



The common word prosody in Northern Wu

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Abstract

This study revisits the phonological representation and phonetic implementation of tone sandhi of Wu dialects by examining three Northern Wu dialects that still have seven or eight monosyllabic tones. It is found that the implementation of tone sandhi is highly variable across tonal categories and dialects, and complete spreading is relatively rare. Despite all kinds of variations, we found that there is a common word prosody template shared by Northern Wu dialects: 1) non-initial syllables also contribute to the sandhi patterns; 2) both initial and non-initial syllables undergo neutralization, with the initial syllable neutralizing contours and the non-initial syllable neutralizing registers. In addition, because of the reduced pitch range of the non-initial syllables, the contribution of the non-initial syllables is likely to get lost in Wu dialects.

Index Terms: Tone sandhi, word prosody, Wu dialects

1. Introduction

Tone sandhi is a very important phonological process of Chinese Wu dialects, as it is involved in word formation and is sensitive to both prosodic organization and morphosyntactic structures [1–5]. Tone sandhi domain in Wu usually contains 2-3 syllables, which is regarded as the metrical domain of Wu dialects [6]. As shown by [7], in Shanghaiese, phonological tone sandhi only applies for modifier + Noun structures, but not for Verb + Noun structures. So the tone sandhi domains essentially mark the boundaries of words. Given its importance in language processing, the phonetic implementation and phonological representation of the tone sandhi of Wu dialects, especially Shanghaiese, has received much discussion. Based on the dominancy and direction of tone sandhi, there are two major types of tone sandhi among Chinese dialects, i.e., left-dominant or right-dominant [8–11]. Mandarin is a typical right-dominant language, as Tone 3 sandhi in Mandarin applies to the first syllable of a two-Tone3 sequence: 214 + 214 \Rightarrow 35 + 214. Shanghaiese, one of the Northern Wu dialects, on the other hand, is known as a typical left-dominant language, as the overall sandhi contour is determined by the first syllable and the underlying tone of the second syllable is essentially deleted. The tonal contour of the first syllable spreads over two (or more) syllables. For example, 53 + X \Rightarrow 55 + 31 (X = any tones in Shanghaiese).

However, the implementation of tone sandhi is not completely categorical. For example, although phonological analyses generally agree that non-initial tones in the sandhi domain is deleted, careful phonetic analysis [7] showed that complete neutralization is only found for Tone 1 (53) and Tone 5 (12, underline indicates checked tones); for Tone 2 (34), 3 (13) and 4 (55), the second syllable still plays a weak but statistically significant role. Therefore, it is possible that the implementation of spreading is actually gradient than categorical. Related to the

phonetic gradiency, Chen [12] found that there is a Low tone at the end of the polysyllabic sandhi domain of Shanghaiese, and thus argued that the fundamental mechanism of tone sandhi in Shanghaiese is comparable to neutral tone (i.e. qingsheng) in standard Mandarin. That is, domain non-initial tones gradually neutralize into a Low tone. These studies brought out an interesting question: to what extent the tone sandhi contour is determined by phonological process, and to what extent the contour is determined by phonetic implementation, such as reduction and gradient neutralization.

Furthermore, although tone sandhi in Shanghaiese is clearly left-dominant and rightwards spreading, tone sandhi process is found to be much more complicated and more variable in other Wu dialects. Scholars usually divide Wu dialects into two major groups – Northern Wu and Southern Wu, and generally agree that the sandhi types are quite different for these two Wu sub-dialects [8, 13–16]. However, even among Northern Wu dialects, it is usually hard to reach consensus of how many sandhi patterns there are in a given dialect variety. For example, the number of tone sandhi patterns in Shaoxing, a Northern Wu dialect, is reported to be 18, 22, and 8, in [2, 17, 18], respectively. The variability of tone sandhi will be discussed in detail in the 4.1 section. Adding on to the complexity, it seems that other tone sandhi mechanisms other than spreading, such as substitution, can co-exist in the same dialect [19]. For example, in Wuxi, two steps are involved in the derivation of tone sandhi, substitution (i.e., base tone replaced by another tone) before spreading. Therefore, to better understand the phonological representation and phonetic implementation of tone sandhi in Wu dialects, it is necessary to explore other Wu varieties. Since the tonal inventory in Shanghaiese has been significantly simplified compared to other Wu dialects, it is especially necessary to explore the dialect varieties that have relatively more conservative tone system. By doing this, we will also have a better understanding of the historical change of tone sandhi in Wu dialects.

