Structure-Dependent Tone Sandhi in Real and Nonce Words in Shanghai Wu

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Abstract

Disyllabic sequences in Shanghai Wu undergo different types of tone sandhi depending on their syntactic structure: modifier-noun compounds spread the initial tone across the disyllable, while verb-noun phrases often maintain the final tone and neutralize the nonfinal tone, especially if the phrase has a low frequency of occurrence. We investigated the productivity of the two tone sandhi types through 48 speakers’ productions of real and nonce words. Our results showed that Shanghai speakers were sensitive to the structure-dependency of the sandhi pattern and performed different sandhis according to the disyllable’s syntactic structure in both real and nonce words. But in nonce words, the productivity of each specific sandhi varies, and the difference between left- and right-dominant sandhis is attenuated. Additionally, neither the left- nor right-dominant sandhi involves complete tonal neutralization. These results indicate that in order to arrive at a full picture of the sandhi patterning, traditional impressionistic descriptions need to be complemented by instrumental data.

Index Terms: tone, tone sandhi, Shanghai Wu, productivity, incomplete neutralization

1. Introduction

Chinese dialects are often characterized by complex patterns of tonal alternations conditioned by adjacent tones or the morphosyntactic/prosodic position in which a tone appears, commonly referred to as tone sandhi [1-2]. Tonaly induced and positionally induced tone sandhi patterns are illustrated in the two examples below from Standard Chinese and Taiwanese, respectively. In Standard Chinese, the third tone 213 becomes the second tone 35 before another third tone, and in Taiwanese, a tone undergoes regular changes whenever it appears in non-XP-final positions [3-4].

Standard Chinese “third-tone sandhi”:

\[ 213 \rightarrow 35 / \_\_ 213 \]

Taiwanese “tone circle” (unchecked syllables):

\[ 51 \rightarrow 55 \rightarrow 33 \rightarrow 24 \text{ in non-XP-final positions} \]

\[ 21 \]

The tone sandhi pattern in Shanghai Wu is unique in that it simultaneously embodies tonally and positionally induced sandhi and that the sandhi pattern is structure-dependent. The tonal inventory of Shanghai is given in Figure 1. Tones 1 (51), 2 (35), and 3 (24) occur on unchecked syllables, while Tones 4 (44) and 5 (12) occur on checked (7-closed) syllables.

Disyllabic sequences in Shanghai undergo different types of tone sandhi depending on their syntactic structure. For instance, modifier-noun compounds spread the initial tone across the entire word (left-dominant sandhi), while verb-noun phrases often maintain the final tone and reduce the contour of the nonfinal tone, especially if the phrase has a low frequency of occurrence (right-dominant sandhi). Patterns of left-dominant and right-dominant sandhisis in Shanghai reported in the literature [5-9] are summarized in Table 1. For left-dominant sandhisis, two observations can be made: first, the tone on the second syllable is entirely determined by the tone on the first syllable and hence completely loses its contrastive status; second, the spreading pattern can be separated into two types depending on the tone on the first syllable — contour extension for Tones 1 to 4 and contour displacement for Tone 5. For right-dominant sandhisis, the general pattern is that the first syllable loses the tonal contours, and Tones 1 (51) and 2 (35) are neutralized to 44.

Figure 1: Shanghai tonal inventory.

Table 1. Left- and right-dominant sandhis in Shanghai. “X” indicates any tone in the tonal inventory.

<table>
<thead>
<tr>
<th>Left-dominant sandhis:</th>
<th>Right-dominant sandhis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>51-X [55-31]</td>
<td>51-X [44-X]</td>
</tr>
<tr>
<td>35-X [33-44]</td>
<td>35-X [44-X]</td>
</tr>
<tr>
<td>24-X [22-44]</td>
<td>24-X [33-X]</td>
</tr>
<tr>
<td>44-X [33-44]</td>
<td>44-X [44-X]</td>
</tr>
</tbody>
</table>

The structure-dependency of the tone sandhi pattern is further illustrated in the examples below:

\[ /ts\tilde{5}35 \text{ mi24/} \rightarrow [ts\tilde{3}33 \text{ mi55}] \] ‘fried noodles’ (3)
\[ /ts\tilde{5}35 \text{ mi24/} \rightarrow [ts\tilde{4}44 \text{ mi24}] \] ‘to fry noodles’

