Dual Prominence in Tone Mapping: A Case of Tone Movement

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1. Introduction

The present paper proposes a theory of dual prominence in tone mapping. Evidence is drawn from tone movement observed in the lexical tone sandhi of the Chinese Zhenhai dialect. In this theory, two prominent positions, prosodic edge and metrical head, are singled out in phonology. They are referred to by both positional faithfulness and positional markedness constraints in an Optimality-Theoretic analysis of tone movement.

Most tone sandhi processes in Chinese Wu dialects are characterized as deletion of tones on unstressed syllables, followed by spreading (or re-association) of the tone on the stressed syllable in a tone sandhi domain. An often-cited example is New Shanghai, which has five lexical tones, three long tones and two short checked tones (marked by ʔ). Its tone inventory is given in (1):

(1)

tone 1	tone 2	tone 3	tone 4	tone 5
HL	MH	LM	Mʔ	Lʔ

The tone sandhi process is illustrated in (2):

(2) a. Tone 1 + T
HL + T → H + L

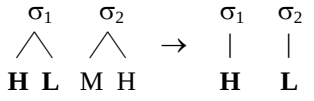
"weather"	"thin"
thi-tshi	tæ-buʔ
HL-MH	HL-LMʔ
H-L	H-Lʔ

b. Tone 2 + T
MH + T → M + H

"anger"	"to requite"	(T= tone)
hut-shi	pø-taʔ	
MH-MH	MH-LMʔ	citation tone
M-H	M-Hʔ	sandhi tone

It is observed here that the lexically associated tone of the initial syllable in a compound is preserved while those of the non-initial syllables are deleted. The preserved tone then maps to the syllables from left to right in a one-to-one fashion, reminiscent of tone mapping in African tone languages (Goldsmith 1976, Pulleyblank 1986). For example, the initial falling tone (HL) in (2a) is retained. H is then mapped to the first syllable and L to the second. The rising tone (MH) associated with the second syllable is deleted. This process can be represented in autosegmental terms as in (3):

(3)



Tone preservation on the initial syllable and tone deletion on non-initial syllables have been argued to correlate with left-headed metrical structure in Shanghai in many current analyses, most notably Duanmu (1993, 1995, 1999). Duanmu (1995) argues for left-headed stress in Shanghai by drawing on evidence from word length restrictions and contrastive focus. He notes that in a trisyllabic compound consisting of two lexical words (W1 and W2), either one or two tone sandhi domains can be formed, depending on the length of W1 and W2. In 2+1 structures (i.e. W1 disyllabic, W2

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monosyllabic), both options are permissible. In 1+2 structures (i.e. W1 monosyllabic, W2 disyllabic), only one domain can be formed. The word length effect on domain formation follows from Duanmu's metrical analysis by assuming that word stress and compound stress are both left-headed in Shanghai. The unattested metrical structure in (4a, left) is ruled out because it creates a stress clash, resolved by removing the weaker stress (4a, right). There is no stress clash in (4b) though, and the deletion of weaker stress is optional.

(4) a.	stress clash		b.	no stress clash			
	x	x		x	x		word level
	x x	x		x x	x		compound level
	*(σ)(σ σ) →	(σ σ σ)		(σ σ)(σ)	or	(σ σ σ)	metrical structure

The Shanghai tone sandhi is also sensitive to contrastive focus, whose primary effect is to insert a prosodic boundary to the left of the focused constituent and optionally delete the post-focus tones (Selkirk and Shen 1990, Duanmu 1995), pointing to left-headed stress. When a stress clash results from contrastive focus, it is resolved by removing the stress on the right in a way similar to (4a).

In addition to phonological evidence, recent phonetic studies reveal effects of left-headed stress on syllable duration in Shanghai (Duanmu 1994, Zhu 1995). According to Zhu's (1995) measurements of Shanghai tones, in a disyllabic word the rime duration of the first syllable is averaging about 200 ms and that of the second syllable is about 100 ms, excluding syllables in short tones (tones 4 and 5).

As Chen (2000) points out, the prevailing analysis of tone sandhi in Shanghai and other Chinese Wu dialects, illustrated in (3), sees a direct link between tone preservation and metrical prominence. Since metrical head is the only relevant parameter for tone preservation, we call it a single prominence theory. Under this view, only the underlying tone of the stressed syllable is retained and shows up on the surface. It excludes the opposite scenario in which the underlying tone of the unstressed syllable is retained and realized while the stressed syllable loses its underlying tone.

