

Directionality of Disyllabic Tone Sandhi across Chinese Dialects is Conditioned by Phonetically-Grounded Structural Simplicity

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1 Introduction

Tone sandhi refers to the alternation of phonetic tone shape conditioned by adjacent tones or by prosodic or morphosyntactic position (Chen, 2000). For example, when there are two adjacent dipping-rising tones, i.e., tone 3 in Mandarin, the first tone becomes a rising tone, i.e., tone 2, as in ni213¹ + hao213 → ni35 hao213 ‘hi’. In the analysis of Chinese tone sandhi, one of the most widely discussed properties has been their phonetic grounds. Despite its partial success in accounting for some tone sandhi patterns, whether relying on durational components (Zhang & Lai, 2010; Zhang & Liu, 2016) or the Obligatory Contour Principle (OCP) (Chen, 2000), phonetic-based analysis is not sufficient to account for the whole picture of Chinese tone sandhi system (Zhang, 2014). Another tone sandhi property that has been widely examined along with its phonetic grounds is a structural property of tone sandhi, namely tone sandhi directionality (Chen, 2000; Zhang, 2007). Tone sandhi directionality denotes the tendency to keep either the left or the right tones between the two tones in the input at the surface form. Right dominant tone sandhi is the case when the right tone remains unchanged while the left tone undergoes a tone change (e.g., Mandarin 213 → 35 / __ 213), and the left dominant tone sandhi is the opposite (e.g., Chengdu 13 → 11 / T²__). In bi-directional tone sandhi system, either the left or the right tone alternates (e.g., Chaoyang 53 → 31/ T __; 55 → 11/ __T). Previous studies provide various descriptions and analyses of tone sandhi directionality. For example, Zhang (2007) observed a relation between tone sandhi directionality and phonological processes: Right-dominant tone sandhi often involves local substitution and neutralization of nonfinal tones; left-dominant tone sandhi often involves rightward extension of initial tones. Although previous directionality analyses can help us understand how sandhi processes are implemented, the underlying mechanism that governs tone sandhi directionality remains to be investigated.

We note that the two widely discussed properties of tone sandhi, their phonetic grounds and directionality, correspond to two types of cognitive biases which have been proposed to affect the shapes of phonological universals, namely substantive bias and structural bias respectively (see Section 2 for the details). Based on the link, this paper hypothesizes that the observed Chinese tone sandhi patterns might reflect the properties of substantive bias and structural bias. This study examines structural simplicity and phonetic naturalness of tone sandhi patterns across seventeen Chinese varieties. Our structure-based analysis shows that tone sandhi patterns are overwhelmingly uni-directional (i.e. structurally simple) either throughout a sandhi system or within each grammatical category. Crucially, uni-directionality is largely right-dominant, which could be attributed to its phonetic grounding. We propose that the combination of the ideas behind the two cognitive biases, namely phonetically-grounded structural simplicity, plays a role in forming tone sandhi patterns across Chinese dialects. The Chinese varieties that are considered in this study include Mandarin, Tianjin, Boshan, Kunming, Wuyi, Xiamen, Fuzhou, Yudu, Chengdu, Dongkou, Changzhou, Huojia, Shanghai, Tangxi, Chaoyang, Pingyao and Changsha, classified into six Chinese dialectal groups (Northern, Wu, Min, Hakka, Xiang and Jin). The 17 dialects cover wide geographic regions: the north (e.g. Beijing, Tianjin,

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¹ Tones in this paper are transcribed in the Chao tone letter system, where “1” represents the lowest and “5” the highest pitch (Chao, 1948).

² In this paper, T represents any tone of the dialect.

Shanxi), northeast (e.g. Shandong), southeast (eg. Shanghai, Fujian, Jiangsu), southwest (e.g. Sichuan, Yunnan) and central (e.g. Changsha, Henan) areas of China.

Section 2 first provides the definitions of structural bias and substantive bias, which we link to the simplicity and phonetic motivations of tone sandhi respectively. The structure-based and phonetic-based analyses of tone sandhi patterns across the 17 Chinese dialects are provided in Sections 3 and 4 respectively, with conclusion in Section 5.

