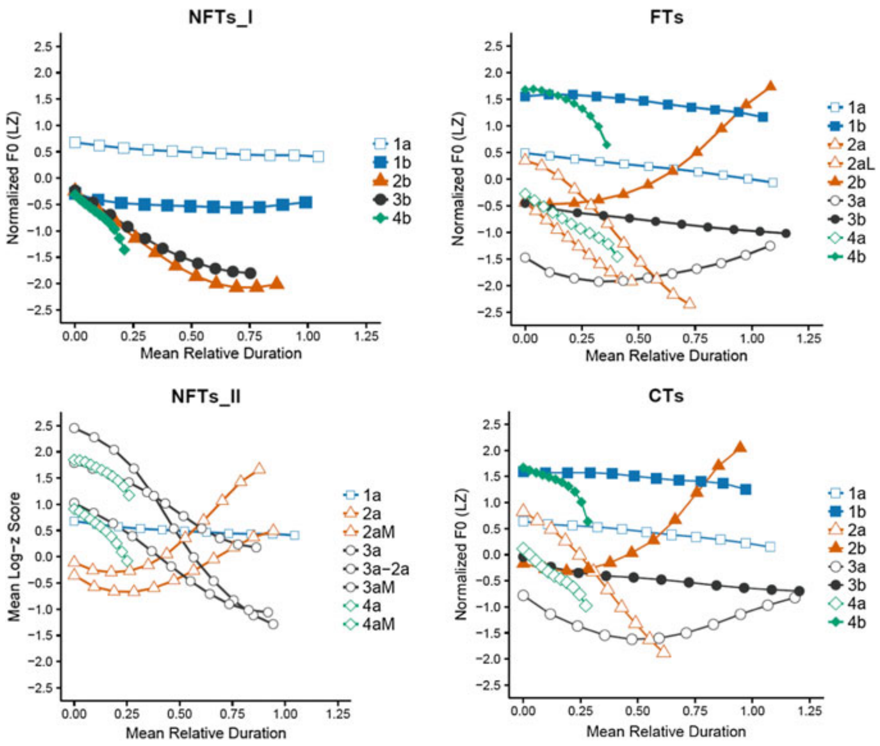

Fig. 4.11 Average LZ curves of the NFTs, FTs and CTs of Jieyang, produced by speaker LHR

Table 4.6 Jieyang's tones

	1a	2a	3a	1b	2b	3b	4a	4b
NFT	44	35/34	54/53/43	33	32		54/43	32
FT	44	42/32	22	55	35	33	32	54
CT	44	42	22	55	35	33	32	54

First of all, in Anbu, NFT 1b also exhibits context-conditioned tonal splits besides NFT 2a, 3a and 4a. Anbu's NFT 1b is a low rising tone when followed by FT 1a, 1b, 2a, 4b, and it is a low rising tone when followed by other FTs. Note that the conditions of NFT 1b split are different from those of NFT 2a/3a/4a.

Secondly, in the dissyllabic combination "T3a + T2a", Anbu's NFT 3a realizes almost like a high level tone, while in other Chao-Shan varieties the NFT 3a here is a straight high falling tone.

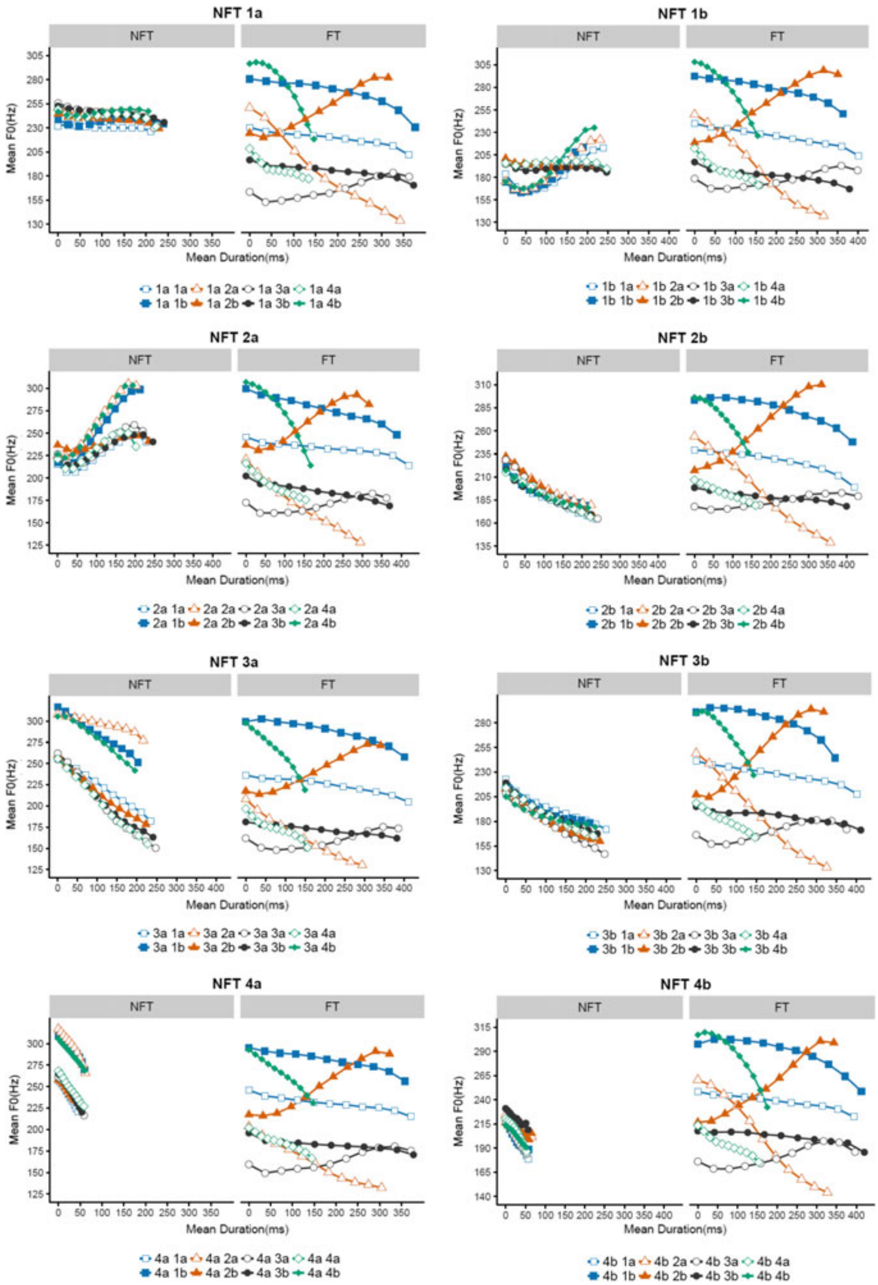

Fig. 4.12 The 8 NFTs, each followed by 8 FTs, of Anbu, produced by speaker LLW

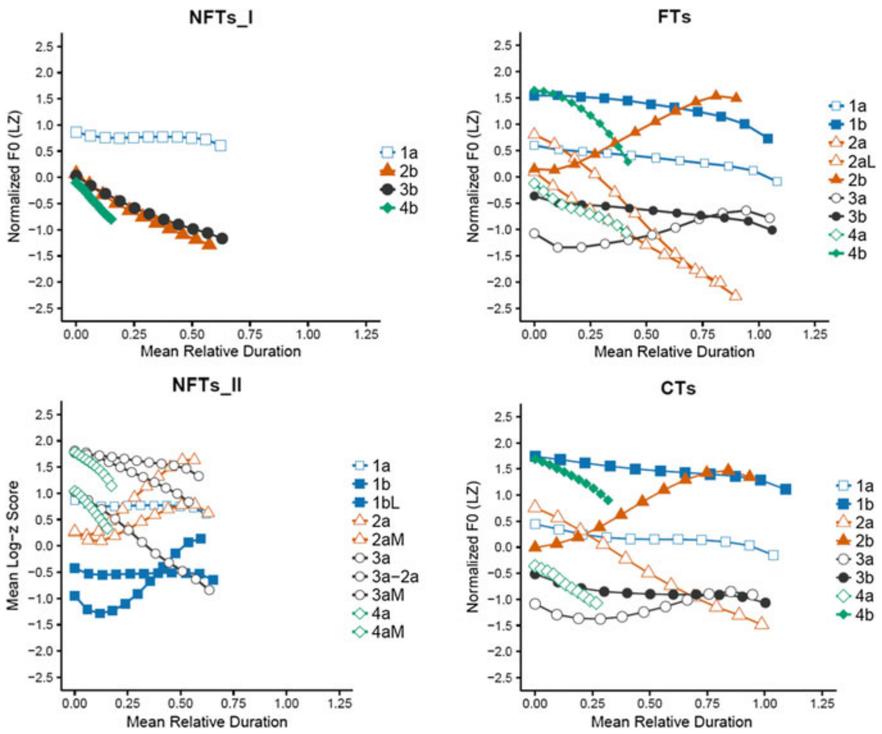

Fig. 4.13 Average LZ curves of the NFTs, FTs, and CTs of Anbu, produced by speaker LLW

Table 4.7 Anbu's tones

	1a	2a	3a	1b	2b	3b	4a	4b
NFT	44	35/34	55/54/43	23/33	32		54/43	32
FT	44	42/32	23	55	35	33	32	54
CT	44	42	22	55	35	33	32	54

Figure 4.13 displays the average LZ curves of the NFTs, FTs, and CTs of Anbu, plotted against relative duration. The mean duration of the long CTs is 152 ms (SD = 9 ms), and the mean F_0 of the long CTs is 208 Hz (SD = 38 Hz). The mean duration of the long FTs is 367 ms (SD = 37 ms), and the mean F_0 of the long FTs is 215 Hz (SD = 47 Hz).

Based upon the RL model, Anbu tones are transcribed as follows (Table 4.7).

The rising allotone of NFT 1b is transcribed here as a low rising tone /23/, but strictly speaking, its offset lies between /3/ and /4/ and therefore is a bit higher than the offset of the level allotone of NFT 1b (/33/).

The conditions of the tonal splits are listed below:

(3) The splits of NFT 2a, 3a, and 4a in Anbu

NFT 2a	>/35/ before /55/, /54/, and /32/
	>/34/ before /44/, /35/, /33/, /32/, /22/
NFT 4a	>/54/ before /55/, /54/, and /32/
	>/43/ before /44/, /35/, /33/, /32/, /22/
NFT 3a	>/54/ before /55/, /54/, and /32/
	>/43/ before /44/, /35/, /33/, /32/, /22/

(4) The split of NFT 1b in Anbu

NFT 1b	>/23/ before /55/, /54/, /44/, and /42/
	>/33/ before /35/, /33/, /32/, /22/

(5) The split of FT 2a in Anbu

FT 2a	>/42/ after /34/, /32/, /32/, /23/
	>/32/ after /35/, /53/ and /54/

4.3 The Changes of Chao-Shan FTs

Table 4.8 summarizes the values of the FTs of the 6 Chao-Shan varieties.

Compared to the CTs listed in Table 4.1, the only change of FTs is the split of T2a. Given that /53/ is supposed to be the earlier form of CT 2a, the diachronic changes of FT 2a can be illustrated as follows (Fig. 4.14).

In Batou and Raoping, FT 2a remain unchanged. In Chaozhou and Chengcheng, FT 2a is lowered to /32/ when produced after /35/, /53/ and /54/, while in other contexts it remains unchanged. In Jieyang and Anbu, the unchanged allotone of FT 2a is lowered to /42/, probably in sync with the lowering of CT 2a (this lowering could happen either before or after the split of FT 2a).

