

BOSHAN TONE SANDHI^{*}

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ABSTRACT

This paper investigates the tone sandhi phenomenon in Boshan, which is remarkable for its seemingly unpredictable rule application directionalities observed in tri-tonal strings. Based on the constraint-based theory of OT, this paper shows that the rule application directionalities in Boshan are by no means ungoverned. Normally tone sandhi applies from left to right for identity reasons, unless highly marked forms would be generated. In that case, tone sandhi applies reversely from right to left. Thus, the rule application directionalities are naturally predicted by the interaction of the identity and markedness constraints. The investigation of the issue of directionality in Boshan also supports the view that identity preservation between prosodically related outputs is important in tone sandhi. The output-to-output correspondence relation may force a tonal output to deviate from the canonical surface patterns of the language, so that it becomes more like a tonal base to which it prosodically relates. Identity preservation is highly respected in tone sandhi, unless this would produce forms that are highly marked.

1. INTRODUCTION

Tone sandhi refers to the tonal change of one tone in the environment of another tone. Recently, there is a growing interest in the study of directional tone sandhi, that is, tonal changes that must be derived by certain rule application directionalities, which appear to be ungoverned (Chen 2000, 2002; Hyman and VanBik 2002; Lin 2002). Boshan tone sandhi (Qian 1993, Chen 2000) examined in this paper exhibits the

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characteristic of directional tone sandhi. In Boshan, tone sandhi rules must apply from left to right to derive the outputs for some tri-tonal patterns and from right to left to account for the others. The rule application directionalities appear to be ungoverned. To date, there are six general principles that are proposed to be the possible criteria that govern the rule application directionalities. They are Structure Affinity, Temporal Sequence, Derivational Economy, Transparency, Simplicity and Wellformedness (Chen 2002: 8). Structure Affinity refers to cyclicity following the syntactic bracketing. Temporal Sequence refers to the temporal sequence of speech organization thus prefers the left-to-right directionality. Derivational Economy chooses the shortest derivational path, thus prefers bleeding and counterfeeding. Transparency, on the other hand, favors feeding and bleeding. Simplicity prefers simple (level) to complex (contour) tones. Finally, Wellformedness favors a derivation that yields unmarked tonal combinations. As will be shown below in §2, none of the six concepts alone would predict for Boshan tone sandhi. Chen (2000) proposes an analysis that relies on the interactions of some derivational constraints. The constraints, which are derivational in nature, are ranked like the OT constraints. However, the analysis proposed in Chen (2000) has not only conceptual but also technical problems (see discussion in §5).

In the present study, based on the constraint-based theory of OT (Prince and Smolensky 1995), the motivation behind the different rule application directionalities in Boshan is examined in depth. This paper shows that the rule application directionality in Boshan is by no means ungoverned. Normally tone sandhi applies from left to right for identity reasons, unless highly marked forms would be resulted. In that case, tone sandhi applies reversely from right to left. Thus, the attested outputs which are derived by different directionalities can be predicted naturally by the interaction of the identity and markedness constraints.

The paper is organized as below. After presenting the tonal facts of Boshan in §2, I discuss some theories and assumptions that are essential in the present OT analysis in §3. In §4, I propose an OT analysis to account for Boshan tone sandhi where I show that the rule application directionalities in Boshan are highly correlated to the preservation of identity between prosodically related tonal outputs. In §5, I consider some alternative analyses, which include the rule-based analysis and the analysis based on derivational constraints (Chen 2000), and show that neither of the analyses can capture Boshan tone sandhi as naturally as the

present analysis. §6 concludes this paper.