Our study aims to address the following unanswered questions on Shanghai tone sandhi. First, does the tone sandhi involve true neutralization? In particular, does the left-dominant sandhi involve complete tonal neutralization on the second syllable, as the spreading description implies? What is the nature of the right-dominant sandhi — phonological leveling with prespecified, neutralized level targets or phonetic contour reduction? Second, are Shanghai speakers sensitive to the structure-dependency of the sandhi pattern when they are tested with novel compounds and phrases, and are there productivity differences between the two types of sandhi? Third, are there sandhi productivity differences among...
different tonal combinations? For instance, are contour extension and contour displacement equally productive? These are important questions as recent works on tone sandhi in Chinese dialects have shown that contra traditional descriptions, incomplete neutralization [10], free and lexical variation [11], and lack of full productivity [12] are characteristic of a number of Chinese tone sandhi systems, and how these effects manifest themselves in a structure-dependent tone sandhi system is unknown. Answers to these questions will therefore provide necessary empirical data to guide us in our endeavor to understand the inner workings of tone sandhi systems in Shanghai and elsewhere.

2. Methodology

The basic methodology of our study was to elicit disyllabic utterances from native speakers of Shanghai by presenting them with two separate monosyllables and asking them to pronounce them together as a real disyllabic word or phrase in Shanghai. The tonal realization of the two syllables was then measured to quantify the application of the tone sandhi. Two experiments were conducted to investigate the sandhi behavior of two different types of words.

Experiment 1 investigated tone sandhi in disyllabic real words in Shanghai. The stimuli included all 25 disyllabic tonal combinations. For each tonal combination, two words with a left-dominant sandhi pattern and two words with a right-dominant sandhi pattern were used, but each speaker only saw one word for each pattern. The sandhi patterns for the words used were reported in [6] and [13] and verified by two native speakers of Shanghai. The syntactic structures of the left-dominant words were primarily modifier-noun, but also coordination and lexicalized compounds and proper names. The syntactic structure of the right-dominant words was consistently verb-noun. A sample of the wordlist is given in Table 2.

Table 2. Experiment 1 sample wordlist.

<table>
<thead>
<tr>
<th>Base tones</th>
<th>Left-dominant sandhi</th>
<th>Right-dominant sandhi</th>
</tr>
</thead>
<tbody>
<tr>
<td>51-51</td>
<td>伤风 “to catch a cold” 冰糕 “ice-cream”</td>
<td>开花 “to bloom” 贪多 “to be greedy”</td>
</tr>
<tr>
<td>35-12</td>
<td>早熟 “premature” 夕毒 “malignant”</td>
<td>变热 “to turn hot” 打贼 “to hit a thief”</td>
</tr>
<tr>
<td>44-44</td>
<td>角色 “role” 漆黑 “pitch-black”</td>
<td>发黑 “to turn black” 脱发 “to lose hair”</td>
</tr>
</tbody>
</table>

During this experiment, the subjects were given two syllables in their base tones aurally separated by a 800ms pause; the Chinese characters associated with the syllables also appeared on a computer screen in front of the subjects as the syllables played. The subjects were then prompted to pronounce the words out loud in a clear and natural way. The stimuli were randomized for each speaker.

Experiment 2 involved the subjects’ production of disyllabic nonce words. The nonce words were formed by using a syllable accidentally missing from the Shanghai syllabary (legal segmentals and legal tone, but the segments-tone combination happens to be nonexistent) as the first syllable (σ1) of a disyllabic word and providing a meaning for the syllable as either a nominal modifier or a verb; the second syllable (σ2) is always an existing noun. All 25 disyllabic tonal combinations were included. For each tonal combination, two nonce syllables were used in σ1 position, and each syllable is associated with two meanings — a modifier meaning and a verb meaning. Each speaker, however, only heard one meaning for each syllable. For example, two nonce syllables with Tone 1 (51) were used in σ1 position: itmap51 and itmap51; one speaker would hear itmap51 used as a modifier and itmap51 used as a verb, while another speaker would hear itmap51 as a verb and itmap51 as a modifier. The same monosyllabic nouns followed these nonce syllables in σ2 position. Therefore, the same σ1-σ2 sequence would have a modifier-noun structure for one speaker, but a verb-noun structure for the other. The number of speakers for each group was matched.