2 Cognitive biases in tone sandhi

2.1 Structural simplicity in tone sandhi An assumption in linguistics is that language learners are a priori biased toward certain linguistic patterns over others, the tendency of which is reflected in typological universals (Chomsky, 1964). In phonology, a type of bias that has been widely studied is a structural bias (Moreton et al., 2015). Previous work defined structural bias in segmental phonology with distinctive features involved in phonological classifications or processes: patterns involving more phonological features are harder to learn than patterns involving fewer features (Moreton & Pater, 2012a). Assuming language changes reflect tendencies in language learning, structurally simpler phonological patterns are better represented in typological universals. For example, in natural languages, an inventory with e.g., [p t k] are easier to learn thus are more common than an inventory with e.g., [p t g], because the former one involves fewer phonological features to define while the latter one requires the involvement of more features. Structural bias hypothesis has been actively tested and supported in phonology (see Moreton & Pater, 2012a for an overview).

As an extension of structural bias hypothesis to tone sandhi, we predict the structural simplicity in tone sandhi as follows: uni-directional tone sandhi systems are structurally simpler than bi-directional systems. The assumption behind the structural bias in tone sandhi is that the direction is considered as a *feature*, thus the number of directions determines simplicity. Psychological experiments have revealed that the learning difficulty increases as the number of relevant *features* (distinctive from phonological features) increases defined in non-linguistic units (Shepard et al., 1961). For instance, research has shown that geometric figures that vary in color (black vs. white), shape (circle vs. triangle), and size (large vs. small) are easier to distinguish when only one feature differs, e.g., when the figures differ only in color rather than in both color and shape (Shepard et al., 1961). If a directionality is assumed as a target ‘feature’, it is predicted that a uni-directional tone sandhi will be easier than bi-directional one. In consideration of phonological features, the complexity level involved in uni-directional alternations is lower than bi-directional ones. A schematic of uni-directional and bi-directional tone sandhi systems in the rule-based phonology (Chomsky & Halle, 1968) is given in Illustration 1 below.

Illustration 1. Uni-directional and bi-directional sandhi systems in the rule-based phonology

Unidirectional system	Bidirectional system
A → B / X ____	A → B / X ____
C → D / Y ____	C → D / ____ Y

Although the number of symbols in both systems is equal, it is possible for the two rules in the uni-directional system to be combined into a single rule, because the conditioning environments, X and Y, are both preceding the target alternation position: [A, C] → [B, D]/[X, Y] _____. In other words, there is a possibility that the number of symbols involved in the uni-directional system can be reduced so far as tones in the same phonological positions, i.e., [A, C], [B, D], or [X, Y], share their features. In contrast, the two rules in the bi-directional system cannot be combined into a single rule, because the conditioning environments differ in their positions. Taken together, when the evaluations of systems’ complexity from both general cognitive grounds and from phonological formalisms are taken into consideration, we conclude that bi-directional tone sandhi systems are overall structurally more complex than uni-directional systems.

2.2 Phonetic basis of tone sandhi directionality A substantive bias hypothesis predicts that patterns grounded on phonetic factors are better learned than those that are not (Wilson, 2006), thus are more prevalent in languages. For example, velar palatalization before a high front vowel can be found in various languages, and it is phonetically better grounded than before other phonological environment (e.g., before a low back vowel [ɑ]) due to acoustic, articulatory, and perceptual factors (Wilson, 2006). If the idea of phonetic substance is applied to tone sandhi directionality, its phonetic grounds are as follows. First, when contour