This paper shows that the lexical tone sandhi in Zhenhai represents exactly the excluded pattern. According to the description of disyllabic tone sandhi in Rose (1990), if both syllables are long, the underlying tone of the unstressed initial syllable is preserved, and then shifted to the stressed final syllable, whose underlying tone is supplanted. This kind of tone movement is inexplicable in the single prominence theory since it implicates two different positions. It calls for a theory separating tone preservation and tone realization, i.e. where a tone originates and where it ends up on the surface are independent of each other. We argue for a dual prominence theory, in which multiple prominent positions are referred to by both positional faithfulness and positional markedness constraints.

2. Lexical tone sandhi in Zhenhai

2.1. Zhenhai tones

Zhenhai is a northern Wu dialect spoken in Zhejiang province. Rose (1990) describes its tonal system and disyllabic lexical tone sandhi in detail. Our analysis is based on his description of the data. The tone inventory is summarized in (5).

(5)

		tone	Example	notation	Gloss
long tone	*high register*	1	tɕi	HL	"to fill"
		2	tɕiʔ	MH	"chicken"
	low register	3	tɕ̈i	ML	"to ride"
		4	tɕ̈iʔ	LM	"he/she/it"
short tone	*high register*	5	tɕɪʔ	Hʔ	"knot"
	low register	6	tɕ̈ɛʔ	Lʔ	"straight"

In Zhenhai, the four long tones are all contour tones, two rising tones and two falling tones. They are further distinguished by register specifications. For example, tone 2 is a high rising tone (MH)

while tone 4 is a low rising tone (LM). Tones 5 and 6 are checked tones. They are much shorter in duration than long tones.

Rose (1990) points out that disyllabic compounds fall into two metrical patterns: S-W (strong-weak) and W-S (weak-strong). As a result, there are two types of tone sandhi patterns. Tone movement occurs in the W-S tone sandhi when the preserved initial tone is attracted to the final stressed syllable.

2.2. Tone movement in W-S tone sandhi

The W-S tone sandhi patterns are summarized in (6). Examples follow in (7).

(6)

patterns	A: T1 + T	B: T3 + T	C: T4 + T	D: T6 + T
input	*HL* – T	*ML* – T	*LM* – T	Lʔ – T
output	M – *HL*	L – *HL*	L – *MH*	Lʔ – T^h
	-ʔ M – Hʔ	L – Hʔ	L – Hʔ	L – Hʔ

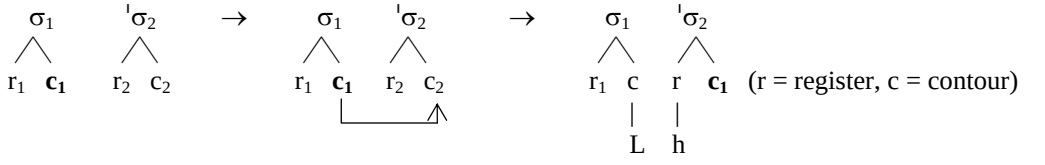
(T = any tone, T^h = tone in high register)

(7)

A.	“spring”	“western calendar”	
	tshʏŋ thĩ	ɕi lɪʔ	
	HL-HL	HL-Lʔ	citation tone
	M-HL	M-Hʔ	sandhi tone
B.	“coal mine”	“hair”	
	mei khwɑ̃	tœy faʔ	
	ML-ML	ML-Hʔ	citation tone
	L-HL	L-Hʔ	sandhi tone
C.	“place”	“yesterday”	
	ti fɑ̃	sɑ̃ ɲɪʔ	
	LM-HL	LM-Lʔ	citation tone
	L-MH	L-Hʔ	sandhi tone
D.	“tongue”	“special”	
	ɕɛ tœy	ta pɛʔ	
	Lʔ-ML	Lʔ-Hʔ	citation tone
	Lʔ-HL	Lʔ-Hʔ	sandhi tone

Disyllabic tone sandhi in Zhenhai exhibits a case of dramatic positional neutralization. In the W-S tone sandhi, stress falls on the final syllable. When the first syllable is phonologically long, as in patterns A, B and C, the stressed second syllable does not show up with its underlying tone. Rather, as Rose (1990:28) suggests, the underlying tone of the first syllable appears on the second syllable, whose underlying tone is completely supplanted. Further, when the initial tone moves to the stressed syllable, it is realized in the high register. In (6c) and (7c), for example, the initial tone is a low rise (LM) in the input, but realized as a high rise (MH) on the stressed final syllable. The initial syllable takes on a level tone, whose actual scaling is determined by its underlying register specification. In (6a) and (7a), the initial syllable ends up with a M tone since its underlying tone is a high-register tone (e.g. HL). In (6b) and (7b), it is realized in a L tone since its underlying tone is in the low register (e.g. ML). This process of tone movement and its concomitant effects are shown in (8). Bao’s (1990) model of tone is assumed here with a separation of register (h, l) and contour features (H, L).