The split of FT 2a reveals a change for high falling tone to lower its height when it occurs after high tones, more specifically, tones begin or end with the highest pitch

Table 4.8 FTs of 6 Chao-Shan varieties

Dialects	1a	2a	3a	1b	2b	3b	4a	4b
RP	44	53	22	55	35	32	32	54
BT	44	53	22	55	35	33	32	54
CC	44	53/32	22	55	35	33	32	54
CZ	44	53/32	22	55	35	32	32	54
JY	44	42/32	22	55	35	33	32	54
AB	44	42/32	22	55	35	33	32	54

FT 2a **53** [RP, BT]	> **53** (after 34, 32, 32, and 23) > **32** (after 35, 53 and 54)	[CZ, CC]
	> **42** (after 44, 32, 32, and 23) > **32** (after 35, 53 and 54)	[JY, AB]

Fig. 4.14 Changes of FT 2a in Chao-Shan

Table 4.9 NFTs of 6 Chao-Shan varieties

Dialects	1a	2a	3a	1b	2b	3b	4a	4b
RP	44	35	55	33			54	32
BT	44	35	55	33	43		54	32
CC	34	35/34	54/53/43	23	33	=1b	54/43	32
CZ	34	35/34	54/53/43	23	32	=1b	54/43	32
JY	44	35/34	54/53/43	33	32		54/43	32
AB	44	35/34	55/54/43	23/33	32		54/43	32

value /5/. Notice that FT 2a only splits in dialects where the high NFTs split. This suggests that the split of FT 2a and the split of NFT 2a/3a/4a are correlative. Besides, FT 2a, which was originally a high falling tone /53/, is the only FT that exhibits tonal split. It seems that high falling tone is more susceptible to contextual effect than other tones are.

4.4 The Changes of Chao-Shan NFTs

Table 4.9 summarizes the values of the NFTs of the 6 Chao-Shan varieties.

Generally speaking, there are three major changes that the NFTs of the 6 Chao-Shan varieties have undergone: tonal neutralization, tonal split, and tonal shift. **Neutralization** occurs mainly in the b tones. In Raoping all long b tones are neutralized

NFT 1b	**23**	[CC, CZ]	>	**33**	[BT, JY, RP]
NFT 2b	**32**	[CZ, JY, AB]	>	**33**	[CC, RP]

Fig. 4.15 Changes of NFT 1b and NFT 2b in Chao-Shan

into /33/. In Batou, Jieyang, and Anbu, NFT 2b and NFT 3b are neutralized. In Chengcheng and Chaozhou, NFT 1b and NFT 3b are neutralized. NFT 3b never emerge as a single tone category by itself, and therefore it is impossible to know its original value from the above materials. As for NFT 1b and NFT 2b, it should be safe to assume that their earlier values are /23/ and /32/ respectively. And either or both of them became a mid level tone /33/ afterwards. The changes of NFT 1b and NFT 2b in Chao-Shan are illustrated in Fig. 4.15.

But note that, in Batou, NFT 2b is a mid falling tone /43/. For now it is difficult to decide the role of this mid falling value in the process of the change of NFT 1b. This problem will be resolved in the next chapter, where two more similar examples from the Zhangzhou variety of SM are presented.

In addition to the neutralization of b tones, there is one more neutralization process occurring between NFT 1a and the lower allotone of NFT 2a in Chaozhou and Chengcheng. In this neutralization NFT 1a becomes /34/ from /44/, which contradicts with the general tendency of NFTs to simplify contour, indicating that this neutralization is probably not driven by the duration-induced tonal variation disccused in Sect. 2.3.2. It might be owing to perceptual confusion.

The second type of change attested in the NFTs of Chao-Shan is context-conditioned **tonal split**. The tone sandhi of Raoping and Batou is context-free, no contextual tonal split occurs in their NFTs or FTs. I take this context-free type of tone sandhi as the earlier form of Chao-Shan tone sandhi. It is generally assumed that a tone sandhi system can be traced back to a tone system without sandhi, in which there is only one tone value for each tone category no matter where it occurs (as in the case of Cantonese, Vietnamese, and Standard Thai). Consequently, the most straightforward way to consider the development of Chao-Shan tone sandhi is to think of it as a two-stage development: in the first stage non-final and final tones became separate and different in terms of tonal values (i.e. the divergence between NFT and FT)—this is when context-free tone sandhi is formed; after that contextual tonal split occurred.

Therefore, for each set of allotones, we could assign a tone value as the starting point of the tonal splits. For NFT 2a/3a/4a, their higher alloforms are regarded as the original values, since NFT 2a/3a/4a are all high tones in Raoping and Batou (as well as in many other SM dialects, as can be seen in the next chapter). The splits of NFT 2a/3a/4a in Chao-Shan are illustrated in Fig. 4.16.

Notice that, according to the analyses presented above, in Raoping and Batou NFT 3a has undergo a context-free **tonal shift**: * /53/ > /55/ (more examples of this change will be presented in the next chapter). I choose /53/ instead of /55/ to be

NFT 2a	**35**	[RP, BT]	… **35** (before 55, 54, and 32) > **34** (before 44, 35, 33/32, and 32)	[CC, CZ, JY, AB]
NFT 4a	**54**	[RP, BT]	… **54** (before 55, 54, and 32) > **43** (before 44, 35, 33/32, and 32)	[CC, CZ, JY, AB]
NFT 3a	***53**		… **53** (before 32) > **54** (before 55 and 54) > **43** (before 44, 35, 33/32, and 32)	[CC, CZ, JY]
			> **55** (before 32) > **54** (before 55 and 54) > **43** (before 44, 35, 33/32, and 32)	[AB]
			> **55**	[RP, BT]

Fig. 4.16 Changes of NFT2a/3a/4a in Chao-Shan

NFT 1b ***23**	… **23** (before 55, 54, 44, and 42) > **33** (before 35, 33, 32, and 22)

Fig. 4.17 Split of NFT 1b in Anbu

Table 4.10 Earlier values of Chao-Shan NFTs

	1a	2a	3a	1b	2b	3b	4a	4b
NFT	*44	*35	*53	*23	*32	?	*54	*32

the starting point of the split of NFT 3a, because if /55/ were the original value, we should expect it to stay the same when produced before /55/ and /54/.

Lastly, in Anbu, there is one more tonal split in NFT 1b. Given that we have already established /23/ as the earlier value of NFT 1b, the starting point of the split of NFT 1b should also be /23/. The split of NFT 1b in Anbu is illustrated in Fig. 4.17.

According to the changes proposed above, the earlier values of Chao-Shan NFTs are given in Table 4.10.

4.4.1 The Motivation of NFT Change

The conditions of the split of NFT 1b are clear cut: when the onset of the following tone is relatively high (/5_/ and /4_/), NFT 1b keeps its original low rising contour;

when the onset of the following tone is relatively low (/3_/ and /2_/), NFT 1b becomes a mid level tone.

The conditions of the splits of NFT 2a/3a/4a are less straightforward, owing to the split of FT 2a (/53/ > /32/, as discussed in Sect. 4.3). But as long as we restore the original value of FT 2a (i.e., /53/), the conditions of the splits of NFT 2a/3a/4a will become transparent: they maintain their high pitch (/35/, /53, 54 or 55/, /54/) when the onset of the following tone is the highest (/5_/), and get lowered (/34/, /43/, /43/) when the onset of the following tone is not the highest.

Given that the NFT splits are conditioned by the onset of the following tones, it seems reasonable to associate the tonal split with the effect of tonal coarticulation (i.e., the phonetic influence of one tone on adjacent tones). However, there is little empirical support for the idea that phonetic tonal coarticulation is a precursor to right-prominent tone sandhi (in the same way as vowel-to-vowel coarticulation is a precursor to vowel harmony). In fact, in a tone system with right-prominent tone sandhi, very often the phonetic tonal coarticulation pattern and the tone sandhi patterns are not parallel.[3] Xu (1997) and Zhang and Liu (2011) conducted careful acoustic examinations on the tonal coarticulation and tone sandhi of Mandarin and Tianjing respectively, and they both found that although the tone sandhi of Mandarin and Tianjing were regressively dissimilative in nature, their tonal coarticulation were primarily progressively assimilative.

Relatedly, experiments on Taiwanese tonal coarticulation also failed to find a predominantly regressive effect, despite the fact that Taiwanese tone sandhi is undoubtedly final-prominent. Lin (1988) reported a perseveratory effect but no anticipatory effect in tonal coarticulation. Peng (1997) found a significant effect of anticipatory assimilation for contour tones, but its magnitude is much smaller than the effect of prosodic position. In Hsieh (2004)'s corpus research, perseveratory assimilation was found in high tone, mid tone and low tone; on the other hand, anticipatory assimilation was only found in mid tone. Chang and Hsieh (2012)'s experiment on Malaysia Yongchun (a SM variety spoken in Malaysia) reported that carryover and anticipatory tonal influences do not substantially differ in magnitude.

Consistent with the previous studies, the phonetic tonal coarticulation and the phonological tonal split of Chao-Shan is also unparalleled. If the splits of NFT 2a/3a/4a are grounded in tonal coarticulation, we should be able to find a significant effect of anticipatory assimilation in dialects where NFT 2a/3a/4a have not undergone split yet. The NFT 2a and NFT 4a of Raoping and Batou were tested to see whether they vary according to the onset of the following tones. The productions of two speakers of Raoping and two speakers of Batou were used. NFT tokens followed by /55/, /53/, and /54/ were put in the "Before High" group; those followed by /35/, /32 or 33/, /32/, and /22/ were put in the "Before Non-high" group. For NFT 4a, average LZ (the last three measuring points were excluded because they were greatly influenced by the type of stop) were calculated for each group. As for NFT 2a, average LZ range were calculated for each group. LZ range was calculated from the differences

[3]For left-prominent tone sandhi (and the tone assignment of neutral tone), however, normally the phonetic tonal coarticulation pattern and the tone sandhi patterns are more parallel (Zhang, 2007).

Table 4.11 Results of Welch Two Sample t-tests on NFT 4a

Dialect (Speaker)	Before high	Before non-high	Difference	t	df	*p*-value
RP (CLH)	1.14	1.25	0.11	−1.69	34.00	$p > 0.05$
RP (ZX)	1.83	2.18	0.35	−2.20	35.85	$p < 0.05$
BT (WMX)	1.27	1.64	0.37	−3.72	30.28	$p < 0.001$
BT (LY)	1.85	1.91	0.06	−0.35	17.03	$p > 0.05$

Table 4.12 Results of Welch Two Sample t-tests on NFT 2a

Dialect (Speaker)	Before high	Before non-high	Difference	t	df	*p*-value
RP (CLH)	1.04	1.29	0.25	−3.06	33.51	$p < 0.01$
RP (ZX)	1.11	1.26	0.15	−1.26	29.45	$p > 0.05$
BT (WMX)	0.57	1.19	0.62	−6.29	38.87	$p < 0.001$
BT (LY)	0.32	0.86	0.54	−4.68	28.83	$p < 0.001$

between offset (the average of the last three measuring points) and onset (the average of the first three measuring points).

Welch Two Sample t-tests were conducted to compare the average LZ of NFT 4a in "Before High" and "Before Non-high" conditions. The results, presented in Table 4.11, show that the effect of tonal coarticulation, if any, is dissimilatory in nature. The average LZ of NFT 4a is higher when following by non-high tones.

Similarly, the results of the Welch Two Sample t-tests conducted on the average LZ range of NFT 2a, presented in Table 4.12, show that the effect of tonal coarticulation is also dissimilatory in nature. The average LZ range of NFT 2a is larger when followed by non-high tones.

These results indicate that Chao-Shan's context-dependent NFT splits are probably not rooted in tonal coarticulation. Instead, tonal variation driven by prosodic modulation might be the major underlying cause of NFT splits. Recall that Peng (1997) found a much greater effect of prosodic position than the effect of tonal coarticulation. Besides, notice that the NFT splits of Chao-Shan gave rise to a series of allotones which are simpler in terms of contour (NFT 2a: 35 > 34; NFT 3a: 53 > 54/43/55; NFT 1b: 23 > 33). We have seen in Sect. 2.3.2 that non-final tones are generally produced with shorter duration and/or smaller dynamic range than final tones are. The results of Chao-Shan's NFT splits are consistent with the phonetic tendency for non-final tones to reduce their contour dynamic.

It is worth pointing out that the implementation of NFT simplification is not necessarily context-dependent. For example, in Raoping and Batou, NFT 3a changes from /53/ to /55/ as a whole; in Batou and Jieyang, NFT 1b changes from /23/ to /33/ as a whole; in Chengcheng, NFT 2b changes from /32/ to /33/ as a whole. These NFT changes are context-free (more cases of context-free NFT change will be given in the next chapter). In other words, prosodic-driven contour simplification should be considered as a general evolution trend for NFTs, and languages can differ in whether the implementation of this change is context-free or context-dependent.