tones are involved in tone sandhi processes, the relevant phonetic ground is a syllable's contour tone bearing ability which is crucially dependent on duration (Zhang, 2002). In producing contour tones, the acoustic change is made by a single articulator, the vocal folds. Vocal fold tension changes due to laryngeal muscle contraction and relaxation, which must be sequenced to produce the pitch variation in contour tones. Therefore, a contour tone needs enough duration to be produced (Zhang, 2002). As to the perception, the acoustic consequence of the change in complex segments is sudden. But for contour tones, the sequenced stretching or relaxation of the vocal folds requires a greater duration of its carrier (Zhang, 2002). Therefore, contour tones require longer duration. For a syllable's contour tone bearing ability, the non-final syllables have relatively insufficient duration to carry contour tones in comparison to the final syllable, because the final syllable of a prosodic unit is subject to lengthening and word-final lengthening has been well-documented (Oller, 1973; Beckham & Edwards, 1990, cited in Zhang, 2007). In tone sandhi patterns, the substitution of contour tones on the initial syllable (right-dominant local tone substitution) or extension of contour tones on the initial syllable (left-dominant tone extension) can be attributed to the initial syllable's lacking of contour tone bearing ability (Zhang, 2007). For instance, in Mandarin right-dominant local tone substitution, the third tone 213 is dipping-rising in isolation and word-finally, but it is dipping when preceding the other three tones. In Changzhou left-dominant rightward tone extension, the tone 523 with three pitch targets is extended as 55 – 23. The two patterns can be explained by phonetic motivation: the left (non-final) syllable has insufficient duration to carry the tone with three pitch targets, so the contour tone is substituted or extended to reduce tonal duration on the left syllable (Zhang, 2002).

Second, when the input does not involve a contour tone on the left syllable, a rightward directionality is also phonetically grounded, both for right-dominant local tone substitution and left-dominant rightward tone extension. Rightward tone sandhi aligns with a universal tone rule that tone spreading tends to be progressive (Hyman & Schuh, 1974). Progressive tone spreading has phonetic motivations. First, the rightward tone spreading can be understood from the P-map (Steriade, 2008): If the speaker knows that the input will have progressive coarticulation, an output with progressive spreading will be perceptually more similar to the input than one with regressive spreading (Zhang, 2007). Another possible phonetic explanation of progressive tone spreading is that the auditory processing of tones is slower than the processing of segments, because fundamental frequency is processed more slowly than the formants in vowels (Hyman & Schuh, 1974; Javkin, 1979). Therefore, a listener would perceive a tone as occurring later within a sequence of segments than when it was produced by the speaker. If the misperception occurred constantly within a language community, progressive tone spreading rather than regressive spreading would be favored. In order for tone change and segment change to be perceived as simultaneous, the amount by which an F0 change would have to lead (Javkin, 1979). Taken together, duration in contour tone bearing ability; perceptual similarity between input and output in tonal coarticulation; and the nonsynchrony of tones and segments predict that applying tone sandhi rightward (either right-dominant substitution or rightward extension) is phonetically better grounded than leftward tone sandhi.

The fact that the structural and substantive biases are widely attested in segmental alternations (Moreton & Pater, 2012a, b) and that the major properties studied so far for tone sandhi are related to their structural (directionality) and substantive (phonetic grounds) components, we hypothesize that tone sandhi typology reflects the two cognitive biases. Specifically, we predict that tone sandhi patterns would tend to be uni-directional (i.e. structurally simple), and the uni-directionality would tend to be rightward (i.e. phonetically natural).

3 Structure-based analysis

This section examines the structural simplicity of tone sandhi directionality across 17 Chinese dialects. Our survey showed that among the 17 dialects, uni-directional tone sandhi systems are more common than bi-directional ones. Moreover, among the dialects with bi-directional tone sandhi systems, when the lexical items undergoing tone sandhi are placed into different grammatical structures, tone sandhi largely applies in a specific direction within each type of grammatical category, suggesting a structural simplicity within each grammatical category. Table 1 below summarizes tone sandhi directionality of the 17 dialects.