2. DATA AND GENERALIZATION

Boshan is a northern Mandarin dialect spoken in Shandong Province. It has three citation tones: 214, 55, and 31. Two tone sandhi processes can be observed in the dialect. The first process is the disallowance of identical tones to occur in adjacent position. When identical tones occur, tone sandhi takes place and alters the tone at the left edge to a sandhi tone. For example, 214 changes to 55 when preceded by another 214 tone (e.g. (1)). The citation tone 55 comes from two underlying representations 55a and 55b. The two underlying tones come from two distinct tonal categories in Middle Chinese, 55a generally derives from Middle Chinese lower register *ping* categories while 55b is the modern reflex of Middle Chinese *shang* tone (Chen 2000: 213). Besides, 55a and 55b surface as different tones before another 55 tone. Before a 55 tone, 55a surfaces as 53 while 55b as 214 (e.g. (2) and (3)). 31 tone, when followed by another 31 tone, could change to a 24 tone. However, the tonal change of 31 tone before another 31 tone is optimal. This can be illustrated in (4) and (5). The second tone sandhi process in this dialect is neutralization. Tones are neutralized to 24 in front of the 31 tones (e.g. (6) and (7)).¹ (The Boshan data below are drawn from Chen (2000).)

(1) ‘the spring equinox’

	<i>chun fen</i>
Base tone	214.214
Tonal change	55
Sandhi tone	55 .214
Key: tones are separated by ‘.’	
T = base tone, unchanged	
T = tones that undergoes tonal change	

¹ The tonal change of 31 before another 31, when appears, can be regarded as either caused by the disallowance of identical tones in sequence or by neutralization.

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(2) ‘horse-riding’	<i>qi ma</i>
Base tone	55a.55
Tonal change	53
Sandhi tone	53.55
(3) ‘to confess’	<i>tan bai</i>
Base tone	55b.55
Tonal change	214
Sandhi tone	214.55
(4) ‘mid-night’	<i>ban ye</i>
Base tone	31.31
Tonal change	24
Sandhi tone	24.31
(5) ‘target’	<i>dui xiang</i>
Base tone	31.31
Tonal change	n/a
Sandhi tone	31.31
(6) ‘country side’	<i>xiang xia</i>
Base tone	214.31
Tonal change	24
Sandhi tone	24.31
(7) ‘city’	<i>cheng shi</i>
Base tone	55.31
Tonal change	24
Sandhi tone	24.31

The tonal combinations and changes can be summarized in (8). And the tone sandhi phenomena can be captured by the rules in (9)-(12) in the

traditional derivational theory.

(8)

1 st tone	2 nd tone		
	214	55	31
214	55. 214		24. 31
55a		53. 55	24. 31
55b		214. 55	
31			(24. 31)

(9) 214 → 55/ ___ 214

(10) 55a → 53/ ___ 55

(11) 55b → 214/ ___ 55

(12) T → 24/ ___ 31

When it comes to tri-tonal strings, the question regarding which two tones should be scanned first for tonal changes would be raised. Logically, there are two possibilities: one is that the two tones on the left are scanned first, and then the two tones on the right, e.g. (13a). The other is the reverse; that is, the two tones on the right are scanned for tonal changes first and then the two tones on the left, e.g. (13b). In (13a), it looks as if tone sandhi has operated in the direction of left-to-right; in (13b), tone sandhi can be seen as operating from right to left. The outputs resulted from the different rule application directionalities are different.

- (13) Underlying Tone: /Ta.Tb.Tc/
 Tone Sandhi Rule: Ta → **Ta**/ — Tb
 Tb → **Tb**/ — Tc

Left-to-right ⇒	Right-to-left ⇐
(a) <u>Ta.Tb.Tc</u> Ta.Tb.Tc Ta.Tb.Tc	(b) Ta. <u>Tb.Tc</u> Ta. Tb .Tc (n/a) Ta. Tb .Tc

Key: T.T = current two-tone window scanned for possible rule application
 ⇒ / ⇐ = the rule application directionalities by which the tonal outputs are derived

Of course, the results of different rule application directionalities do not always need to be different. This happens when there is only one tone sandhi rule involved.