There is no doubt that some sort of contextual factors must play a role in the formation of context-dependent tonal split, otherwise we cannot explain the source of the contextual conditions. Perhaps tonal context has an effect on the perceptual compensation for prosodic influence. Further research should be undertaken to deal with this problem.

4.5 Summary

In this chapter I presented a survey of the acoustics of the tone sandhi of 6 Chao-Shan varieties and analyzed the diachronic tonal changes that these varieties have undergone.

Generally speaking, the CTs/FTs of these 6 Chao-Shan varieties are very similar. Only T2a and T3b exhibit slight regional variations. On the contrary, Chao-Shan's NFTs have undergone a series of complex changes. In sum, three types of tonal changes are involved: tonal neutralization, context-free tonal shift, and context-conditioned tonal split. Every NFT, except for NFT 4b, takes part in at least one kind of change.

NFT neutralization neutralizes two or three tone categories in each Chao-Shan variety, while no FT/CT neutralization is attested. This result is consistent with our prediction made in Chap. 2 that SM NFTs should be more liable to contrast neutralization than the FT/CTs are.

NFT shift generally turns a falling or rising tone into a level tone (NFT 3a:/53/ > /55/, NFT 1b:/23/ > /33/, NFT 2b:/32/ > /33/), reflecting a tendency for NFT to reduce in contour complexity, and thus again is consistent with our prediction made in Chap. 2 that SM NFTs would undergo prosodic-driven tonal contour simplification.

NFT split is another way to simplify the contour of NFTs. If judging only by the contextual conditions of the splits, it seems that Chao-Shan's NFT splits are rooted in anticipatory assimilation. However, anticipatory assimilation is unable to explain the splits satisfatorily, as no significant effect of anticipatory assimilation is attested in dialects without tonal split. Other factors must be taken into account. What is crucial here is that, in most cases, the new allotones generated by the splits have simpler contour compared to the original tones (NFT 2a:/35/ > /34/; NFT 3a:/53/ > /54,43,55/; NFT 1b:/23/ > /33/; the exception being NFT 4a:/$\underline{54}$/ > /$\underline{43}$/, which is a short tone). Therefore, it is reasonable to consider these NFT splits as reduction-oriented, and thus it is not essentially different from the other two kinds of NFT change.

In conclusion, the tone sandhis of Chao-Shan show a clear tendency for NFTs to reduce in contour complexity, changing from straight falling/rising tones to slight falling/rising tone or level tones. This contour-reduction tendency can be accomplished through context-free tonal shift or context-conditioned tonal split. In addition, NFTs are found to be more liable to tonal neutralization than FTs/CTs are.

In this chapter I demonstrated how SM NFTs change by comparing several SM varieties which are similar in their FTs/CTs but vary in their NFTs. Two questions that ensue are: (1) how SM FTs/CTs change; and (2) whether the change of NFTs and the change of FTs would interact. The next chapter sets out to address these two questions.

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Chapter 5
Tonal Changes in Zhang-Quan

This chapter presents the tone sandhi patterns of 10 Zhang-Quan varieties and discusses the diachronic tonal changes involved. The tone sandhis discussed in the current chapter are all typical context-free final-prominent tone sandhi.

In Sect. 5.1, a common "three levels and one rising" NFT pattern is identified in 5 SM varieties, one from Chao-Shan and four from different subgroups of Zhang-Quan. These 5 SM varieties share a similar NFT system but vary widely in terms of FTs/CTs, which is a strong piece of evidence showing that SM's FTs/CTs are able to change without interfering the change of NFTs.

Section 5.2 presents the tone sandhi patterns of 7 SM varieties, including Xiamen. These 7 SM varieties are grouped as "Zhangzhou varieties" in the following discussions, as their T2b and T3b are neutralized in both FT/CT and NFT positions, and Zhangzhou (ZZ) is a recognized representative of this tone pattern. It should be noted that not all the Zhangzhou varieties are located in the city of Zhangzhou.

Sections 5.3 and 5.4 deal with the changes of the NFTs and FTs of the 7 Zhangzhou varieties respectively. The changes of Zhangzhou NFTs include tonal neutralization and tonal shift, both can be explained by prosodic-driven tone reduction. In the meanwhile, the changes of Zhangzhou FTs can be characterized as a series of chain shifts, which shows a clear non-reductive feature.

The locations of the Zhang-Quan varieties under study are shown in Fig. 5.1.

There are four Zhang-Quan varieties (XP, NJ, ZZ, and CT) where first-hand data are available, and therefore the descriptions of their tones will be based upon the results of my tone production experiments. As in the case of Chao-Shan, I choose one speaker as the representative for each locality, and his/her acoustic results will be presented in full detail. Other speakers' results will be presented when additional information is needed. Earlier auditory-based transcriptions will not be discussed. Some personal information about the participants of the tone production experiments is given below:

Q. Lin, *The Diachrony of Tone Sandhi*, Frontiers in Chinese Linguistics 6,
https://doi.org/10.1007/978-981-13-1939-6_5

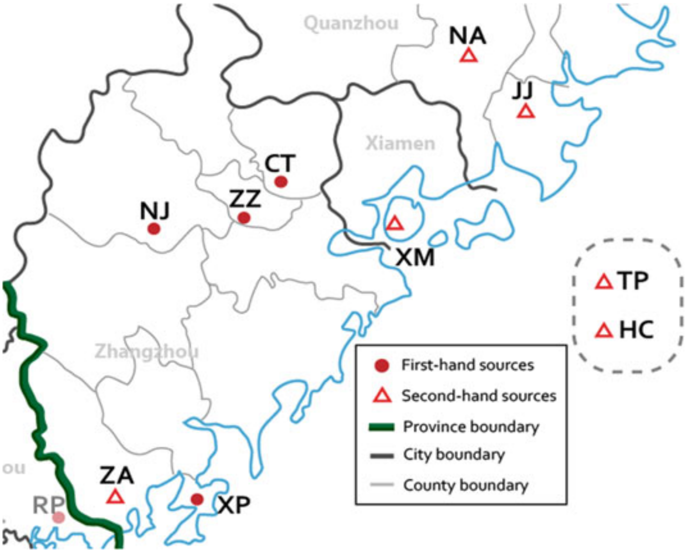

Fig. 5.1 Locations of the investigated Zhang-Quan varieties

(1) Xipu (XP): 2 speakers took part in the experiment. The representative speaker is SJF, who was a 47-year-old male at the time of recording.
(2) Changtai (CT): 2 speakers took part in the experiment. Both of them were born and bred in the Heting village of the Changtai county. The representative speaker is HCR, who was a 45-year-old male at the time of recording.
(3) Nanjing (NJ): 2 speakers took part in the experiment. Both of them were born and bred in the Shancheng town (the administrative center) of the Nanjing county. The representative speaker is WZW, who was a 43-year-old male at the time of recording.
(4) Zhangzhou (ZZ): 3 speakers took part in the experiment. All of them were born and bred in the Xiangcheng district (the administrative center) of the Zhangzhou city. The representative speaker is HYP, who was a 52-year-old male at the time of recording.

5.1 A Common NFT Pattern Across Different SM Subgroups

In the previous chapter, we have seen two cases of context-free tone sandhi systems—Raoping and Batou—and have discussed the changes involved. Interestingly, similar NFT patterns can be found in many other SM dialects outside Chan-Shan, despite that the FT/CT patterns of these SM dialects are dramatically different.

Table 5.1 Raoping tones

	1a	2a	3a	1b	2b	3b
NFT	44	35	55	33		
FT/CT	44	53	22	55	35	32

This section is specifically concerned with the Raoping-type NFT pattern. The values of Raoping tones are reproduced in Table 5.1.

The features of Raoping's NFT pattern are: (1) T1b, T2b, and T3b are neutralized into one low level tone; (2) T1a is a mid level tone, T2a is a rising tone, and T3a is a high level tone (originally was a high falling tone). To summarize, we can call Raoping's NFT pattern as a "three levels and one rising" pattern. Similar NFT patterns are attested in 4 other SM dialects: Xipu, Nan'an, Jingjiang, and Hsinchu.

5.1.1 A Case from Zhangzhou: Xipu (XP)

The average F_0 curves, plotted against average duration, of the 8 NFT blocks produced by the male Xipu speaker SJF are given in Fig. 5.2.

Like the tone sandhi of Raoping, Xipu's tone sandhis are all context-free. Figure 5.3 displays the average LZ curves of the NFTs, FTs and CTs of Xipu from left to right. The mean duration of the long CTs is 255 ms (SD = 29 ms), and the mean F_0 of the long CTs is 155 Hz (SD = 21 Hz). The mean duration of the long FTs is 225 ms (SD = 29 ms), and the mean F_0 of the long FTs is 155 Hz (SD = 21 Hz).

Two conclusions can be drawn from the acoustic results. Firstly, Xipu's FTs are the same as its CTs, which is unsurprising given that SM tone sandhis are typically final-prominent. Secondly, but more interestingly, Xipu's NFTs form a "three levels and one rising" pattern, identical to Raoping's NFTs. Notice that the FTs of Xipu and Raoping are very different: (a) Xipu merges T2b with T3b while Raoping does not see any merger; (b) T1b is the lowest tone in Xipu but the highest one in Raoping; (c) T1a, and T3a are higher in Xipu than in Raoping.

Considering that Xipu is geographically not far from Raopin (see Fig. 5.1), one possible explanation for their identical NFTs is that it is caused by language contact. However, this contact account is unsatisfactory in many ways. Firstly, one might wonder why the FTs are immune from such language contact. Besides, there is a Zhao'an county lying between Xipu and Raoping, whose NFTs pattern is different from that of Xipu and Raoping (its NFT 1b is not neutralized with NFT 2b and NFT 3b, and its NFT 3a is a rising tone, cf. Zhang, 2016). Most importantly, similar NFT pattern can also be found in dialects that are far away from Raoping and Xipu (see the next two subsections).

Based upon the RL model, Xipu's tones are transcribed in Table 5.2:

As can be seen in Fig. 5.3, the onset of FT 2a is acoustically much higher than the onset of FT 1a. However, they both are transcribed as high tones, /53/ and /55/ respectively. There are two reasons for this. First, empirically it is very common for

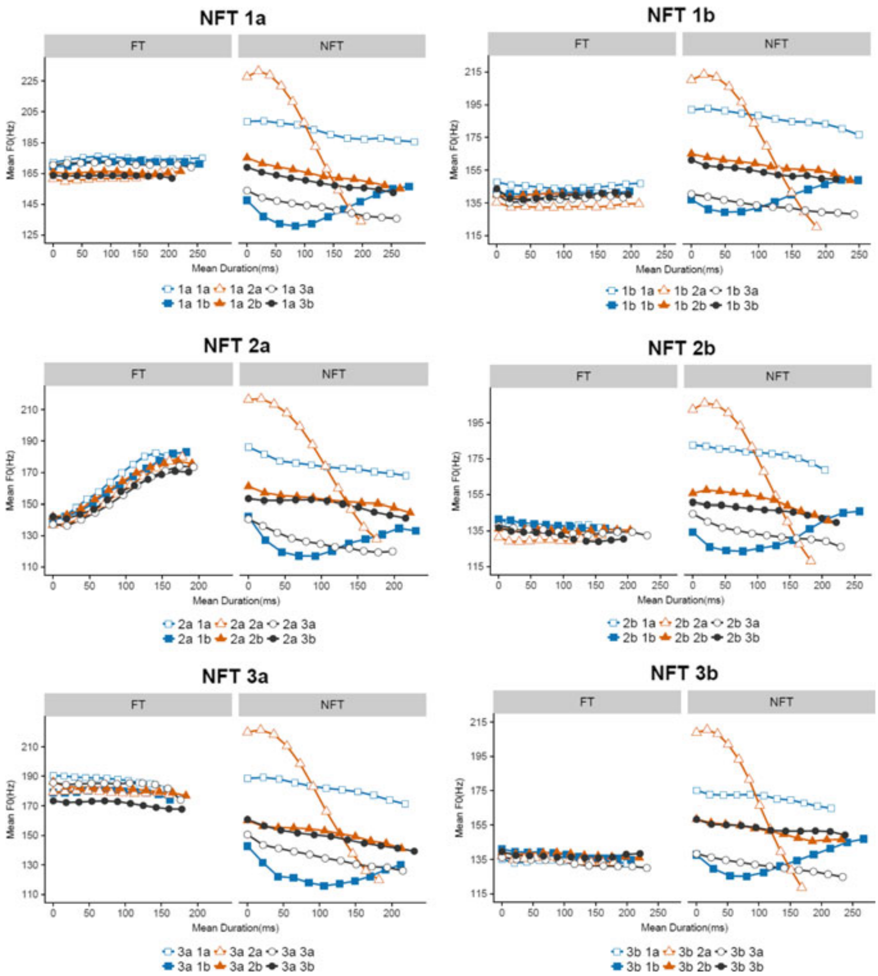

Fig. 5.2 The 8 NFTs, each followed by 8 FTs, of XP, produced by SJF

high falling tone to have a higher onset than high level tone; second, judging by auditory perception, FT 2b3b is undoubtedly mid level /44/, and there is no prove that language can contrast two levels of Height above the mid level within the Modal register. Consequently, the acoustic differences between the onset of FT 2a and FT 1a are ignored here.