In summary, the goal of this paper is to revisit issues of phonological representation and phonetic implementation of tone sandhi in several Northern Wu dialects. Specifically, we would like to examine the role of underlying tones of both initial and non-initial syllables in a sandhi domain, by modeling the tonal spaces of both syllables. As a preview, we shall argue that, despite all kinds of variability within and across different dialects, there is a general lexical prosody among Northern Wu dialects, which greatly influences the path of historical change of tone sandhi in Wu.

2. Languages

In this paper, we will discuss three Northern Wu dialects which have either seven or eight underlying tones.

2.1. Shaoxing

Shaoxing city is located on the southeastern coast of China, about 200 kilometers south of Shanghai. According to [2, 20], the tonal system of Shaoxing displays a proto-typical system of eight tones corresponding to traditional eight-tone system of Middle Chinese, as shown in Table 1. Essentially, the tonal system is organized with two features: 2 tonal registers (High and Low) and 4 tonal categories that are primarily distinguished in the shape of contours (i.e., Ping ("level"), Shang ("rising"), Qu ("falling"), Ru (checked, with a glottal stop coda), in traditional terms). Of course, the actual contour shapes of Shaoxing are different from the names of the historical categories.

Table 1: *The tonal inventory of Shaoxing*

	Ping	Shang	Qu	Ru
High	52	335	33	<u>5</u>
Low	231	113	11	<u>2</u>

2.2. Zhuji

Zhuji county is located in the northwest of Shaoxing city. Zhuji and Shaoxing are mutually intelligible, and their sound systems mainly differ in tones. It is interesting that, although High Qu has merged into High Ping in monosyllabic syllables, they are still distinctive categories in the sandhi. The following sandhi analysis thus will be based on eight tonal categories. The tonal inventory of Zhuji is shown in Table 2. Data come from [21].

Table 2: *The tonal inventory of Zhuji*

	Ping	Shang	Qu	Ru
High	31	41		<u>4</u>
Low	23	251	231	<u>2</u>

2.3. Xinzhuang

Xinzhuang is a town located in the suburban area of Shanghai. This Wu dialect has seven monosyllabic tones, and is considered to reflect the earlier stage of the Urban Shanghainese before it underwent mergers. The tonal patterns of Xinzhuang and Urban Shanghainese reported in [22] are summarized in Table 3. As shown in Table 3, there is a clear correspondence between Shanghainese and Xinzhuang dialect. Similar to Zhuji, although there are only seven monosyllabic tones, the tone sandhi patterns are based on eight underlying categories.

Table 3: *The tonal inventory of Xinzhuang and Urban Shanghainese*

	Ping	Shang	Qu	Ru
Xinzhuang				
High	53	55	35	<u>55</u>
Low	31	13		<u>23</u>
Shanghai				
High	53		34	<u>55</u>
Low			13	<u>12</u>

3. Methods

Recordings were made in a field trip in China. 10 speakers from Shaoxing (average 55 years old), 6 speakers from Zhuji (average 66 years old), 11 speakers from Xinzhuang (average 61 years old) were recruited for this study. Each speaker was asked to read a randomized word list with all eight x eight tonal combinations (five words for each combination) that are disyllabic nominal compounds. Each token was repeated twice.

F0 values were extracted with Praat using autocorrelation method [23]. Before analysis, raw F0 values were within-speaker normalized based on each speaker's mean F0. The tonal spaces in 4.2 section were modeled based on functional principal component analysis, using the *fda* package in *R* [24]. This method takes account in the holistic shape of the F0 contours while being able to represent the variability of the F0 contours in a low dimensional space. [25] found this method effectively captures the cross-linguistic variation among a few tonal languages with phonologically meaningful dimensions. To parameterize F0 contours, smoothing was first applied to transform a contour into a smooth continuous function of time. B-splines was chosen as the function set for smoothing [26]. In order to find the optimal values for two parameters (k ; λ), generalized cross-validation (GCV), proposed by [24] was employed. Then Functional Principal Component Analysis (FPCA) was applied on the smoothed data to generate the mean curve and several principal component curves, as well as weights for the principle component curves, based on the same principles as ordinary PCA [27,28]. The rank of the PCs reflects the decreasing percentage of variance in the input data that the PCs explain.