Chinese dialects	Tone sandhi directionality
Beijing Mandarin (Zhang & Lai, 2010; Lin, 1992)	Right-dominant
Tianjin (Zhang & Liu, 2016)	Right-dominant
Boshan (Lin, 2004)	Right-dominant
Kunming (Lin, 2019)	Right-dominant
Wuyi (Zhang, 2007)	Right-dominant
Xiamen (Chen, 1987)	Right-dominant
Fuzhou (Zhang, 2014)	Right-dominant
Yudu (Zhang, 2007)	Right-dominant
Chengdu (Lin, 2015)	Left-dominant
Dongkou (Zhang, 2007)	Left-dominant
Changzhou (Zhang, 2007)	Left-dominant
Shanghai (Zhang & Meng, 2016)	Uni-directional in each grammatical category
Tangxi (Zhang, 2007)	Uni-directional in each grammatical category
Chaoyang (Zhang, 2007)	Uni-directional in each grammatical category
Pingyao (Lin, 2012)	Uni-directional in one grammatical category, bi-directional in another category
Changsha (Lin, 2011)	Bi-directional in each grammatical category
Huojia (Zhang, 2007; He, 1979)	Bi-directional

Table 1. Summary of tone sandhi directionality

3.1 Uni-directional tone sandhi systems As shown in Table 1, 11 dialects have uni-directional tone sandhi systems, among which eight systems are right-dominant. Tianjin³ is an example of right-dominant sandhi with local substitution. According to Shi's (1990) transcription, this Northern dialect has four citation tones: 11, 55, 24 and 53. According to Zhang & Liu (2016), Tianjin has six tone sandhi patterns, which are described below in (1). All six patterns preserve the tone on the right syllable and tones on the left syllable undergo sandhi, supporting the structural simplicity hypothesis of tone sandhi directionality.

(1) Tianjin

- a. 11 + 11 → 24 + 11
fei11 - ji11 → fei24 - ji11 “airplane”
- b. 24 + 24 → 55 + 24
xi24 - lian24 → xi55 - lian24 “wash one’s face”
- c. 53 + 11 → 55 + 11
ren53 - zhen11 → ren55 - zhen11 “earnest”
- d. 53 + 53 → 11 + 53
jing53 - zhong53 → jing11 - zhong53 “net weight”
- e. 24 + 55 → 11 + 55
shen24 - yang55 → shen11 - yang55 “Shenyang” (place name)
- f. 24 + 53 → 11 + 53
hao24 - xiao53 → hao11 - xiao53 “funny”

Chengdu⁴, a dialect of Southwestern Mandarin Chinese, provides evidence for the opposite directionality, left-dominant sandhi with local substitution. Chengdu shows a left-dominant sandhi with local substitution. According to Lin (2015), Chengdu has four citation tones: 45, 31, 55, and 13. Tone 31 never undergoes tone sandhi. For the other three tones, there are three sandhi patterns, as shown in (2). The left syllable always preserves its tone, and the tone on the right syllable undergoes sandhi. Therefore, Chengdu tone sandhi could be considered as a structurally simple system.

³ Real-world examples of Tianjin tone sandhi are transcribed in pinyin from Chen (2000) and Wee (2004).

⁴ Real-world examples of Chengdu tone sandhi are transcribed in IPA from Lin (2015).

(2) Chengdu

- a. 45 → 44 / T ___
tso31 - tʰien 45 → tso31 - tʰien 44 “yesterday”
- b. 55 → 53 / ___]
fu13 - mu55 → fu13 - mu53 “parents”
- c. 13 → 11 / T ___
tsau55 - fan13 → tsau55 - fan11 “breakfast”
 (“]” = phrase final boundary)

3.2 Bi-directional tone sandhi systems As shown in Table 1, among the six dialects with bi-directional tone sandhi system, tone sandhi patterns are uni-directional in different grammatical categories in Shanghai, Tangxi and Chaoyang. Shanghai⁵, a Northern Wu dialect, is an example of bi-directional system. Shanghai has five citation tones, of which three are non-checked tones 53, 34, 13 and two are checked tones 55, 12 (Zhang & Meng, 2016). Tone sandhis in Shanghai are applied in both directions. The left-dominant tone sandhi patterns are illustrated in Table 2 and real-world examples are provided in (3). Left-dominant sandhi in Shanghai involves rightward extension, as the left tone is spread across the disyllabic word.