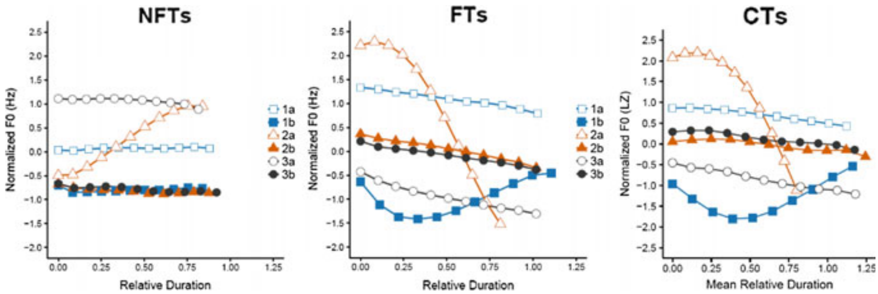

Fig. 5.3 Average LZ curves of XP's NFTs, FTs, and CTs, produced by SJF

Table 5.2 XP tones

	1a	2a	3a	1b	2b	3b
NFT	44	35	55	33		
FT/CT	55	53	33	324	44	

5.1.2 Two Cases from Quanzhou: Nan'an (NA) and Jinjiang (JJ)

Li (2001) provided two more cases of the "three levels and one rising" NFT pattern—Nan'an and Jinjiang, as shown in Tables 5.3 and 5.4, both located in the Quanzhou city. The transcriptions were auditory-based and were conducted under the traditional five-point scale, with 1 representing the lowest pitch and 5 the highest, and thus the tone values in the tables are shown in italic.

According to the above transcriptions, Nan'an and Jinjiang have identical NFTs, which show a "three levels and one rising" pattern: T1b, T2b, and T3b are neutralized into one low level tone; T1a is a mid level tone, T2a is a rising tone, and T3a is a high level tone. If taken into account the differences between the four-point scale of the RL model and the five-point scale used here, it seems safe to say that the NFTs of Nan'an and Jinjiang and the NFTs of Raoping and Xipu are basically the same.

Table 5.3 Nan'an tones, from Li (2001)

	1a	2a	3a	1b	2b	3b
NFT	*33*	*24*	*55*	*22*		
FT/CT	*33*	*55*	*31*	*24*	*22*	*=3a*

Table 5.4 Jinjiang tones, from Li (2001)

	1a	2a	3a	1b	2b	3b
NFT	*33*	*24*	*55*	*22*		
FT/CT	*33*	*55*	*42*	*24*	*=1a*	*=3a*

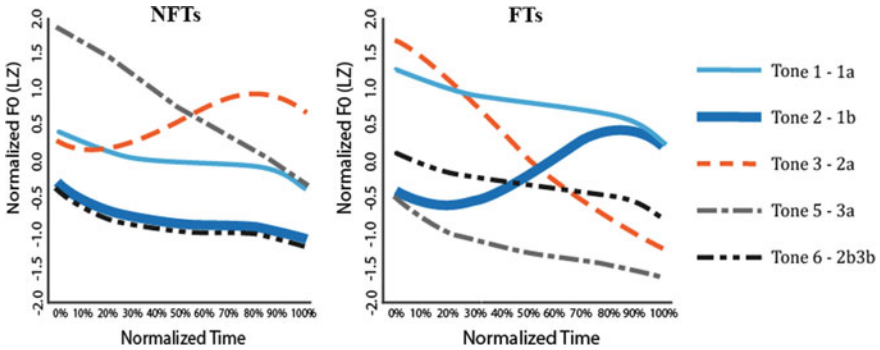

Fig. 5.4 Average LZ curves of HC's NFTs and FTs. Adapted from Peng (2011, Figs. 6.40 and 5.22)

However, the FTs/CTs of Nan'an and Jinjiang exhibit significant variations. If compared to the FT/CT system of Raoping or Xipu, the FT/CT systems of Nan'an and Jinjiang resemble neither of them not only in the tonal values but also in which categories they neutralize.

5.1.3 A Case from Coastal Taiwanese: Hsinchu (HC)

Another case in point comes from Hsinchu, a variety of SM spoken in Southern Taiwan. Peng (2011) examined the acoustics of the NFTs, FTs and CTs of Hsinchu. The LZ-normalized results of NFTs and FTs are presented in Fig. 5.4. Each curve is a time-normalized average of 192 tokens produced by four speakers.

Compared to the NFTs of Raoping and Xipu, the NFTs of Hsinchu show two interesting variations: first, Hsinchu's NFT 3a is a slight falling tone instead of a high level tone; second, the rising excursion of NFT 2a seems to be smaller in Hsinchu than in Raoping and Xipu. As discussed in Sect. 4.4, originally NFT 3a should be a high falling tone */53/, and therefore the falling contour of Hsinchu's NFT 3a is actually a preservation of the earlier form of NFT 3a. As for NFT 2a, Hsinchu's smaller rising range can be accounted for by assuming a general rule of NFT change to reduce contour dynamic—the same rule motivating the leveling of NFT 3a. In other words, the falling NFT and the rising NFT both undergo minor contour reduction in Hsinchu, while in Raoping and Xipu (Nan'an and Jinjiang as well), only the falling tone has undergo (and has completed) contour leveling. Therefore, despite the differences between the NFTs of Hsinchu and the "three levels and one rising" pattern, the correlations between them are clear.

Based upon the RL model, Hsinchu's tones are transcribed as follows (Table 5.5):

Table 5.5 Hsinchu tones

	1a	2a	3a	1b	2b	3b
NFT	44	45	54	33		
FT/CT	55	53	33	35	44	

Table 5.6 NFTs of 5 SM varieties

Dialects	1a	2a	3a	1b	2b	3b
*SC	*44	*35	*53	*23	*32	?
RP	44	35	55	33		
XP	44	35	55	33		
HC	44	45	54	33		
NA	*33*	*24*	*55*	*22*		
JJ	*33*	*24*	*55*	*22*		

Table 5.7 FTs/CTs of 5 SM varieties

Dialects	1a	2a	3a	1b	2b	3b
RP	44	53	22	55	35	32
XP	55	53	33	324	44	
HC	55	53	33	35	44	
NA	*33*	*55*	*41*	*24*	*22*	*=3a*
JJ	*33*	*55*	*31*	*24*	*=1a*	*=3a*

5.1.4 Discussion

Tables 5.6 and 5.7 summarize the NFTs and the FTs of the 5 SM varieties discussed above. In Table 5.6, the hypothetical NFT system of earlier Chao-Shan (*SC) is also listed as a reference. The NFTs of the 2 Quanzhou are shown in italic as they were transcribed with the traditional five-point scale.

The existence of such a similarity in the NFTs among different SM dialects should not be an accident. Several conclusions can be drawn from this interesting fact:

(1) It is very likely that the SM dialects listed above have undergone parallel evolution in their NFTs;
(2) The parallel evolution of NFTs in this case confirms our observations that there is a general tendency for NFTs to reduce in contour dynamic, and to have greater extent of neutralization than FTs do;
(3) The NFTs are unaffected by the changes of FTs. Therefore, even though the FTs of these dialects have become very different, their NFTs are still basically the same.

A further implication is that the variations among the tone sandhi patterns of the SM dialects discussed here are much more understandable by resorting to the divergent changes of FTs and NFTs than to the tonal alternation rules or constraints.

If we view tone sandhi patterning from a phonological perspective and attempt to explain the regional variations in terms of the composition of tonal alternation rules or constraints, first we need to find a way to define FT 1b, 2b, and 3b as a natural class, in order to account for the neutralization of T1b/2b/3b in NFTs. This is almost an impossible task, given the diverse values of FT 1b/2b/3b in different SM dialects. Obviously, a position-based diachronic account towards the variations in tone sandhi patterning is much more practical.

So far we don't have enough material to infer all the FTs changes that the dialects discussed above have undergo. But we will zoom into the cases of Xipu and Hsinchu, and see five additional cases, to explore how FTs change diachronically.

5.2 The Tone Sandhi Patterns of 7 Zhangzhou Varieties

The 7 Zhangzhou varieties that will be discussed below are: Xipu (XP), Hsinchu (HC), Taipei (TP), Xiamen (XM), Changtai (CT), Zhangzhou (ZZ), Nanjing (NJ). We've seen the tone patterns of Xipu and Hsinchu in Sect. 5.1. The tone patterns of the other five Zhangzhou varieties will be presented in this section.

The tone sandhis of all these 7 Zhangzhou varieties are context-free, and the values of their FTs are the same as their CTs, as in the case of Xipu. Therefore, for the sake of brevity, only the average normalized LZ curves of NFTs and FTs will be presented for each variety. The results of CTs and the details of each NFT blocks will not be shown here.

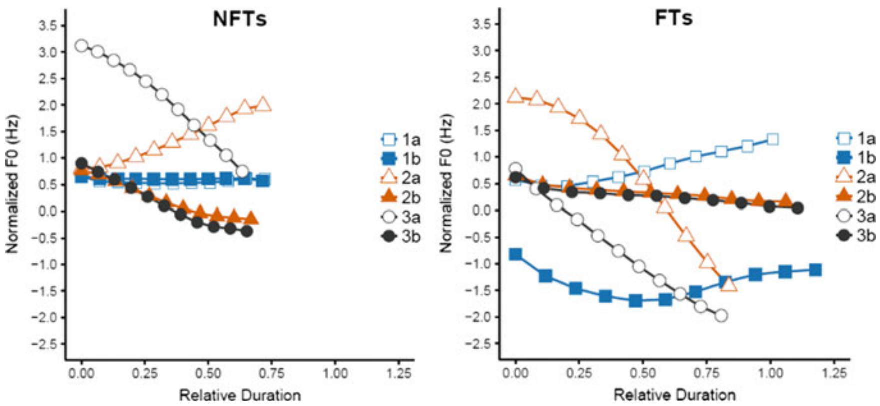

Fig. 5.5 Average LZ curves of the NFTs and FTs of Zhangzhou, produced by speaker HYP

5.2.1 *Zhangzhou (ZZ)*

The average LZ curves of the NFTs and FTs of Zhangzhou are displayed in Fig. 5.5. The mean duration of the FTs is 280 ms (SD = 47 ms), and the mean F_0 of the FTs is 93 Hz (SD = 17 Hz).

Based upon the RL model, Zhangzhou's tones are transcribed as follows (Table 5.8):

5.2.2 *Taipei (TP)*

Chen, Myers, and Tsay (2010) provided acoustic results of Taipei disyllabic tone sandhi produced in carrier sentences, as shown in Fig. 5.6. The average F_0 tracks plotted against normalized time are presented below. Each curve is an average of 40 tokens.