4. Results and Discussions

4.1. Variability of tone sandhi contours

We plotted F0 contours of all eight x eight tonal combinations for all the three dialects to observe the sandhi patterns. Due to the space limitation, it is not possible present all pitch contours here. Therefore we will highlight some of the important observations with examples. An overall observation is that both initial and non-initial syllables play important roles in sandhi contours, but the actual contributions from the two syllables vary from categories to categories. For example, as shown in Figure 1, in Shaoxing, when the initial tone is High Shang (335, Figure 1a) or High Qu (33, Figure 1b), there is a clear spreading pattern, as the overall sandhi contour is determined by the first syllables, and the second syllables are largely neutralized (except for Ru tones). And the overall falling contour of the second syllables indicates that there is a L target inserted at the end of the domain (same analysis is also suggested by [15]).

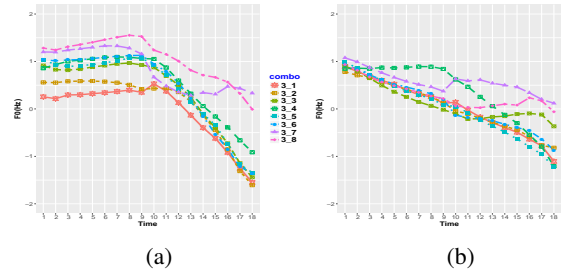


Figure 1: *Examples of near-complete spreading in Shaoxing: (a) 335 (H Shang) + X; (b) 33 (H Qu) + X. T1,T2=Ping; T3,T4=Shang; T5,T6=Qu, T7,T8=Ru.*

However, when the initial tone is a Ping tone, either High Ping (52, Figure 2a) or Low Ping (231, Figure 2b), the overall sandhi contours are determined by both the initial and non-initial syllables. Although the sandhi contours to some extent can be seen as the extension of the first syllable, the overall contours are also distinguished by the contour categories (i.e., Ping, Shang, Qu and Ru) of the second syllables. A three-way contrast can be observed here: Ping vs. Shang/Qu vs. Ru.

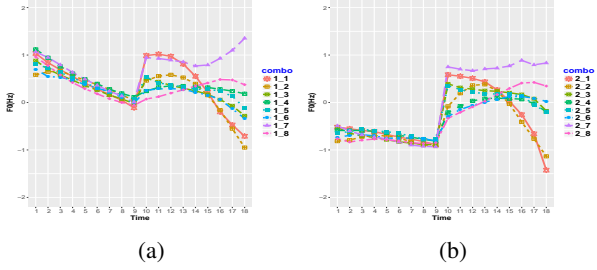


Figure 2: Examples from Shaoxing: (a) 53 (H Ping) + X; (b) 231 (L Ping) + X. $T1, T2 = \text{Ping}$; $T3, T4 = \text{Shang}$; $T5, T6 = \text{Qu}$, $T7, T8 = \text{Ru}$.

When we compare Shaoxing and Zhuji, the two very closely related dialects, dialectal variation can be clearly seen as well. Comparing Figure 3 (Zhuji) with Figure 1 (Shaoxing), although a overall trend of spreading based on the first syllable can still be seen in Figure 3, the variability of sandhi contours in Zhuji is so much greater. Non-initial Ping/Shang contours are well distinguished from non-initial Qu/Ru contours. In Zhuji, there is no complete or near-complete spreading as in Figure 1. Overall the second syllables play a much heavier role in Zhuji's tone sandhi.

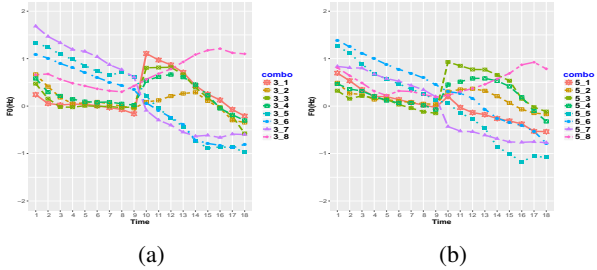


Figure 3: Examples from Zhuji: (a) 335 (H Shang) + X; (b) 33 (H Qu) + X. $T1, T2 = \text{Ping}$; $T3, T4 = \text{Shang}$; $T5, T6 = \text{Qu}$, $T7, T8 = \text{Ru}$.

Similar dialectal variation is also observed between Xinzhuang and Shanghai, the two most comparable varieties. For example (Figure 4), the second syllables in the combination of High Ping (53) + X in Shanghainese are completely neutralized, while in Xinzhuang it is still partially determined by the contour categories of the second syllables. Specifically, non-initial Qu and Ru contours are separate from Ping and Shang.