- (14) Underlying Tone: /Td.Te.Tf/
 Tone Sandhi Rule: Te → **Te**/ — Tf

Left-to-right ⇒	Right-to-left ⇐
(a) <u>Td.Te.Tf</u> (n/a) Td. <u>Te.Tf</u> Td. Te .Tf	(b) Td. <u>Te.Tf</u> Td. Te .Tf (n/a) Td. Te .Tf

Cases like that presented in (13) where different outputs would be resulted when tone sandhi operates in different directionalities will be referred to as *direction-sensitive tone sandhi*. Cases like that presented in (14) where no different outputs would be resulted even though tone sandhi has operated in different directionalities will be referred to as *direction-neutral tone sandhi*. Here below, direction-sensitive tone sandhi, which is more complex, will be the focus of the discussion.

In Boshan, there are nine patterns of tri-tonal strings that are direction-sensitive. For example, as shown in (15), (P1)-(P4) must be derived with a left-to-right rule application directionality:

(15) Tone sandhi must apply left-to-right in (P1) - (P4)

a.	(P1) $\underline{55a.214.214} \rightarrow 55.214.214 \rightarrow 55.55.214$ \Rightarrow (P2) $\underline{55b.214.214} \rightarrow 55.214.214 \rightarrow 55.55.214$ (P3) $\underline{214.214.214} \rightarrow 55.214.214 \rightarrow 55.55.214$ (P4) $\underline{214.214.31} \rightarrow 55.214.31 \rightarrow 55.24.31$	{{ <i>nan guan</i> } <i>jie</i> } ‘Nanguan street’ {{ <i>gui</i> } { <i>chui deng</i> }} ‘dirty tricks’ {{ <i>shou yin</i> } <i>ji</i> } ‘radio’ {{ <i>chuan yi</i> } <i>jing</i> } ‘full-length mirror’
b.	(P1) $\underline{55a.214.214} \rightarrow 55a.55.214 \rightarrow *53.55.214$ \Leftarrow (P2) $\underline{55b.214.214} \rightarrow 55b.55.214 \rightarrow *214.55.214$ (P3) $\underline{214.214.214} \rightarrow *214.55.214$ (P4) $\underline{214.214.31} \rightarrow *214.24.31$	

On the other hand, pattern (5) to pattern (9) must be derived by a right-to-left directionality:

(16) Tone sandhi must apply right-to-left in (P5) to (P9)

a.	(P5) $\underline{55a.55a.55} \rightarrow 55.53.55$ \Leftarrow (P6) $\underline{55b.55b.55} \rightarrow 55.214.55$ (P7) $\underline{55a.55.31} \rightarrow 55.24.31$ (P8) $\underline{55a.55b.55} \rightarrow 55.214.55$ (P9) $\underline{55b.55a.55} \rightarrow 55.53.55$	{{ <i>tai tou</i> } <i>wen</i> } ‘wrinkles on foreheads’ {{ <i>guan li</i> } <i>yuan</i> } ‘person in charge’ {{ <i>chang jing</i> } <i>lu</i> } ‘giraffe’ {{ <i>chang</i> } { <i>guo ren</i> }} ‘peanut’ {{ <i>bi liang</i> } <i>gu</i> } ‘septum’
b.	(P5) $\underline{55a.55a.55} \rightarrow 53.55a.55 \rightarrow *53.53.55$ \Rightarrow (P6) $\underline{55b.55b.55} \rightarrow 214.55b.55 \rightarrow *214.214.55$ (P7) $\underline{55a.55.31} \rightarrow 53.55.31 \rightarrow *53.24.31$ (P8) $\underline{55a.55b.55} \rightarrow 53.55b.55 \rightarrow *53.214.55$ (P9) $\underline{55b.55a.55} \rightarrow 214.55a.55 \rightarrow *214.53.55$	

The question is, what determines toward which direction tone sandhi should operate? Obviously, the directionalities of rule application cannot be governed by the morphosyntactic structures of the tri-syllabic word strings (i.e., the principle of Structural Affinity (Chen 2002:8)). For example, to derive the outputs for pattern (1) to (4), tone sandhi rules should apply from left to right; however, the example of pattern (2) has a right branching morphosyntactic structure. Likewise, while tone sandhi rules need to apply from right to left to derive the outputs for pattern (5) to (9), most of the examples given have left branching morphosyntactic structures. Similarly, the directionalities cannot be governed by the

principle of Temporal Sequence (Chen 2002:8) which requires that rules must operate from left to right, as both left-to-right and right-to-left rule application directionalities are observed in the nine patterns.