	53	34	13	55	12
53		a. 55-31			55-22
34		b. 33-44			33-44
13		c. 22-44			22-44
55		d. 33-44			33-44
12		e. 11-13			11-33

Table 2. Shanghai left-dominant tone sandhi patterns

(3) Shanghai left-dominant tone sandhi

- a. eiã53 - kã34 → eiã55 - kã31 “Hong Kong”
- b. tiŋ34 - bã13 → tiŋ33 - bã44 “ceiling”
- c. dʌ13 - teiã53 → dʌ22 - teiã44 “soy milk”
- d. poʔ55 - dziŋʔ12 → poʔ33 - dziŋʔ44 “North Pole”
- e. voʔ12 - tsã53 → voʔ11 - tsã13 “clothing”

Shanghai also has three right-dominant tone sandhi patterns, all of which involve local substitution and neutralization, as shown in (4).

(4) Shanghai right-dominant tone sandhi

- a. 53, 34, 55 → 44 / ___ T
sɔ53 - tʃe34 → sɔ44 - tʃe34 “to cook dishes”
pʰɔ34 - zo13 → pʰɔ44 - zo13 “to steep tea”
tʰəʔ55 - faʔ55 → tʰəʔ44 - faʔ55 “to lose hair”
- b. 13 → 33 / ___ T
fliŋ13 - teiã34 → fliŋ33 - teiã34 “to accept an award”
- c. 12 → 22 / ___ T
zəʔ12 - səʔ55 → zəʔ22 - səʔ55 “to color”

At first glance, the tone sandhi system seems structurally complex. However, Shanghai tone sandhi is structurally simple within each grammatical category. The choice of left vs. right dominance is dependent on the morphosyntactic structure of words in Shanghai (Zhang & Meng, 2016). Left-dominant sandhi applies to closely connected words; modifier-noun combinations can only undergo left dominant sandhi. Whereas right-dominant sandhi applies to loosely connected words or phrases (verb-object, subject-verb, verb-modifier, and coordinated structures). For example, when 头痛 means “headache” as a compound, left-dominant sandhi is

⁵ Real-world examples of Shanghai tone sandhi are transcribed in IPA from Zhang & Meng (2016).

applied; when it means “(my) head aches” as a subject-predicate phrase, right-dominant sandhi is applied (Yan, 2016).

In sum, eleven out of the seventeen Chinese dialects have uni-directional tone sandhi systems. Among the six dialects with bi-directional tone sandhi system, three dialects have uni-directional patterns in different grammatical categories. However, there are some exceptions. Tone sandhi patterns of some dialects are still bi-directional within a grammatical category. Pingyao is structurally simple in one grammatical category, but complex in another category. Changsha is structurally complex within each grammatical category, meaning multiple tone sandhi directions are attested within each grammatical category. When tone sandhi systems are conditioned by grammatical structures, the structural simplicity component seems play a role in governing the direction of tone sandhi. The structural simplicity component can account for the general tendency toward uni-directional tone sandhi patterns. However, note that within the 11 uni-directional systems, right-dominant systems are prevalent. This directionality asymmetry toward right-dominant patterns cannot be explained by structural simplicity hypothesis, because left- and right-dominant systems are equal in complexity. The following considerations on phonetic grounds of tone sandhi directionality will show that right-dominant local substitutions are preferred in terms of phonetic naturalness over left-dominant ones.

4 Phonetic-based analysis

This section examines the phonetic basis of tone sandhi directionality across the 17 dialects. The directionality asymmetry toward right-dominant tone sandhi in our survey can be accounted for by its durational advantage for contour tones and perceptual motivations in general. And phonetic grounds of the right-dominant, left dominant, and bi-directional systems are analyzed respectively. For each system, tone sandhi patterns involving contour tones are analyzed first followed by the analysis of the patterns involving non-contour tones.