During this experiment, the subjects were given the meanings of the nonce syllables both aurally and in written form. The nonce syllables were pronounced with their base tones twice during the verbal prompt and they were represented orthographically with a box “□” in lieu of a Chinese character on the computer screen. For instance, the subjects would both hear and see “假设上网买物事叫做 manged; if a book has not been manged, we can also say that we have not ___.”) The subject was expected to reply with /itmap51 书 (“manged the book”) with right-dominant sandhi. For each nonce syllable, the five monosyllabic nouns that it combined with appeared together in one block; i.e., once the speakers were given the meaning of itmap51, they were asked to combine it with five different nouns one after another. Different nonce words appeared in random order for each speaker.

Both Experiments 1 and 2 were preceded by an instruction in Shanghai and a short practice session, and both experiments were implemented in Paradigm® [14].

Both experiments were conducted in the Phonetics Laboratory of the Department of Chinese Language and Literature at Fudan University, Shanghai. Forty-eight speakers who lived in urban areas of Shanghai (20 male, 28 female) participated in the experiments. All speakers did Experiment 1 first, then Experiment 2. The speakers’ mean age at the time of participation was 24.6.

All acoustic analyses of the data were conducted in Praat [15]. For every target syllable, we took an f0 measurement at every 10% of the rhyme duration using ProsodyPro script [16], giving eleven f0 measurements for each syllable. The Maxf0 and Minf0 parameters in the script as well as the octave-jump cost were adjusted for each speaker, and the f0 measurements were hand-checked against narrow-band spectrograms in Praat.

F0 results from Experiments 1 and 2 were considered together in statistical analyses. Statistical results on f0 were obtained using Linear Mixed-Effects models with Speaker as a random effect and Base-Tone, Word-Type (real vs. nonce), Structure, Data-Point-in-Syllable as fixed effects.

3. Results

We organize the f0 results in three different ways in this section to address the three research questions raised earlier regarding the nature of Shanghai tone sandhi: (a) Do the two types of sandhis involve complete neutralization? (b) Are the speakers sensitive to the structure dependency of the sandhi pattern? (c) Are there productivity differences among different tonal combinations?
3.1. Neutralization

3.1.1. Left-dominant sandhi

To investigate whether the left-dominant sandhi involves complete neutralization of the tone on the second syllable, we compared the pitch tracks of the second syllable when it has different base tones while keeping the tone on the first syllable constant. Real words and nonce words were compared separately. Figure 2 illustrates the pitch tracks for the two syllables for base tones 51-X, 35-X, 24-X, 44-X, and 12-X (X=one of the five tones) for real words (left) and nonce words (right).

(a) 51-X → 55-31:

(b) 35-X → 33-44:

(c) 24-X → 22-44:

(d) 44-X → 33-44:

(e) 12-X → 11-13:

Figure 2: Pitch tracks for disyllabic words undergoing left-dominant sandhi, organized by tone on the first syllable. For each of the tonal combinations, the graph on the left is for real words (Exp. 1), and the graph on the right is for nonce words (Exp. 2).

Statistical comparisons in pitch were only conducted among the three unchecked base tones (55, 35, and 24) and between the two checked base tones (44 and 12). A significant effect of Base-Tone in the Linear Mixed-Effects model indicates that the two pitch tracks have different F0 means, and a significant interaction between Base-Tone and Data-Point-in-Syllable can be interpreted as the two pitch tracks having different shapes. Our results showed that only when the first syllable had 12, there was no difference between a base 51 and a base 35 on the second syllable in either mean F0 or F0 shape; all other comparisons indicated that the pitch tracks being compared were different in either mean F0 or F0 shape, or both, at the p<.05 level.

The results for left-dominant sandhi, therefore, showed that although rightward tone spreading did apply to both the real and nonce words, the base tone on the second syllable still preserved many of its pitch properties and thus had a significant effect on the surface pitch pattern of the disyllable. In other words, left-dominant sandhi is not truly neutralizing in either real or nonce words.