It is worth noting that, althought the tone sandhi of Standard Taiwanese has long been regarded as "structure-preserving", acoustically NFT2b3b and FT 3a seem to be quite different in slope. The falling contour of NFT2b3b is less steep than that of FT 3a. Lin (1988)'s acoustic investigation on Taiwanese showed a similar result, as illustrated in Fig. 5.7. Lin (1988) used speakers from various regions of Taiwan.

However, it is not easy to conclude whether Taipei's NFT2b3b and FT 3a are two different tones or not. Guo (2013) demonstrated that in the production of a Main-

Table 5.8 Zhangzhou tones

	1a	2a	3a	1b	2b	3b
NFT	44	45	53	=1a	43	
FT	45	53	42	22	44	

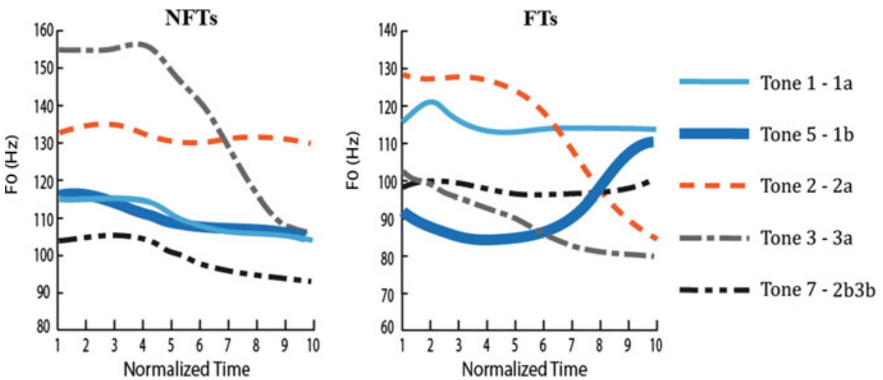

Fig. 5.6 Average F_0 tracks of the NFTs and FTs of Taipei. Adapted from Chen et al. (2010, Figs. 3 and 2)

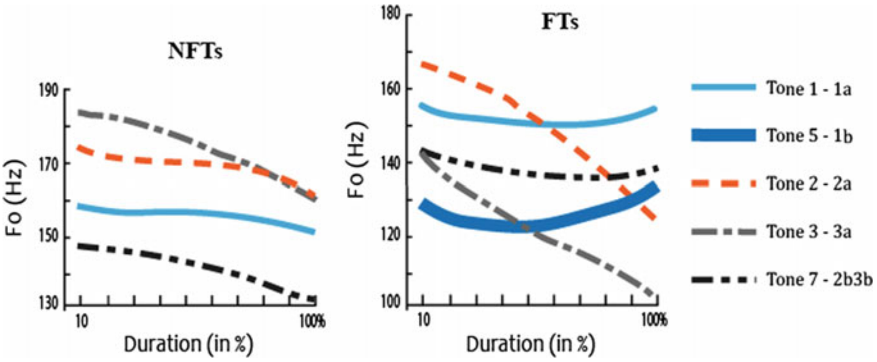

Fig. 5.7 Average F_0 tracks of the NFTs and FTs of Taiwanese. Adapted from Lin (1988, Figs. 2.5 and 2.6)

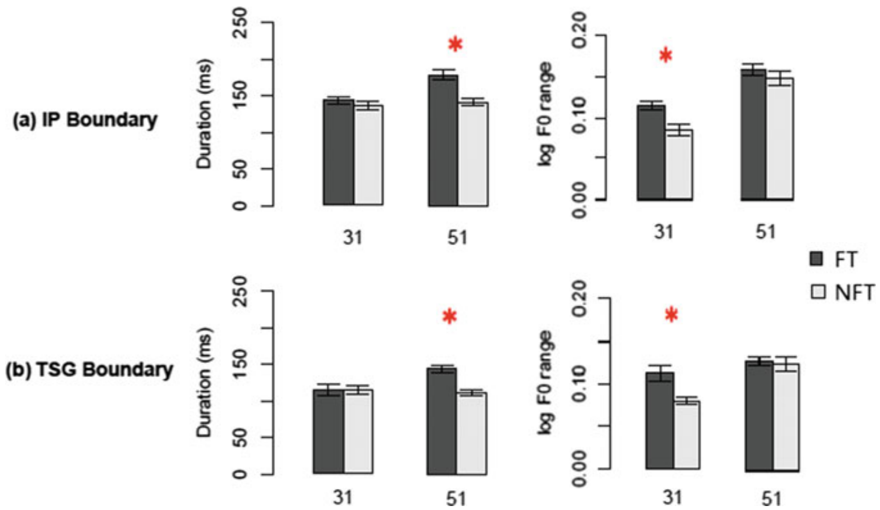

Fig. 5.8 Differences on the duration and F_0 range of FTs and NFTs. Adapted from Guo (2013)

stream Taiwanese speaker, NFT2b3b and FT 3a are indeed significantly different in slope, as shown in Fig. 5.8. But the difference was attributed to the influence of prosodic position.

If we view NFT and FT as two separate tone systems, then it is clear that NFT 2b3b should be transcribed as a low falling tone while FT 3a is in fact a mid falling tone. The onset of FT 3a is as high as the mid level FT 2b3b. For this reason, I decide to treat the NFT 2b3b and FT 3a of Taipei as two different tones for the time being, despite the fact that this is contrary to the lasting impression that Taiwanese tone sandhi is structure-preserving.

Based upon the RL model, Taipei tones are transcribed as follows (Table 5.9):

Table 5.9 Taipei tones

	1a	2a	3a	1b	2b	3b
NFT	44	55	53	=1a	32	
FT	55	53	42	324	44	

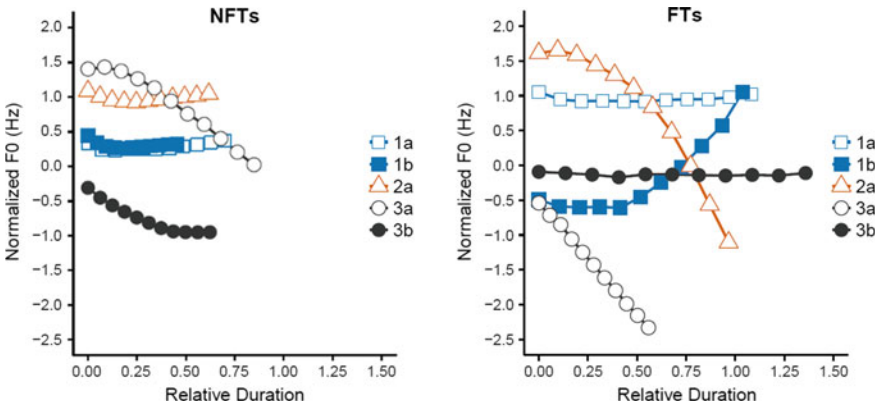

Fig. 5.9 Average LZ curves of the NFTs and FTs of Xiamen, recordings from Lin (2015)

As shown in Fig. 5.6, the onset of NFT 3a is acoustically much higher than the onset of NFT 2a. However, they both are transcribed as high tones, /53/ and /55/ respectively. Similarly, the onset of FT 2a is acoustically much higher than the onset of FT 1a, but in the RL transcriptions they both start at /5/. The acoustic differences between the onset of NFT 3a and NFT 2a and that of FT 2a and FT 1a are ignored here. I have explained the reasons why in Sect. 5.1.1. To add one more supporting evidence, all previous researchers transcribed NFT 1a1b and FT 2b3b as mid level tones (see Lin, 1988: 10).

5.2.3 Xiamen (XM)

The average LZ curves of the NFTs and FTs of Xiamen are displayed in Fig. 5.9. Each NFT curve is the average of 7 tokens, and each FT curve is the average of 5 tokens. The mean duration of the FTs is 300 ms (SD = 89 ms), and the mean F_0 of the FTs is 244 Hz (SD = 77 Hz).

Based upon the RL model, Xiamen's tones are transcribed as follows (Table 5.10):

As in the case of Taipei, Xiamen's NFT2b3b and FT 3a are significantly different in slope—the falling contour of NFT2b3b is less steep than that of FT 3a, even though their durations are about the same. However, they are both transcribed here as low falling tone /32/, because the onset of FT 3a is relatively low in Xiamen's FTs. In

Table 5.10 Xiamen tones

	1a	2a	3a	1b	2b	3b
NFT	44	55	53	=1a	32	
FT	55	53	32	35	44	

other words, the tone sandhi of Xiamen seems to be more "structure-preserving" than the tone sandhi of Taipei does.

5.2.4 Changtai (CT)

The average LZ curves of the NFTs and FTs of Changtai are displayed in Fig. 5.10. The mean duration of the FTs is 354 ms (SD = 59 ms), and the mean F_0 of the FTs is 203 Hz (SD = 47 Hz).

Based upon the RL model, Changtai's tones are transcribed as follows (Table 5.11):

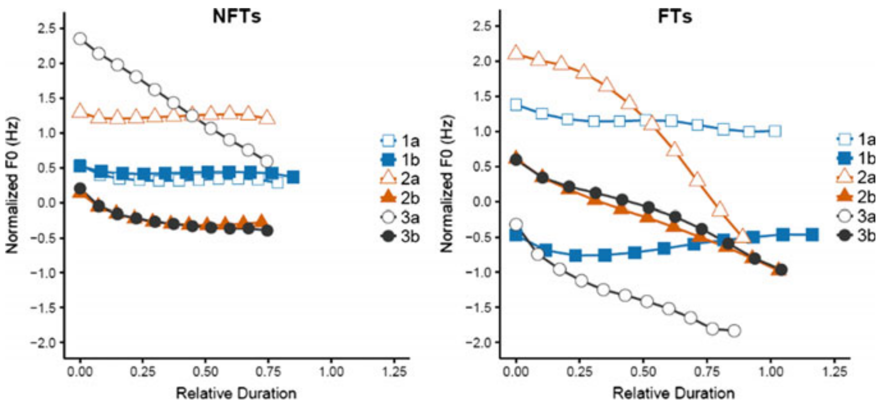

Fig. 5.10 Average LZ curves of the NFTs and FTs of Changtai, produced by speaker HCR

Table 5.11 Changtai tones

	1a	2a	3a	1b	2b	3b
NFT	44	55	53	=1a	33	
FT	55	53	32	23	43	

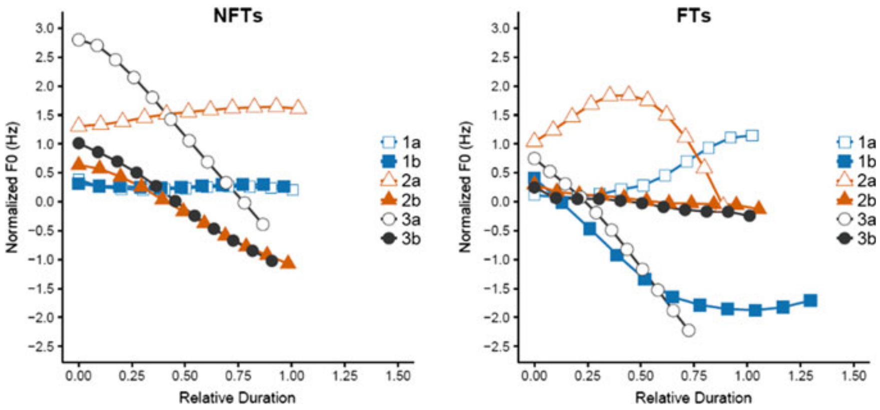

Fig. 5.11 Average LZ curves of the NFTs and FTs of Nanjing, produced by speaker WZW

Table 5.12 Nanjing tones

	1a	2a	3a	1b	2b	3b
NFT	44	55	53	=1a	42	
FT	45	453	42	422	44	

5.2.5 Nanjing (NJ)

The average LZ curves of the NFTs and FTs of Nanjing are displayed in Fig. 5.11. The mean duration of the FTs is 208 ms (SD = 26 ms), and the mean F_0 of the FTs is 147 Hz (SD = 35 Hz).