4.1 Phonetic basis of right-dominant systems There are eight dialects in the survey with right-dominant tone sandhi systems, all with local tone substitutions (e.g. Mandarin 213 → 35 / __ 213, the tone 213 on the left syllable is substituted by 35). First, the duration-based analysis can account for each pattern involving contour tone reduction, as shown in Table 3. For the patterns that are motivated by duration in contour tone bearing ability, they reduce tonal duration on the left syllable. Because the left syllable is not a position for lengthening, in local tone substitutions, the contour tone on the left syllable is under a greater pressure to be substituted. Therefore, right-dominant local tone substitutions have a durational advantage over left-dominant ones (Zhang, 2007). Across the eight dialects in the survey, the patterns that are duration-based either reduce pitch excursion, e.g. Kunming 53 → 55/ __ T and Fuzhou 53 → 32/ __ 53; or substitute a rising tone with a falling tone, e.g. Yudu 35 → 31/ __ T; or reduce pitch targets, e.g. Beijing Mandarin 213 → 21/ __ {55, 35, 51} and Fuzhou {212, 242} → 44/ __ {44, 53}.

	Contour-tone reduction	Non contour-tone reduction
Beijing Mandarin (Zhang & Lai, 2010; Lin, 1992)	213 → 35 / __ 21 213 → 21/ __ {55, 35, 51} 51 → 53/ __ 51	
Tianjin (Zhang & Liu, 2016)	24 + 24 → 55 + 24 53 + 11 → 55 + 11 53 + 53 → 11 + 53 24 + 55 → 11 + 55 24 + 53 → 11 + 53	11 + 11 → 24 + 11
Boshan (Lin, 2004)	214 → 55/ __ 214 214 → 24/ __ 31	55a → 53/ __ 55 55b → 214/ __ 55 55 → 24/ __ 31 31 → 24/ __ 31
Kunming (Lin, 2019)	53 → 55/ __ T	44 → 35/ __ {31, 53, 11}
Wuyi (Zhang, 2007)	24, 213, 53 → 55/ __ T 31, 55, 13 → 11/ __ T	

Xiamen (Chen, 1987)	24 → 22/ __ T 53 → 44/ __ T 32 → 4/ __ T	22 → 21/ __ T 21 → 53/ __ T 44 → 22/ __ T 4 → 21/ __ T 32 → 53/ __ T
Fuzhou (Zhang, 2014)	{212, 242} → 44/ __ {44, 53} {212, 242} → 53/ __ {242, 212, 32} 53 → 44/ __ 44 53 → 32/ __ 53 53 → 21/ __ {242, 212} 53 → 32/ __ 32 32 → 44/ __ {242, 212}	44 → 53/ __ {242, 212, 32} 32 → 21/ __ {44, 53} 32 → 24/ __ 32
Yudu (Zhang, 2007)	35 → 31/ __ T	22 → 44/ __ T

Table 3. A duration-based analysis of right-dominant tone sandhi patterns

Because some of the right-dominant patterns do not involve contour tone reduction, the duration-based analysis cannot account for every single right-dominant tone sandhi pattern. However, the right-dominant directionality in general, regardless of durational reduction, can be captured by its perceptual motivation. As mentioned in Section 2.2, an output with progressive tone spreading is perceptually more similar to the input than one with regressive spreading. Moreover, because the processing of tones is slower than the processing of segments, tone change would have to occur earlier in order for tone change and segment change to be perceived as simultaneous (Hyman & Schuh, 1974; Javkin, 1979). In general, the uni-directionality of the eight dialects with local tone substitution can be captured by structural simplicity and their right-dominance can be accounted for by phonetic underpinnings.

4.2 Phonetic basis of left-dominant systems There are three dialects in the survey with left-dominant tone sandhi systems. Chengdu and Dongkou involve local tone substitutions. For example, in Chengdu 13 → 11 / T __, the rising tone 13 changes to the level tone 11 on the right syllable. As mentioned above, in local tone substitutions, right-dominance is phonetically grounded for contour and non-contour tones. Therefore, the left-dominant tone sandhi systems of Chengdu and Dongkou lack phonetic motivation.