3.1.2. Right-dominant sandhi

Neutralizing properties of the right-dominant sandhi were investigated by comparing the pitch tracks of the first syllable when it has different base tones while keeping the tone on the second syllable constant. Real words and nonce words were again compared separately. Figure 3 illustrates the pitch tracks for the two syllables for base tones X-51, X-35, X-24, X-44, and X-12 (X=one of the five tones) for real (left) and nonce words (right). “Y” simply indicates that tone sandhi is expected to occur and change the base tone X on the first syllable.

The pitch tracks in Figure 3 showed that right-dominant sandhi indeed induced less pronounced tonal contours on σ1, but the height and direction of base contours were largely maintained, indicating that the sandhi likely resulted from phonetic contour reduction. Statistical comparisons showed that all unchecked base tones remained distinct from each other in either mean F0 or F0 shape, or both, at the p<.05 level, so did the two checked tones, for both real and nonce words. Right-dominant sandhi, therefore, does not incur complete neutralization in either real or nonce words either. In particular, the complete neutralization between Tones 1 and 2 reported in the literature was not observed in our results.

(a) X-51 → Y-51:

(b) X-35 → Y-35:

(c) X-24 → Y-24:
3.2. Structure dependency

To investigate the speakers’ sensitivity to the effect of structure on tone sandhi, we compared the tonal realizations of the same base tones when the syntactic structures of the disyllables are different. For real words, the comparison was between words that undergo left-dominant sandhi and those that undergo right-dominant sandhi — a largely structure-based difference; for nonce words, the comparison was between disyllables identical in both segmental contents and base tones, but different in syntactic structure cued by contexts. Due to space limitation, we only report the results for X-51 base tone combinations here. These are the tonal combinations that could potentially elicit the largest difference between left- and right-dominant sandhis as right-dominant sandhi would preserve the large fall on the second syllable, while left-dominant sandhi would primarily put a level or rising tone on the second syllable as most tones in the tonal inventory of Shanghai appearing in $\sigma_1$ are rising tones.

Figure 4 illustrates X-51 base tone sequences that differ in syntactic structure for real (left) and nonce words (right). Overall, the two different structures induced different tonal patterns for both syllables for both real words and nonce words, and the differences were all in the expected directions. For instance, for a 51-51 sequence, we expected to find a more drastic fall from a higher pitch on the second syllable for the verb-noun structure, and that was exactly what the data showed. The only case in which there was no effect of structure was the 44-51 sequence in nonce words. This indicates that overall, speakers were sensitive to the structure dependency of the tone sandhi pattern and the dependency carried over to nonce words. However, we can also notice that the magnitude of the tonal differences between the two structures often seems greater in real words than in nonce words, as in 51-51, 44-51, and 12-51, indicating that the structure dependency may not be fully productive.

3.3. Productivity

To further investigate the productivity of the sandhi pattern, we compared the tonal realizations between the real and nonce words for the same base tones in the same syntactic structure. We again only report the results for X-51 base tone sequences. The results are summarized in Figure 5.

A number of tonal comparisons for the left-dominant sandhi in Figure 5 indicate that the sandhi is not fully productive in nonce words. For 51-51 $\rightarrow$ 55-31, in the nonce words, the tone on the first syllable preserved more of the falling contour, and the tone on the second syllable preserved more of the higher fall from the base tones. For 24-51 $\rightarrow$ 22-44, the tone on the first syllable of the nonce words preserved more of the rise, and the tone on the second syllable preserved a greater fall. The most interesting difference came from 12-
51 → 11-13: the real words seemed to have indeed undergone contour displacement, whereby the the rising tone on the first syllable was displaced onto the second syllable, but the sandhi pattern in the nonce words was more akin to contour extension, indicating that contour displacement seemed to have been underlearned, or more appropriately, mislearned as the more general contour extension.

For both left- and right-dominant sandhias, a relatively consistent difference between real and nonce words is that the nonce words had a lower pitch on the first syllable than the real words. This difference is particularly apparent when \( \alpha = 35 \). This was likely due to the fact that the Shanghai speaker who recorded the vocal prompts for the experiments pronounced the nonce Tone 2 (35) syllables with a lower-than-expected pitch. No generalizations on the productivity of right-dominant sandhias can be made.