Moreover, although neutralization was mostly discussed for the non-initial syllables, we found that actually the initial syllables also undergo neutralization. For example, as shown in Figure 5, for the X + High Shang combinations in Shaoxing and Zhuji, the initial syllables are neutralized into two groups based on registers. Again, the extent of neutralization is much less in Zhuji. Figure 5 also supports the observation (c.f. Figure 3) that the influence from the initial syllable is much weaker for

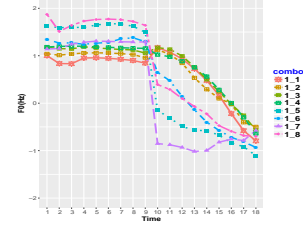


Figure 4: Examples from Xinzhuang: 53 (H Ping) + X. $T1, T2 = \text{Ping}$; $T3, T4 = \text{Shang}$; $T5, T6 = \text{Qu}$, $T7, T8 = \text{Ru}$.

Zhuji than for Shaoxing.

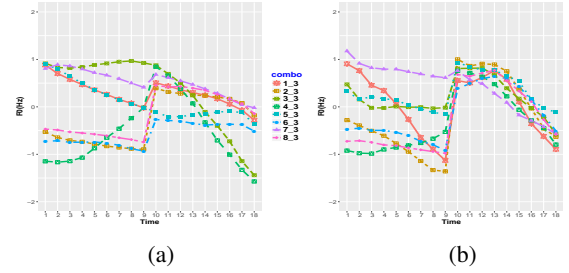


Figure 5: X + H Shang in (a) Shaoxing; (b) Zhuji. $T1, T2 = \text{Ping}$; $T3, T4 = \text{Shang}$; $T5, T6 = \text{Qu}$, $T7, T8 = \text{Ru}$.

In summary, this section demonstrates that tone sandhi in Wu dialects is highly variable from category to category, and from dialect to dialect. The three Wu dialects discussed here probably exhibit the earlier forms of tone sandhi of Wu. While the general principle of tone sandhi among the three Wu dialects is rightwards spreading, the implementation of spreading is gradient in nature: 1) both initial syllable and non-initial syllables contribute to the overall shape of the sandhi contours, but weights can vary across categories and dialects; 2) both syllables undergo neutralization, but again the extent can vary across categories and dialects. Because of the gradiency, it is not surprising that researchers were not able to reach consensus of the actual number of sandhi categories. The question for us is then: Are we able to capture the general pattern of tone sandhi while taking account into the variations across categories and dialects?

4.2. Tonal spaces for initial and non-initial syllables

For each dialect, PFCA models were fitted for F0 contours of all syllables, following the procedure described in section 2. Similar first four Functional Principal Components (FPCs) are found for the three languages, which are also similar to other tonal languages [25]. As illustrated in Figure 6, the four FPCs basically represent the first four dimensions of the F0 contours, which are phonologically meaningful: The first FPC varies in height, with higher scores for higher-pitched tones; the second FPC varies in direction, positive scores for rising contours and negative scores for falling contours; likewise, the third FPC represents dipping or convex contours. Since the first two FPCs (height and direction) can account for over 90% variation for all three dialects, we plotted tonal spaces based on the first two FPCs. Tonal spaces were plotted for the initial and non-initial syllables based on their underlying tones separately. Figure 7, 8 and 9 are sandhi spaces from the three dialects.