(8)



As shown in (8), the underlying tone (register and contour) of the initial syllable is retained. Its contour feature moves to the stressed final syllable, where a high register is inserted (e.g. turning a low rise into a high rise as in 6C and 7C). The initial syllable is realized in a L or M tone, depending on its underlying register specification. Note that while the stressed final syllable attracts the underlying contour of the initial syllable, it loses its underlying tone (register and contour) completely.

Complications arise when short checked tones are involved. When the final syllable is a short syllable (in tones 5 and 6), a H tone always shows up, as shown in the last row in (6). When the first syllable is a short syllable (6D), the second syllable, if it is a long syllable, keeps its underlying contour and realizes it in high register. In either case, the initial syllable takes on a L or M tone.

2.3. S-W tone sandhi

The S-W tone sandhi in Zhenhai does not feature tone movement, but it exemplifies initial tone preservation as in the W-S tone sandhi. The patterns are summarized in (9). It should be pointed out that our interpretation of the data is different from Rose's (1990) regarding the second syllable. Recent studies of tone implementation (Xu and Wang 2001) give us a better understanding of the realization of tone targets in different tonal contexts. For example, a falling tone might look similar to a L tone if the L tone is preceded by a H tone or a rising tone. The falling f_0 (fundamental frequency) is the result of the f_0 transition for a L tone. For more details, please refer to Li (2003, ch.4).

(9)

patterns	A: T1 + T	B: T2 + T	C: T4 + T	D: T5 + T
input	HL – T	MH – T	LM – T	HʔL – T
output	H – L	MH – L	LM – L	HʔL – L

In the S-W tone sandhi, stress falls on the initial syllable. Except for pattern A, the first tone is faithfully preserved in the output. The second syllable loses its underlying tone (register and contour) completely. It takes on a L tone (in low register).

To summarize, like other Chinese Wu dialects, Zhenhai disyllabic tone sandhi is characteristic of dramatic positional neutralization. Putting aside short syllables, what is special about Zhenhai is that the initial tone is always preserved in the output, but it is only realized on the stressed syllable. Tone movement results when stress falls on the final syllable as in the W-S tone sandhi. The initial syllable, be it stressed or unstressed, retains its underlying register specification. The final syllable, when it is stressed, takes on a high register.

What seems to emerge from the discussion so far is that initial syllables and stressed syllables are both important in the determination of surface tone patterns in Zhenhai because, as we suggest, they both occupy phonologically prominence positions.

2.4. Initial prominence and metrical prominence

Rose (1990) distinguishes two metrical patterns (S-W and W-S) in disyllabic expressions, mostly compounds. The prominence judgments are confirmed by native speakers. However, when we examine the distribution of tones, the following asymmetry is observed: while any lexical tone can appear on the second syllable, S-W tone sandhi is used when the first syllable bears tone 2 and tone 5, and W-S tone sandhi is used when the first syllable bears tone 3 and tone 6. We find syllables in tone 1 and tone 4 occur in both S-W and W-S tone sandhi. According to Rose (1990), tone 1 in Zhenhai is derived from two different tonal categories in middle Chinese, so is tone 4. This explains why they occur in both tone sandhi. Once the metrical pattern is ascertained, the surface sandhi forms are predictable on the basis of the underlying tone of the first syllable.

It is expected that stressed syllables have longer duration than unstressed syllables. However, this is not clearly attested in Zhenhai disyllabic expressions at all. Rather we find that initial syllables are significantly longer than final syllables in both metrical patterns. The following graphs illustrates systematic durational differences in the two syllables.