4. Discussion

Our f0 results demonstrated two levels of gradience in the tone sandhi pattern of Shanghai. First, in real words, neither the left- or right-dominant sandhi is fully neutralizing. This is particularly surprising for left-dominant sandhi, as previous literature [5-9] has documented this type of sandhi as the spreading of the initial-syllable tone across the entire sandhi domain and analyzed the sandhi formally as such. Second, the structure dependency of the tone sandhi extends into nonce words, but only gradually so, in that the structure-induced differences are attenuated in nonce words. This is primarily due to the lack of full productivity of the left-dominant sandhi, as indicated by the greater preservation of the tonal properties of the base tones in nonce words.

It remains an open question what the source of the observed gradient effects is — phonetically gradient application of the sandhis or lexical variation. For incomplete neutralization in real words, it is more likely that the results are due to phonetic gradient production, whose effect on tone sandhi has been widely documented (e.g., [10]). But for the gradient underlearning of the sandhi patterns, previous studies have shown that this could be due to gradient production [17], lexical variation [12], or a combination of both [11]. An indication that the gradient productivity here may be due to a combination of gradient production and lexical variation is that the classification of whether a nonce word had undergone the left-dominant sandhi, the right-dominant sandhi, or no sandhi at all in our data was very often difficult: some cases were clear, but many were ambiguous and thus difficult to classify one way or another.

Another interesting question to ponder is why some sandhias are more productive than others. For right-dominant sandhi, the fact that no generalization can be made regarding its productivity in nonce words is consistent with our interpretation that the sandhi is phonetic contour reduction. For left-dominant sandhi, however, it was clear from our results that the sandhi was not fully productive in nonce words, particularly the contour displacement sandhi 12-51 → 11-13. The lack of complete productivity of tone sandhi has been previously documented in other dialects of Chinese including Beijing [17], Taiwanese [12], [18], [19], and Tianjin [20], and the reasons suggested for the unproductivity include phonological opacity, low lexical frequency, lexical variation, and phonetic unnaturalness of the sandhi pattern. Opacity and lexical variation are not the cause for the unproductivity of contour displacement, as the pattern itself is transparent and for 12-X combinations, 11-13 is consistently the sandhi form, while all four contour extension patterns have considerably more variations [6-9]. Due to the lack of frequency data, we cannot rule out the possibility that the unproductivity is related to low lexical frequency, but the reported effects of frequency are typically smaller than what found here. The phonetic nature of the sandhi also remains a viable interpretation. At least three phonetic properties of contour displacement may have caused its unproductivity: the mismatch between phonological stress (left) and phonetic prominence (right) [8], the dissimilarity between the base and sandhi contours for the disyllable, and the pronounced rise as a sandhi tone on the second syllable.

Our results echo the point made in [21] regarding Chinese tone sandhi that rushing into an analysis of a sandhi pattern before testing it experimentally is premature, as the speakers’
knowledge of the tone sandhi pattern may not be identical to the pattern in the lexicon, and impressionistic transcriptions, no matter how careful, have their limitations. It is particularly noteworthy that recent work on experimental phonology has shown that the differences between the speakers’ knowledge and the lexical patterns are informative of the nature of phonological grammar [12], [22], [23]. The study of Chinese tones, therefore, has much to gain from carefully designed phonetic and psycholinguistic investigations.

5. Conclusions

Through a production experiment on disyllabic tone sandhi in both real and nonce words in Shanghai Wu, we found that neither left-dominant nor right-dominant sandhi in Shanghai causes complete tonal neutralization. The f0 pattern of the base tone on the second syllable in left-dominant sandhi and that on the first syllable in right-dominant sandhi both have a significant effect on the f0 output of disyllabic words. For right-dominant sandhi in particular, the pitch properties of the base tone on the first syllable are largely preserved, indicating that the sandhi is likely better interpreted as phonetic contour reduction. Our results also showed that Shanghai speakers are sensitive to the structure-dependency of tone sandhi in nonce words, but only gradiently so, as manifested in the lack of full productivity of some left-dominant sandhi patterns in nonce words, especially contour displacement. This causes the difference between left- and right-dominant sandhis to be attenuated in nonce words. The grammar of tone sandhi for Shanghai, therefore, needs to be quantitative and flexible enough to capture the structure dependency, incomplete neutralization, and selective underlearning in the patterns. The recognition of this set of issues does not make the discovery of tonal grammars any easier, but it does mean that the difficulty may lie elsewhere from what we originally thought.

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7. References