Based upon the modified RL model, Nanjing's tones are transcribed as follows (Table 5.12):

FT 1b is a long mid falling tone. Speaker WZW always produced FT 1b with a level tail (same as his CT productions). However, in the production of the other speaker of Nanjing—TMH, FT 1b is a straight mid falling, and it contrasts with FT 3a in Length (same as his CT productions). The F_0 tracks of all the tokens of CT 1b and CT 3a produced by WZW and TMH are given in Fig. 5.12.

Therefore, the level tail of FT/CT 1b in the production of WZW can be considered as a special strategy to maintain its longness. This variation in pitch contour serves as a precursor to the change of FT/CT 1b. We will return to this point in Sect. 5.4.

5.3 The Changes of Zhangzhou NFTs

Table 5.13 summarizes the values of the NFTs of the 7 Zhangzhou varieties.

Generally speaking, there are two major changes that the NFTs of the 7 Zhangzhou varieties have undergone: tonal neutralization and tonal shift. Neutralization occurs

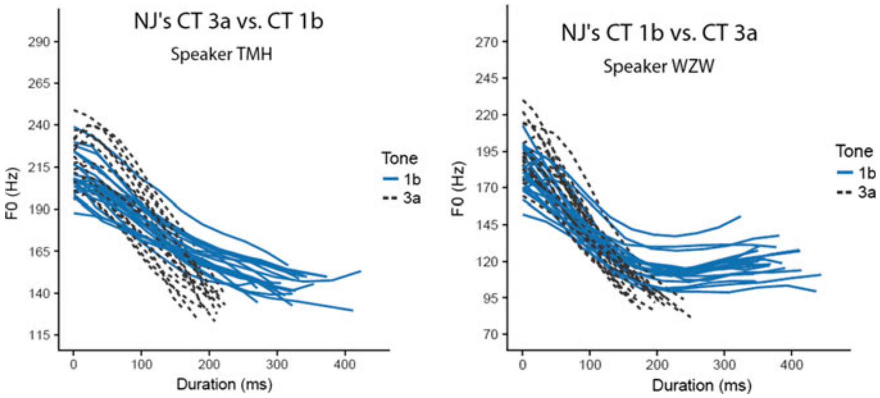

Fig. 5.12 F_0 tracks of CT 1b and CT 3a produced by WZW and TMH

mainly in the b tones (as in the case of Chao-Shan varieties). In Xipu and Hsinchu all b tones were neutralized. Other Zhangzhou varieties neutralized T2b with T3b, and T1b with T1a.

The other major change attested is context-free tonal shift. In order to gain a broader picture of the tonal shifts, Table 5.14 provides a list of the NFTs of all the context-free tone sandhi systems that have been discussed so far.

As shown in the table above, the NFTs of different SM dialects exhibit close correspondence. The mid level tone NFT 1a stays unchanged in all varieties. NFT 1b is a low level /33/ in Batou, and it is neutralized into /33/ or /44/ in other places. NFT 2b3b has three kinds of realizations: mid falling, low falling, and low level. Following the assumption that contour tones are prone to contour simplification when occur in NFT position, the most likely course of the change of NFT 2b3b is the one that starts from straight falling, heading towards slight falling, and ends in level, as illustrated in Fig. 5.13:

In a similar vein, we can persist with the conclusions draw in the previous chapter that the earlier values of NFT 2a and NFT 3a are /35/ and /53/ respectively. Then, NFT 2a changed from /35/ to /45/ in Zhangzhou and Hsinchu, and further into /55/

Table 5.13 NFTs of 7 Zhangzhou varieties

Dialects	1a	2a	3a	1b	2b	3b
ZZ	44	45	53	=1a	43	
TP	44	55	53	=1a	32	
XM	44	55	53	=1a	32	
CT	44	55	53	=1a	33	
NJ	44	55	53	=1a	42	
XP	44	35	55	33		
HC	44	45	54	33		

NFT 2b3b 42 [NJ]	> 43 [ZZ, BT]	> 33 [CT, XP, RP, HC, *NA, JJ*]
	> 32 [TP, XM]	

Fig. 5.13 Changes of NFT 2b3b in context-free tone sandhi varieties

NFT 2a 35 [BT, XP, RP, *NA, JJ*]	> 45 [HC, ZZ]	> 55 [NJ, TP, XM, CT]
NFT 3a 53 [ZZ, NJ, TP, XM, CT]	> 54 [HC]	> 55 [BT, XP, RP, *NA, JJ*]

Fig. 5.14 Changes of NFT 2a and NFT 3a in context-free tone sandhi varieties

in Nanjing, Taipei, Xiamen and Changtai. In the meantime, NFT 3a changed from /53/ to /54/ in Hsinchu, and further into /55/ in Batou, Xipu, Raoping, Nan'an, and Jinjing (Fig. 5.14). If this leveling change proceeds even further, NFT 2a and NFT 3a might get neutralized.

If the above interpretation of the regional variations of NFT 2a and NFT 3a is correct, then it seems that the rising tone and the falling tone have equal opportunity of undergoing leveling. In other words, the rising tone is not suffering from a greater pressure to reduce its contour. This seems to be at odds with a common belief that rising tones are more susceptible to tonal change than falling tones are as they are articulatorily more demanding than falling tones of equal pitch excursion (cf. Xu, 2004; Barrie, 2006; Zhang, Lai, & Sailor, 2009). But there is also evidence showing that rising tones require less duration than falling tones for listeners to perceive. Therefore, it also makes sense that rising tones are not more susceptible to tonal change than falling tones are. Further work needs to be done to clarify this issue.

Table 5.14 NFTs of the context-free tone sandhi systems

Dialects	1a	2a	3a	1b	2b	3b
ZZ	44	45	53	=1a	43	
NJ	44	55	53	=1a	42	
TP	44	55	53	=1a	32	
XM	44	55	53	=1a	32	
CT	44	55	53	=1a	33	
BT	44	35	55	33	43	
XP	44	35	55	33		
RP	44	35	55	33		
HC	44	45	54	33		
NA	*33*	*24*	*55*	*22*		
JJ	*33*	*24*	*55*	*22*		

5.4 The Changes of Zhangzhou FTs/CTs

The average LZ curves of the FTs of the 7 Zhangzhou varieties are reproduced in Fig. 5.15. The values of their CTs are the same as their FTs.

The FT values of these 7 Zhangzhou varieties are summarized as follows (Table 5.15):

As shown in the above table, every FT has undergone some extent of diachronic change. T1a is a high rising tone /45/ in Nanjing and Zhangzhou, and it is a high level /55/ in other places. T2a is a high circumflex /453/ in Nanjing, and it is a high falling /53/ in other places. T3a is a mid falling /42/ in Nanjing, Zhangzhou, and Taipei, low falling /32/ in Changtai and Xiamen, and it is a mid level /33/ in Xipu and Hsinchu. T2b3b is a mid falling /43/ in Changtai, and it is a mid level /44/ in other places.

T1b is the most variable tone in the 7 Zhangzhou varieties. It is a long mid falling tone in Nanjing, having [432] (a.k.a. a long /42/) and [422] two kinds of realizations,

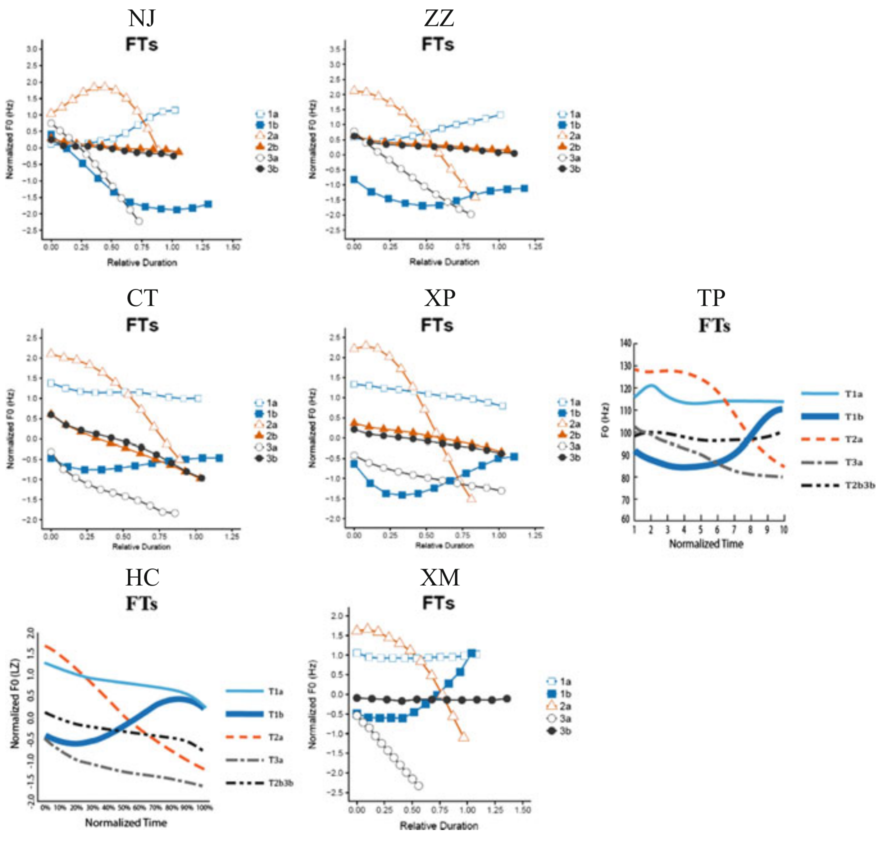

Fig. 5.15 LZ curves of the FTs of 7 Zhangzhou varieties

Table 5.15 FTs/CTs of the 7 Zhangzhou varieties

Dialects	1a	2a	3a	1b	2b	3b
NJ	45	453	42	422	44	
ZZ	45	53	42	22	44	
CT	55	53	32	23	43	
XP	55	53	33	324	44	
TP	55	53	42	324	44	
HC	55	53	33	35	44	
XM	55	53	32	35	44	

FT 1b:	432	> 422	> 22	> 23	> 324	> 35
	[NJ]	[NJ]	[ZZ]	[CT]	[XP, TP]	[HC, XM]

Fig. 5.16 Diachronic changes of FT 1b in the 7 Zhangzhou varieties

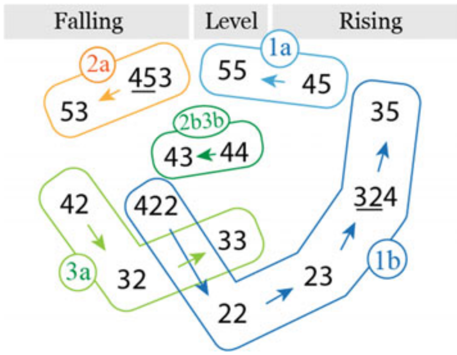

Fig. 5.17 Diachronic changes of the FTs/CTs in the 7 Zhangzhou varieties

and it is a bottom level /22/ in Zhangzhou. In other places T1b is characterized by a rising contour. It is a low rising /23/ in Changtai, front dipping /324/in Xipu and Taipei, and it is a high rising /35/ in Hsinchu and Xiamen.

The different regional variants of T1b can be connected together to form a chain of tonal change. Recall that in Nanjing, T1b contrasts with T3a in Length. Such "mid short vs. long" contrast is attested only in Nanjing. What's more, it would be easier to explain how this contrast in Length is converted to a contrast in contour than the other way around, as long straight falling is a marked form in tone typology (Zhu, 2012). Therefore, I prefer to use the tone pattern of Nanjing as the starting point. Accordingly, the diachronic changes of T1b can be illustrated in Fig. 5.16:

The changes of all Zhangzhou FTs are illustrated in Fig. 5.17. A more detailed illustration is given in Fig. 5.18.