Regarding Changzhou, its tone sandhi system involves tone extension. For example, in the pattern 523 → 55 – 23, the tone 523 is rightward extended over a two-syllable domain. The duration-based account work for four sandhi patterns in Changzhou which involve contour tone extension. Because the prosodic-initial position is not for lengthening, when a contour tone is involved in tone extensions, the left syllable is under a greater pressure to extend it than the right syllable. The following patterns in Changzhou 13 → 11 – 13, 45 → 45 – 55, 523 → 55 – 23, 24 → 11 – 24 reduce contour tones to lesser contours on each syllable in the domain (Zhang, 2007), thus they are phonetically motivated. However, in the pattern 55 → 33 – 33, the level tone is not under a durational pressure to be extended, which cannot be accounted for by tonal duration. Although the duration-based account does not work for all left-dominant tone extensions, the left-dominant rightward tone extension in general has perceptual motivations. As mentioned above, tone change occurring early is perceptually more similar to the input and motivated by the nonsynchrony of tones and segments. Taken together, the uni-directionality of the three dialects can be attributed to structural simplicity. The left-dominance of Chengdu and Dongkou with local tone substitutions lack phonetic motivations, while the left-dominance of Changzhou with rightward tone extensions is phonetically grounded.

4.3 Phonetic basis of bi-directional systems In the survey, Shanghai, Tangxi and Chaoyang with bi-directional systems have uni-directional tone sandhi patterns within each grammatical category. In Shanghai and Tangxi, the local tone substitution patterns are right-dominant and the tone extension patterns are left-dominant. In Chaoyang, both the left- and right-dominant patterns are local tone substitution. Therefore, following the phonetic analysis of tone sandhi directionality in the above sections, the directionality of Shanghai and Tangxi tone sandhi is phonetically grounded, while the directionality of Chaoyang tone sandhi cannot be fully attributed to phonetic motivations.

In general, concurring with Zhang's (2007) tone sandhi observations, local tone substitutions are often right-dominant and tone extensions are often left-dominant. The rightward directionality of tone sandhi has

phonetic underpinnings. To sum up, the majority of the 17 dialects are governed by structural simplicity. They have either a uni-directional tone sandhi system or uni-directional tone sandhi patterns within each grammatical category. Within uni-directional patterns, right-dominant local tone substitution and left-dominance tone extensions are phonetically grounded. Because most of the dialects in the survey involve local tone substitution, the directionality asymmetry toward right-dominance is durationally motivated for contour tones and perceptually grounded globally. Therefore, we propose that the concept of ‘structural simplicity’ should be incorporated with phonetic naturalness to better capture Chinese tone sandhi directionality.

5 Conclusion

To conclude, among the seventeen dialects from six dialectal groups in Chinese, structural simplicity largely governs the majority of sandhi directionalities, as evidenced by the overwhelming uni-directionality of sandhi patterns. The seemingly complex dialects with bi-directional tone sandhi systems largely have uni-directional sandhi patterns within each grammatical category. Crucially, the uni-directional systems are largely right-dominant, which could be attributed to phonetic motivations that the left contour tone is under a greater durational pressure to be substituted and the left tone in general is perceptually motivated to be changed. In the bi-directional systems with uni-directional sandhi patterns in each grammatical category, the right-dominant local tone substitutions and left-dominant tone extensions have phonetic underpinnings. Therefore, we propose a phonetically-grounded structural simplicity to account for Chinese tone sandhi patterns. The role of ‘structural simplicity’ has been widely confirmed in segmental phonology. The bias toward segmental patterns with simpler featural descriptions has been reflected by natural-language typology and laboratory studies (as summarized by Moreton & Pater, 2012a). So far, only a few studies have investigated the bias in suprasegmental phonology (e.g. Guest et al., 2000; Pater, 2012) and no study has investigated its role in tone sandhi. This paper fills the gap in suprasegmental phonology by introducing structural simplicity to tone sandhi. Future research involves the investigation of the role of structural simplicity in tone sandhi learning.

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