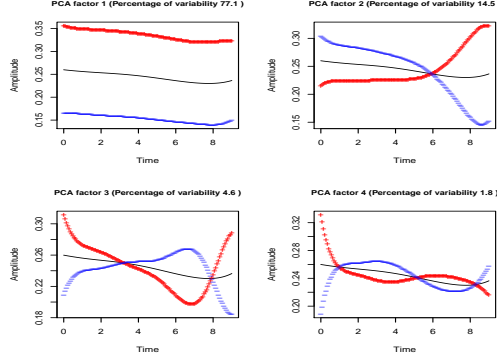


Figure 6: First four functional principle components

The tonal spaces are fairly similar across the three dialects, which confirms that there indeed is a general word prosody shared by the three Northern Wu dialects. Overall, in the tonal space of the initial syllable, the eight underlying tones are mostly clustered by the two registers along the first FPC dimension (pitch height, c.f. Figure 6); while in the tonal space of the second syllable, the tonal categories are mostly distinguished by contour categories (i.e., Ping, Shang, Qu and Ru) along the second FPC dimension (direction). These tonal spaces have several important implications for the nature of tone sandhi in Wu dialects: 1) It is clear that register and contours are two independent dimensions in Northern Wu, and they have different weights in the first and second syllables; 2) related to 1), both initial and non-initial syllables in the sandhi domain contribute to the overall contour of the combination, but their roles are different; 3) indeed both syllables are neutralized to some extent, and the first syllable tends to be neutralized in contours while the second syllable tends to be neutralized in registers. Therefore, the general lexical prosody template of Northern Wu is that: The first syllable preserves registers + the second syllable preserves contours, while the contour of the first syllable spreads. Building upon the basic template of word prosody, dialects and specific tonal categories are allowed to have flexibility and variation in the extent of realization, resulting in the gradient spreading widely observed in various Wu dialects (c.f. previous section).

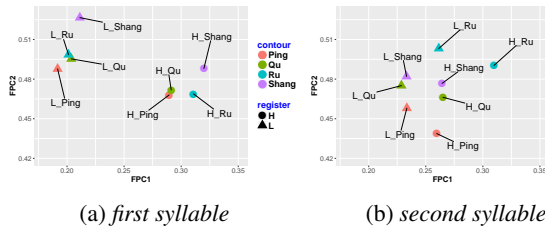


Figure 7: FPC1 X FPC2 tonal spaces for Shaoxing disyllabic sandhi

Moreover, the common word prosody found in this study also sheds light on the historical development of complete spreading, as in Shanghaiese tone sandhis. We propose that the basic word prosody is probably the driving force behind this. As indicated in Figure 7b, 8b and 9b, because of the neutralization in registers, the overall pitch range (reflected in the range of FPC1 scores) of the second syllables is substantially reduced.

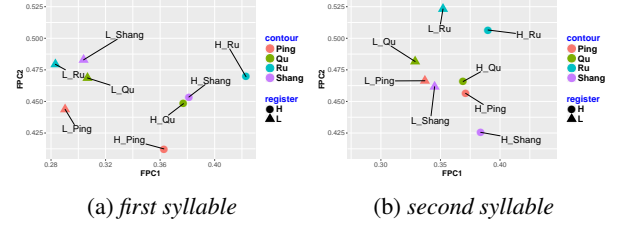


Figure 8: FPC1 X FPC2 tonal spaces for Zhuji disyllabic sandhi

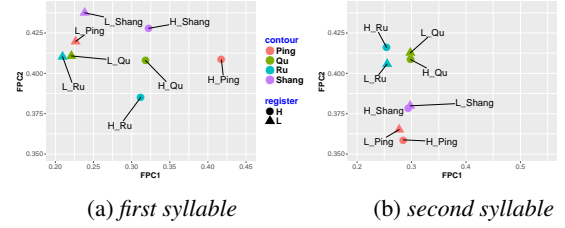


Figure 9: FPC1 X FPC2 tonal spaces for Xinzhuang disyllabic sandhi

As a result, the contour contrasts of the second syllables have to realize in a very narrow pitch range, which is conceivably hard to maintain in production and also confusing in perception. This is possibly why the contribution of the second syllable is generally weaker, and more likely to get lost among Northern Wu dialects. To the extreme end, when the contours of the second syllables are completely neutralized, complete spreading exhibits. We found our proposal here is in line with Chen [12]'s claim, tone sandhi in Northern Wu dialects is a process of tone neutralization that is similar to Standard Mandarin's neutral tone. Similar to the neutral tone in Mandarin, tone sandhi in Wu dialects mostly applies to nominal compounds, presumably because in this morphosyntactic structure, initial syllables are metrically heavier [6].

5. Conclusions and future work

By looking into the phonetic realization of disyllabic tone sandhi patterns from three Northern Wu dialects, we found that, despite all kinds of variations across dialects and tonal categories, there is a common word prosody template shared by Wu dialects: 1) both initial and non-initial syllables contribute to the sandhi patterns; 2) both syllables undergo neutralization, but they neutralize different dimensions. The nature of tone sandhi is essentially a gradient implementation of the basic prosody template.

More work will be done: 1) In this short paper, we only discussed F0 cues; however, it is known that phonation cues are involved in the tonal contrasts of Wu dialects as well. The next step of analysis is to include phonation cues to the tonal spaces; 2) With the understanding of the general principle of tone sandhi implementation, details of implementation can be further explored. For example, the relationship between the process of contour spreading and the process of neutralization of both syllables is still to be explored with more sophisticated modelings. But the FPC representation of the tones has set a solid stage for further quantitative analysis and computational modeling.

6. References

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