Two hypothetical patterns—*A and *B—are added in Fig. 5.19 to serve as the intermediate stages between Zhangzhou and Xiamen. Interestingly, it is very likely that the FTs of Zhao'an, the southernmost county of Zhangzhou, has the pattern of

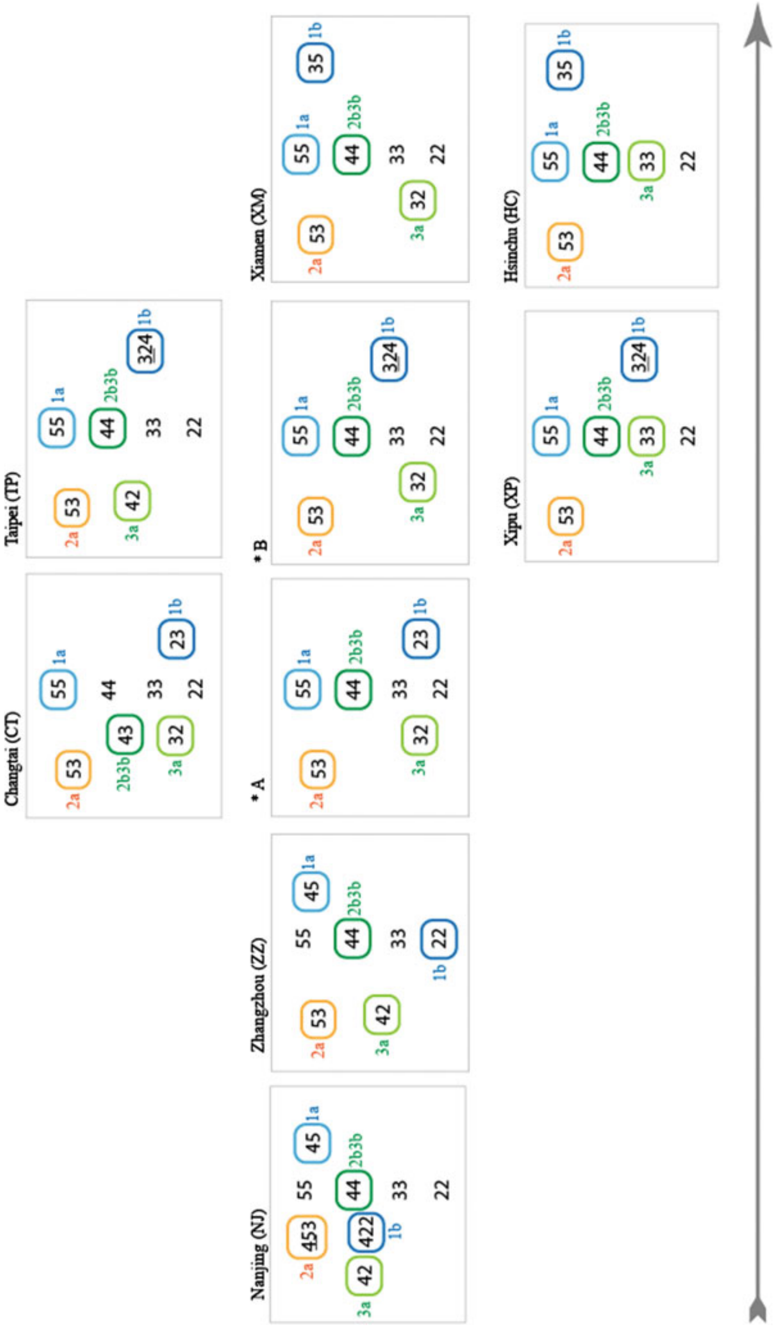

Fig. 5.18 Developments of the FT/CT systems of Zhangzhou varieties

Table 5.16 Zhao'an's FTs/CTs

	1a	2a	3a	1b	2b	3b
FT/CT	*55*	*53*	*21*	*13*	*33*	

*A or *B. Transcriptions provided by Zhang (2016) are given in Table 5.16, in which the traditional five-point scale is used.

The most important point about the changes of Zhangzhou FTs is that we cannot use the contour simplification rule to generalize the changes. The change of FT 1b and FT 2b3b both defy this rule. They change a simple tone into a more complex one (T1b: /22/>/23/>/324/; T2b3b: /44/>/43/).

In fact, the change of FT 1b approximates the change of CT 1b in Meizhou Hakka discussed in Sect. 2.2.1 in many ways. In the original tonal system there is a large gap in the lower region of the tonal space, which allows FT 1b to expand its variants in the direction of this gap and change its center of gravity gradually. In this sense, the change of FT 1b is comparable to the "drag" part of a drag chain. What's more, the shift of FT 1a from /45/ to /55/, which is probably dragged by the shift of FT 3a from /453/ to /53/, leaved a new gap in the rising region of the tonal space, and thus FT 1b can shift all the way to the high rising tone. In the meanwhile, the raising of FT 1b once again created a gap in the lower region of the tonal space, attracting FT 3a to change into a low tone.

The above analysis shows that the change of Zhangzhou's FTs/CTs can be described as a series of chain shifts. This is just what we expected as discussed in Chap. 2.

5.5 Summary

In this chapter I presented the tone sandhi patterns of 10 different Zhang-Quan varieties and analyzed the diachronic tonal changes involved.

To begin with, I reported 5 SM varieties which are similar in their NFTs but vary widely in their FTs/CTs. The existence of such a common NFT pattern across different SM subgroups reinforces the idea that there is a common mechanism underlying the changes of SM NFTs, and therefore different SM dialects may undergo parallel evolution in their NFTs. In fact, all of the NFT patterns discussed in this book can be related together, and most of the changes involved can be accounted for by tonal reduction, which reduces contour complexity and the number of tonal contrasts.

Next, 7 Zhangzhou varieties were selected to address the problem of FT/CT change. The results showed that, the changes of Zhangzhou FTs can be characterized as a series of chain shifts, not necessarily target at tones with simpler contour, and no tonal neutralization is involved. The difference between NFT and FT/CT change is consistent with our prediction made in Chap. 2 that SM NFTs would undergo prosodic-driven tone reduction and FTs/CTs would undergo non-reductive chain shifts.

Fig. 5.19 The disyllabic tone sandhi of Zhangping. Adapted from Zhang (2007)

<table>
<tr><td></td><td>FT 1a</td><td>FT 1b</td><td>FT 3a</td><td>FT 2a</td><td>FT 3b</td></tr>
<tr><td>σ_1 \ σ_2</td><td>24</td><td>11</td><td>53</td><td>31</td><td>21</td></tr>
<tr><td>NFT 1a</td><td colspan="3" rowspan="3">33-T_{σ_2}</td><td colspan="2" rowspan="3">55-T_{σ_2}</td></tr>
<tr><td>NFT 1b</td></tr>
<tr><td>NFT 3a</td></tr>
<tr><td>NFT 2a</td><td colspan="5" rowspan="2">21-T_{σ_2}</td></tr>
<tr><td>NFT 3b</td></tr>
</table>

Two points needs to be clarified here. First, there are still many SM varieties whose NFTs do not show a close correspondence with the NFT patterns discussed above. But the principles of NFT change proposed in this book should also hold true for these SM varieties, as long as their tone sandhis are final-prominent. Take for example the tone sandhi of Zhangping as mentioned in Sect. 2.3.1 (reproduced in Fig. 5.19, added with traditional tone categories).

In Zhangping, NFT 1a, 1b, and 3a have undergone context-dependent tonal split and tonal neutralization, and it is clear that the results of these changes are less tonal contrasts and more level tones. Note also that, if based only on the synchronic values of Zhangping tones, we cannot make any phonetically reasonable generalization about the conditions of these changes. It is likely that Zhangping's FTs/CTs have undergone dramatic changes after its NFT splits.

Second, as far as my data are concerned, there is no clear evidence showing NFT changes in response to the change of FTs/CTs,[1] or vice versa. Of course we should never rule out this possibility, but the current research shows clearly that the changes of SM FTs/CTs and NFTs can be highly independent and divergent from each other.

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[1]Contextual NFT split is not interaction between NFT change and FT change. It reflects the influence of the synchronic tonal value of FTs on the change of NFTs.

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Chapter 6
Conclusions

6.1 The Diachrony of SM Tone Sandhi

The current research puts forward a new position-based diachronic approach to study and explain the final-prominent tone sandhi of Southern Min (SM), which is known for its synchronic arbitrariness and opacity. I argued throughout this book that, in SM, the change of final tones (FTs) and the change of non-final tones (NFTs) can be highly independent and essentially different from each other. Therefore, to fully explain the formation of SM tone sandhi, at least three kinds of tonal change should be considered: (1) the independent change of FTs; (2) the independent change of NFTs; and (3) the interaction between FTs and NFTs. The first two kinds of tonal change give rise to context-free tone sandhi, while the last one results in context-conditioned tone sandhi. Generally speaking, the independent change of FTs follows the change of citation tones (CTs), which often takes the form of chain-shift, driven mainly by system-internal pressure. On the other hand, the independent change of NFTs is reductive in most cases, driven mainly by prosodic modulation. Theoretical bases and empirical evidence supporting this FT-NFT distinction were presented in this book.

In Chap. 1, I first reviewed recent advances in the study of tone sandhi in general. These studies indicated that prosodic-induced tonal variations can be phonologized into tone sandhi, and thus it is natural for a tone sandhi alternation to mirror the prosodic influence on tone production. Then I reviewed studies on SM tone sandhi which showed that many SM tone sandhi alternations are no longer phonetically transparent and the abstract tone alternation rules or constraints no longer play a central role in SM tone sandhi processing. Instead, evidence suggests that SM speakers often store both the FT form and the NFT form of the same morpheme in their lexicon. Therefore, when dealing with SM tone sandhi, synchronic approaches relying on NFT-FT alternations cannot unveil the real nature of the formation of SM tone sandhi. A new position-based diachronic approach is proposed in this book to address this problem.

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In Chap. 2, I established theoretical bases for the position-based diachronic approach. I reviewed latest research findings on the change of citation tones, and typological and phonetic studies concerning differences between tones occurring in domain-final and non-final positions. I concluded that the change of citation tones often takes the form of chain shift, and that it is bidirectional and does not entail a reductive direction, while non-final tones are prone to prosody-driven tone reduction, which reduces the complexity of tonal contour and the number of tonal contrasts.

Then I applied this position-based diachronic approach to SM tone sandhi. Chapter 3 introduced the SM dialects investigated in this book and the tone experiments conducted to elicit first-hand acoustic data from speakers of 6 Chao-Shan varieties and 4 Zhang-Quan varieties.

In Chap. 4, based on the first-hand acoustic data of the tone sandhi of 6 Chao-Shan varieties, I demonstrated that there is indeed a tendency for NFTs to reduce in contour complexity, changing from straight falling/rising tones to slight falling/rising tone or level tones. This contour-reduction tendency can be accomplished through context-free tonal shift or context-conditioned tonal split. In addition, the tendency for NFTs to reduce in contrast number are also found.

In Chap. 5, based on an extensive comparison of the tone sandhi patterns of 10 Zhang-Quan varieties, I demonstrated that SM's FTs/CTs are able to change without interfering the change of NFTs, and the change of FTs/CTs often takes the form of chain-shift, driven mainly by system-internal pressure, while the change of NFT often takes the form of reduction, as in the case of Chao-Shan.

6.2 The Formation of Tone Circle

This book has demonstrated that the position-based diachronic approach can successfully and concisely explain the formation and development of various SM tone sandhi, including the puzzling Tone Circle of Xiamen. The tone sandhi pattern of Xiamen is reproduced in Table 6.1 (the tones are described according to the RL model).

Viewed from a position-based diachronic perspective, the synchronic mappings from FT to NFT (or vice versa) only represent a particular stage of the historical development of FTs and NFTs. Take T1b for example, according to the analyses in Sects. 5.3 and 5.4, NFT 1b has been neutralized with NFT 1a (/44/), while FT 1b has undergone a series of chain shift /422/ > /22/ > /23/ > /324/ > /35/. Therefore, the surface tonal alternation of T1b depends mainly on the development of FT 1b. Similarly, in the case of T3a, the NFT value (/53/) does not undergo any change (as far as my data can tell), while the FT value (/32/) has changed from /42/ to/32/. Viewed from a synchronic perspective, the tone sandhi of T3a looks very unnatural (/32/ > /53/), as the non-final sandhi form is greater in pitch range and higher in pitch height than the final/citational form is. However, this synchronic unnaturalness didn't block the historical change of FT 3a.