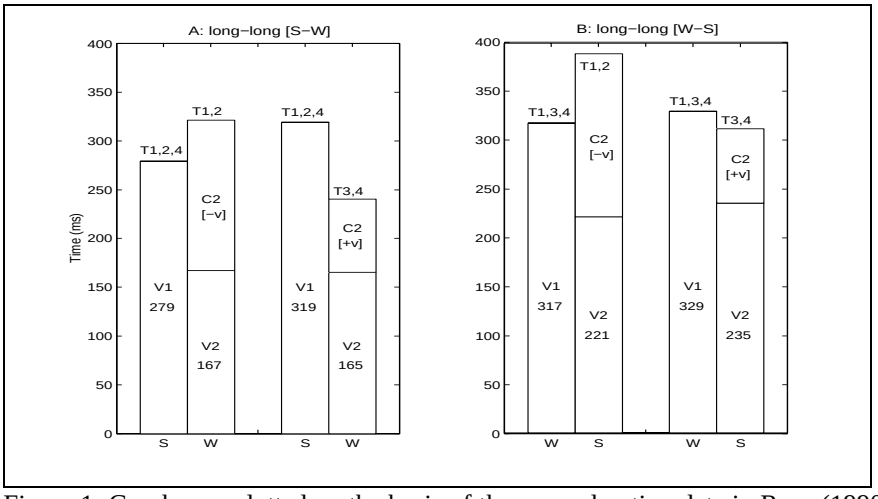


Figure 1: Graphs are plotted on the basis of the mean duration data in Rose (1990:10). V1 and V2 stand for durations of the first-syllable vowel and second-syllable vowel, and C2 for the duration of the second-syllable onset. The voicing of C2 is marked by [±v]: [+v] = "voiced" and [-v] = "voiceless". Voiceless C2 occurs with tones 1, 2, 5, and voiced C2 with tones 3, 4, 6. The numbers are durations (in ms) of V1 and V2.

The most striking observation that emerges from the long syllable combinations is the lack of compelling correlation of metrical prominence (i.e. syllable in strong position in S-W and W-S patterns) with longer syllable duration. Rose (1990:21) also points out that "stress does not correlate with duration in first syllable tones". With that being said, we do observe some effect of stress on duration in the comparison of V2 duration in A and B. More significant is the longer duration of the first syllable. We attribute it to initial syllable lengthening, i.e. the syllable in the domain-initial position is lengthened. Initial lengthening has been observed cross-linguistically as a specific case of a more general process known as initial strengthening (Barnes 2001, Dilley, Shattuck-Hufnagel and Osterndorf 1996, Fougeron and Keating 1996, Keating, Cho, Fougeron, and Hsu 1999, Pierrehumbert and Talkin 1992, *inter alia*).

In addition to being enhanced with longer duration, the initial position in Zhenhai is made prominent by other two cues. As we discussed before, regardless of where metrical prominence is, the underlying tone of the first syllable is preserved in the output, and its underlying register is also preserved. The stressed syllable attracts the preserved initial tone because of metrical prominence. Therefore we end up with two prominent positions that interact to give rise to the surface sandhi forms in Zhenahi.

The dual prominence theory that we propose recognizes both edge prominence (initial prominence in Zhenhai) and metrical prominence. The W-S tone sandhi in Zhenhai illustrates that metrical prominence alone is not able to account for the preservation of the initial tone when the metrically strong position is final. Next, we build the idea of dual prominence into a formal analysis of tone movement in Zhenhai, in which both prominent positions are referred to by phonology. We will also show that both positional faithfulness and positional markedness constraints are necessary.

3. An Optimality-Theoretic analysis of tone movement

The theoretical framework adopted is the Optimality Theory (OT) (Prince and Smolensky 1993). In OT, surface forms are evaluated by a set of ranked, violable constraints. In the Correspondence Theory developed by McCarthy and Prince (1995), faithfulness constraints regulate the identity of correspondent strings in the input-output relation. Compared to context-free faithfulness constraints, positional faithfulness constraints are defined relative to a specific phonological context (Beckman 1998). Positional markedness constraints favor some privileged positions in terms of licensing a specific phonological form. For example, contour tone licensing constraints restrict the preserved tone

to some privileged positions (Zoll 1996, 2003, Zhang 2001). Our analysis of tone movement relies on positional faithfulness constraints and positional markedness constraints, arguing for the necessity of admitting both in the grammar. Most constraints are adapted from Zhang (2001) and Zoll (2003).

Some of the key constraints are defined first:

- MAX(TONE)/INITIAL: if T is a tone in the domain-initial position in the input, then T has a correspondent in the output.
- IDENT(TONE)/σ́: If a stressed syllable has a tonal specification in the input, then its correspondent has identical specification in the output.
- COINCIDE(σ́, CONTOUR): If a syllable is stressed, it bears a contour tone.
- COINCIDE(σ́, H): If a syllable is stressed, it bears a H tone.
- *CONTOUR/SHORT: No contour tone is allowed on a short syllable.

In our constraint system, initial tone preservation is achieved by ranking MAX[TONE]/INITIAL over IDENT[TONE]/σ́, as shown in (10). L- is the boundary tone inserted in response to a positional markedness constraint, BND(L)/EDGE, which requires an unstressed syllable at the edge of a prosodic domain to coincide with a low tone target.

(10)

tone 1 + tone 2	σ_1 $\acute{\sigma}_2$ | | F_1 R_2	MAX(TONE)/INITIAL	IDENT(TONE)/σ́
a.	σ_1 $\acute{\sigma}_2$ | | L- R_2	*!	
b. ☞	σ_1 $\acute{\sigma}_2$ | | L- F_1		*

The general markedness constraint, *TONE, is invoked to delete any tonal specifications on a syllable. In trisyllabic combinations, once MAX(TONE)/INITIAL and BND(L)/EDGE are both satisfied, *TONE will be responsible for eliminating tonal specifications on non-peripheral unstressed syllables, which are not protected by MAX(TONE)/INITIAL, nor filled in with a boundary tone. This is shown in (11), where a trisyllabic sequence with W-W-S metrical pattern is taken from Rose (1994). Candidate (a) is ruled out for assessing more violations of *TONE.

(11) LM + T^l + T^l → L- + Φ + MH (T^l=T in low register, Φ=toneless)

	σ_1 σ_2 $\acute{\sigma}_3$ | | | R_1 F_2 F_3	BND(L)/EDGE	MAX(TONE)/INITIAL	COINCIDE(σ́, CONTOUR)	*TONE
a.	σ_1 σ_2 $\acute{\sigma}_3$ | | | L- F_2 R_1				***!
b.	σ_1 σ_2 $\acute{\sigma}_3$ | | L- R_1			*!	**
c. ☞	σ_1 σ_2 $\acute{\sigma}_3$ | | L- R_1				**

Once the initial tone is preserved, as in (11b) and (11c), its realization on the strong syllable is achieved by contour tone licensing constraints. Specifically, COINCIDE(σ́, CONTOUR) restricts a contour tone to the stressed syllable, favoring candidate (c) over (b) in (11).

In our analysis, positional faithfulness constraints like MAX(TONE)/INITIAL are invoked to preserve the initial tone. We have seen that candidates satisfying MAX(TONE)/INITIAL have to be assessed by positional markedness constraints as well. However, whether or not it will eventually surface on the stressed syllable is determined by contour licensing constraints. For example, in Zhenhai W-S tone sandhi, the initial tone is preserved and attracted to the stressed syllable. The preserved tone actually surfaces on the stressed second syllable when it is phonologically long. When the second syllable is a short syllable, it defaults to H. Therefore, surface sandhi forms emerge from the interaction of positional faithfulness and positional markedness constraints.

In long-short combinations, the underlying tone of the first syllable does not surface on the second, short syllable in strong position due to the high-ranking *CONTOUR/SHORT constraint, shown in (12).

(12) HL (tone 1) + L˨ (tone 6) → L- + H˨, *L- + HL
cf. HL (tone 1) + MH (tone 2) → L- + HL

tone 1 + tone 6	σ_1 $\acute{\sigma}_2$ | | F_1 L_2	*CONTOUR/SHORT	MAX(TONE)/INITIAL	COINCIDE (σ́, CONTOUR)	COINCIDE(σ́, H)
a.	σ_1 $\acute{\sigma}_2$ | | L- F_1	*!			
b. ☞	σ_1 $\acute{\sigma}_2$ | | L- H		*	*	
c.	σ_1 $\acute{\sigma}_2$ | | L- L_2		*	*	*!

In short-long combinations, the second syllable surfaces with its underlying tone and the first syllable with a short level tone. This establishes the ranking of COINCIDE(σ́, CONTOUR) and MAX(TONE)/INITIAL. In (13), candidate (a) satisfies MAX(TONE)/INITIAL by keeping the initial tone, but it violates COINCIDE(σ́, CONTOUR). Candidate (c) loses to (b) in violation of IDENT(TONE)/σ́.

(13) L˨ (tone 6) + MH (tone 2) → L- + MH, *L- + L

tone 6 + tone 2	σ_1 $\acute{\sigma}_2$ | | L_1 R_2	COINCIDE(σ́, CONTOUR)	MAX(TONE)/INITIAL	IDENT(TONE)/σ́
a.	σ_1 $\acute{\sigma}_2$ | | L- L_1	*!		*
b. ☞	σ_1 $\acute{\sigma}_2$ | | L- R_2		*	
c.	σ_1 $\acute{\sigma}_2$ | | L- F		*	*!