Table 6.1 Xiamen tones (reproduced from Table 5.10) [left] and Xiamen tone circle [right]

	1a	2a	3a	1b	2b	3b
FT	55	53	32	35	44	
NFT	44	55	53	=1a	32	

/55/	→	/44/	←	/35/
↑		↓		
/53/	←	/32/		

As mentioned in Sect. 1.3.1, circular or structure-preserving tone sandhi is not an essential characteristic shared by different SM varieties (the tone sandhi patterns of Changtai and Nanjing are reproduced in Table 6.2 as two examples). In fact, even the tone sandhi of Taipei, which is commonly regarded as an exemplar of Tone Circle, is possibly not strictly structure-preserving (as discussed in Sect. 5.2.2). This fact indicates that the diachronic changes of FTs and NFTs are not limited to the existing tones in the tone inventory—they are not candidate-selection processes.

6.3 Implications and Further Challenges

In conclusion, the present research makes the following contributions to the existing literature on tone and tone sandhi:

i. It is the first study to systematically explore the diachronic aspect of SM tone sandhi;
ii. It addresses a new research question of tonal change—the diachronic changes of tones occurring in different prosodic positions;
iii. It provides detailed acoustic documentation of the tone sandhi patterns of 10 SM varieties, which have not yet been phonetically investigated before;
iv. It provides for the first time an explicit and systematic explanation for the patterning of the tone sandhi of different SM varieties.

This book not only shows the great power of diachronic explanation for tone sandhi patterns, it also explicitly demonstrates that the diachronic change of tones occurring in different positions can be completely independent and essentially different, and that we cannot gain a thorough understanding of the formation and development of tone sandhi if this position-based tonal change is not taken into account. Both context-free tone sandhi and context-conditioned tone sandhi (as discussed in Chap. 4) follow the general rules of position-based tonal change.

Previous studies on tone sandhi seldom seriously investigated the separate change of sandhi tones and citation tones, as they were generally more concerned about the alternations between citation tones and sandhi tones. Therefore, the position-based diachronic approach is very promising for future study of tone sandhi.

There is still, of course, a long way to go to uncover the mechanism of the evolution of tone sandhi. The current research is limited in both size and scope. A larger sample size would be needed to fully elucidate the development of SM tone sandhi. More importantly, the current book did not touch on tone sandhi which is not final-prominent. Further research should be undertaken to explore whether the ideas and conclusions drawn from pure final-prominent tone sandhi also hold for other types of tone sandhi systems.

Table 6.2 Changtai tones (reproduced from Table 5.11) [left] and Nanjing tones (reproduced from Table 5.12) [right]

	1a	2a	3a	1b	2b	3b			1a	2a	3a	1b	2b	3b
FT	55	53	32	23	43			FT	45	453	42	422	44	
NFT	44	55	53	=1a	33			NFT	44	55	53	=1a	42	

Appendix A
Monosyllabic Reading List

1a		1b	
家	Home	茶	Tea
猪	Pig	橱	Closet
龟	Turtle	除	To divide
膏	Cream	无	Nothing
刀	Knife	爬	To climb
胶	Glue	逃	To escape
支	CL (of pens)	脾	Spleen
波	Wave	旗	Flag
2a		2b	
父	Father	币	Coin
举	To lift	据	According to
宝	Treasure	技	Skill
假	Fake	咬	To bite
稿	Manuscript	在	In
比	To compare	具	Tool
久	Long	弟	Little brother
短	Short	舅	Uncle
3a		3b	
块	Chunk	袋	Bag
秘	Secret	旧	Old
教	To teach	帽	Hat
智	Wisdom	地	Earth
痣	Nevus	味	Smell
记	To record	闭	To close
报	Newspaper	箸	Chopstick
句	Sentence	避	To avoid

(continued)

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(continued)

4a		4b	
百	Hundred	直	Straight
答	To answer	局	Bureau
得	To get	学	To learn
逼	To force	择	To choose
骨	Bone	独	Alone
甲	Shell	白	White
角	Horn	薄	Thin
竹	Bamboo	木	Wood

Appendix B
Disyllabic Reading List

NFT 1a + FT __			
1a+1a		1a+2a	
三斤	Three jins	三本	Three CL (of books)
猪心	Pig's heart	猪尾	Pig's tail
飞机	Plane	家长	Parents
中秋	Mid-Autumn	基本	Basic
关灯	To close the light	胶水	Glue
1a+3a		1a+4a	
三次	Three times	三节	Three sessions
猪肺	Pig's lung	猪骨	Pig's bone
机器	Machine	中国	China
青菜	Vegetable	工作	Work
分数	Score	春节	Spring Festival
1a+1b		1a+2b	
三楼	Third floor	三倍	Threefold
猪头	Pig's head	猪肚	Pig's tripe
家庭	Family	家具	Furniture
开门	To open the door	兄弟	Brother
冰糖	Rock sugar	鸡卵	Egg
1a+3b		1a+4b	
三袋	Three bags	三十	Thirty
分队	Team	单独	Alone
基地	Base	家族	Clan
生病	To get sick	开学	Beginning of term
军队	Troop	鸡翅	Chicken wing
NFT 2a + FT __			
2a+1a		2a+2a	
九斤	Nine jins	九本	Nine CL (of books)
海鲜	Sea food	水果	Fruit

(continued)

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(continued)

NFT 2a + FT __			
饼干	Biscuit	稿纸	Lined paper
火车	Train	米粉	Rice noodle
广东	Guangdong	请假	To ask for leave
2a+3a		2a+4a	
九次	Nine times	九节	Nine sessions
比较	To compare	改革	Reform
补课	To make up class	主角	Leading role
短裤	Short pants	软骨	Cartilage
炒菜	To fry vegetable	美国	The United States
2a+1b		2a+2b	
九楼	Ninth floor	九倍	Ninefold
枕头	Pillow	水利	Water conservation
语文	Langauge arts	保护	To protect
主题	Subject	主动	Active
肚脐	Navel	领导	Leader
2a+3b		2a+4b	
九袋	Nine bags	九十	Ninety
写字	To write	武术	Martial arts
马路	Road	宝石	Gem
本地	Local	主席	Chairman
炒饭	To fry rice	选择	To choose

NFT 3a + FT __			
3a+1a		3a+2a	
四斤	Four jins	四本	Four CL (of books)
教师	Teacher	酵母	Yeast
半斤	Half jin	报纸	Newspaper
教书	To teach	记者	Reporter
气功	Chikung	气管	Trachea
3a+3a		3a+4a	
四次	Four times	四节	Four sessions
教训	Lesson	教室	Classroom
报告	Report	四角	Four corners
计算	To calculate	价格	Price
校对	To proofread	报失	To report the loss
3a+1b		3a+2b	
四楼	Fourth floor	四倍	Fourfold
教材	Textbook	教授	Professor
钢琴	Piano	智慧	Wisdom
价钱	Price	报道	To report
过年	To celebrate the new year	气象	Weather

(continued)

(continued)

NFT 3a + FT __			
3a+3b		3a+4b	
四袋	Four bags	四十	Forty
教练	Coach	教育	Education
记号	Mark	记录	Record
布袋	Cloth bag	价值	Value
退步	To retrogress	智力	Intelligence
NFT 4a + FT __			
4a+1a		4a+2a	
七斤	Seven jins	七本	Seven CL (of books)
结冰	Frozen	结果	Result
国家	Nation	滴水	To dribble
北京	Beijing	竹管	Bamboo tube
骨科	Orthopedics	色彩	Color
4a+3a		4a+4a	
七次	Seven times	七节	Seven sessions
结构	Structure	结束	To finish
笔记	Note	隔壁	Next-door
国际	International	出血	To bleed
撤退	To retreat	德国	German
4a+1b		4a+2b	
七楼	Seventh floor	七倍	Sevenfold
结缘	Become attached to	结论	Conclusion
国旗	National flag	激动	Exited
骨头	Bone	博士	Doctor
北门	North gate	革命	Revolution
4a+3b		4a+4b	
七袋	Seven bags	七十	Seventy
角度	Angle	结局	Ending
决定	Decide	作业	Homework
速度	Speed	积极	Positive
国外	Foreign	复杂	Complex
NFT 1b + FT __			
1b+1a		1b+2a	
茶杯	Teacup	茶几	Tea table
牛筋	Cow's tendon	牛屎	Cow dung
房间	Room	苹果	Apple
牙膏	Toothpaste	门口	Front door
爬山	To climb hill	长短	Length
1b+3a		1b+4a	
茶费	Cost of tea	茶粕	Dregs of tea

(continued)

(continued)

NFT 1b + FT __			
图案	Pattern	牛角	Ox horn
皮带	Belt	黄色	Yellow
群众	The masses	排骨	Ribs
红布	Red cloth	河北	Hebei
1b+1b		1b+2b	
茶壶	Teapot	茶具	Tea set
牛皮	Cowhide	牛奶	Milk
旗袍	Chi-pao	皮具	Leather product
枇杷	Loquat	棉被	Cotton quilt
葡萄	Grape	条件	Condition
1b+3b		1b+4b	
茶树	Tea tree	茶叶	Tea leaf
桃树	Peach tree	牛肉	Beef
排队	To queue	同学	Classmate
肠胃	Intestines and stomach	桃核	Penult
红豆	Red bean	鹅翅	Goose wing

NFT 2b + FT __			
2b+1a		2b+2a	
五斤	Five jins	五本	Five CL (of books)
电梯	Elevator	电脑	Computer
两支	Two	父母	Parents
坐车	(Go) on a ride	具体	Specific
被单	Bed sheet	校长	Headmaster
2b+3a		2b+4a	
五次	Five times	五节	Five sessions
电器	Electrical appliance	电压	Voltage
两对	Two pairs	两桌	Two desks
市价	Market price	动作	Motion
重要	Important	道德	Morality
2b+1b		2b+2b	
五楼	Fifth floor	五倍	Fivefold
电台	Radio station	电视	Television
两条	Two CL (of ropes)	两件	Two pieces
坐船	(Go) by boat	社会	Society
距离	Distance	护士	Nurse
2b+3b		2b+4b	
五袋	Five bags	五十	Fifty
电话	Telephone	电力	Electricity
两队	Two troops	两粒	Two particles
部队	Troops	拒绝	Refuse
道路	Road	动物	Animal

NFT 3b + FT __

3b+1a		3b+2a	
地区	District	地主	Landlord
味精	MSG	效果	Effect
画家	Painter	渡口	Ferry
第三	Third	第九	Ninth
面包	Bread	地板	Floor
3b+3a		3b+4a	
地价	Land price	地铁	Subway
外套	Coat	大雪	Heavy snow
位置	Location	面色	Facial expression
第四	Fourth	第七	Seventh
尿布	Diaper	外国	Foreign country
3b+1b		3b+2b	
地图	Map	地道	Tunnel
大桥	Bridge	大舅	Elder uncle
豆芽	Bean sprout	味道	Flavor
地球	The Earth	第五	Fifth
面条	Noodle	运动	Exercise
3b+3b		3b+4b	
地洞	Burrow	地域	Region
大事	Major event	饭盒	Lunch box
现代	Modern	艺术	Art
鼻炎	Rhinitis	第六	Sixth
画画	To paint	树木	Tree

NFT 4b + FT __

4b+1a		4b+2a	
六斤	Six jins	六本	Six CL (of books)
学生	Student	学者	Scholar
读书	To read	木板	Board
值班	Be on duty	日本	Japan
律师	Lawyer	月饼	Moon cake
4b+3a		4b+4a	
六次	Six times	六节	Six session
学费	Tuition	合作	Cooperation
目镜	Glasses	及格	Pass (in a test)
日记	Diary	一百	One hundred
实际	Actual	直角	Right angle
4b+1b		4b+2b	
六楼	Sixth floor	六倍	Sixfold
学期	Semester	学校	School
特殊	Special	落雨	To rain

(continued)

(continued)

NFT 4b + FT __			
木棉	Kapok	十五	Fifteen
值钱	Worthy	杂技	Acrobatics
4b+3b		4b+4b	
六袋	Six bags	六十	Sixty
学问	Knowledge	学习	To learn
直路	Straightaway	毒药	Poison
实话	Truth	值日	Be on duty for the day
绿豆	Green bean	独立	Independence

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