To avoid contour simplification, COINCIDE(σ́, CONTOUR) has to outrank COINCIDE(σ́, H) when the stressed syllable is phonologically long. Further, COINCIDE(σ́, H) should be ranked higher than MAX(TONE)/INITIAL so that in short-short combinations, the stressed second syllable will default to H instead of taking the initial L tone, as in L˨ (tone 6) + L˨ (tone 6) → L- + H, *L- + L.

The partial ranking of the constraints is summarized in (14):

(14) a. *CONTOUR/SHORT >> COINCIDE(σ́, CONTOUR) >> COINCIDE(σ́, H) >> MAX(TONE)/INITIAL
b. MAX(TONE)/INITIAL >> IDENT(TONE)/σ́, *TONE

The register specification can be derived similarly. For example, IDENT(REG)/INITIAL should be ranked above REG(H)/σ́ since when stress falls on the initial syllable in the S-W tone sandhi, the surface tonal contour on the initial syllable is realized in its underlying register specification. In the W-S tone sandhi, however, the underlying register of the stressed syllable is replaced with a high register, which motivates REG(H)/σ́ over IDENT(REG)/σ́.

The constraint system we have developed so far accounts for both W-S and S-W tone sandhi patterns in Zhenhai. One pattern that we have not explained is the pattern A in the S-W tone sandhi: HL – T → H – L. Our analysis predicts the output as HL – L since the first syllable is stressed and it will attract the preserved initial tone. We propose that the contour simplification is actually due to tone absorption, a process widely attested in West African languages (Hyman and Schuh 1974). We treat it as a general markedness constraint, *FL, ranked over COINCIDE(σ́, CONTOUR).

Rose (1990, 1994) also reports four trisyllabic tone sandhi patterns with different metrical patterns, shown below:

(15) W-W-S: LM (tone 4) + T^l + T^l → L- + Φ + MH (Φ = toneless)
S-W-W: MH (tone 2) + T + T → MH + Φ + L-
W-S-W: HL (tone 1) + T + T → M- + H + L-
W-S-W: ML (tone 3) + T + T → L- + H + L-

All these patterns are correctly predicted in our analysis. It remains to see whether our analysis is able to handle all the other trisyllabic combinations. The prediction is clear: the initial tone will be preserved and shifted to the stressed syllable when phonologically long syllables are involved. More specific predictions can be readily made regarding register neutralization and contour tone distributions in Zhenhai.

4. Conclusions

The Zhenhai lexical tone sandhi, particularly the W-S tone sandhi, represents a typological pattern in which the initial tone is preserved and then moves to the metrically strong position. It calls for a theory of tone mapping which recognizes two prominent positions. In the dual prominence theory that we propose, both edge prominence (initial prominence in Zhenhai) and metrical prominence play a role in determining the surface sandhi forms. The initial position and metrically strong position are referred to by the phonology in our analysis of tone movement in Zhenahi.

Our theory makes possible a richer typology in which edge prominence and metrical prominence interact to give rise to diverse surface tone sandhi patterns. For example, Zhenhai W-S tone sandhi exhibits tone movement, a tonal process in which the underlying tone of a syllable at one edge of a tone sandhi domain is preserved, but surfaces on the stressed syllable at the other edge in the same domain. As a mirror image of Zhenhai, Wenzhou dialect has a tonal process in which the final tone is preserved, but realized on the initial stressed syllable (Li 2003). When tone retention and tone realization occurs in the same position, there is no tone movement, as in New Shanghai and the S-W tone sandhi in Zhenhai. Whether contour simplification will happen or not depends on how the contour tone licensing constraints are ranked. This paper is thus a contribution to the general OT tone-prominence typology literature (e.g. Barnes 2002, de Lacy 2002, Zhang 2001).

The idea of dual prominence is similar to Zoll's (1997) idea of multiple prominence implicated for prominence-related tonal phenomenon in African languages. We further illustrate that phonological patterns of tone preservation and tone realization emerge from the interaction of edge prominence and metrical prominence in a prosodic domain of tone sandhi.

This paper also argues for the coexistence of both positional faithfulness and positional markedness constraints in the grammar. As Zhenhai lexical tone sandhi demonstrates, positional faithfulness constraints interact with contour tone licensing constraints in determining the surface sandhi forms. Both make reference to the two prominent positions, initial position and stress. The implication of this idea awaits further explorations.

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