Recall that except for Structural Affinity and Temporal Sequence, there are four other criteria proposed in Chen (2002) that may serve to govern the rule application directionalities. Consider Derivational Economy first. The Derivational Economy prefers tonal changes that are derived by the shortest derivational path. However, as shown below, the attested outputs are not always derived by the most economical derivation path. Though it is true that the attested outputs of (P5) and (P6) (i.e., (17a)) are derived by shorter derivational paths than the unattested outputs (i.e., (17a')), the attested outputs of (P3) and (P4) (i.e., (17b')) are derived by longer derivational paths.

(17)

More derivational economic		Less derivational economic	
a.	(P5) 55a.55a.55 → 55.53.55	a'.	(P5) 55a.55a.55 → 53.55a.55 → *53.53.55
⇔	(P6) 55b.55b.55 → 55.214.55	⇒	(P6) 55b.55b.55 → 214.55b.55 → *214.214.55
b.	(P3) 214.214.214 → *214.55.214	b'.	(P3) 214.214.214 → 55.214.214 → 55.55.214
⇔	(P4) 214.214.31 → *214.24.31	⇒	(P4) 214.214.31 → 55.214.31 → 55.24.31

Consider next the principle of Transparency. Transparency prefers transparent outputs to opaque outputs that are either non-surface-true or non-surface-apparent. The terms non-surface-true and non-surface-apparent come from McCarthy (1999). A generalization is non-surface-true if a set of forms fail to undergo a process even though the structure description is met at the surface level; a generalization is non-surface-apparent if the structure description of a rule application is not recoverable at the surface level. Transparency also fails to predict the tonal changes in Boshan tone sandhi because as exemplified below, though transparent outputs are the attested outputs in some patterns (e.g., (P5) and (P6)), opaque outputs turn out to be the attested outputs in others (e.g. (P1) and (P4)). Opacity in (P1) belongs to the non-surface-true type of opacity because impermissible sequence (i.e., 55.55) is observed at surface. (P4), on the other hand, belongs to the type of non-surface-apparent because the tone /214/ on the left changes to 55 even though it is not followed by another 214 at surface.

(18)

Transparency		Opacity	
	<i>Input</i>	<i>Output</i>	
P5	55a.55a.55	55. 53 .55	55a.55a.55
P6	55b.55b.55	55. 214 .55	55b.55b.55
P1	55a.214.214	* 53.55 .214	55a.214.214
P4	214.214.31	* 214.24 .31	214.214.31

The impermissible sequence observed in (P1) also automatically makes the principle of Wellformedness, which requires the outputs to be wellformed, impossible to govern the tonal changes.²

Finally, consider the principle of Simplicity. Simplicity prefers level tones to contour tones. At first glance, it seems that the attested outputs derived by one direction have more simple tones than the unattested outputs derived by the opposite direction.

(19)

More level tones		Less Level Tones	
	<i>Input</i>	<i>Output</i>	
P1	55a.214.214	55.55.214	55a.214.214
P2	55b.214.214	55. 55 .214	55b.214.214
P3	214.214.214	55.55 .214	214.214.214
P4	214.214.31	55.24.31	214.214.31
P5	55a.55a.55	55.53.55	55a.55a.55
P6	55b.55b.55	55.214.55	55b.55b.55
P7	55a.55.31	55. 24 .31	55a.55.31
P8	55a.55b.55	55. 214 .55	55a.55b.55
P9	55b.55a.55	55. 53 .55	55b.55a.55

However, it needs to be noted that the attested outputs are not the most harmonic outputs because complex tones can often be found. To obey the principle of Simplicity, all members of the underlying tones of a tri-tonal string should be surfaced as the level tone 55 (i.e., 55.55.55), but that is

² Thought there might be some overlapping between the criteria of Transparency and Wellformedness since transparent outputs are necessarily wellformed, it is not always true that wellformed outputs must be transparent. For example, though the output of (P4) is opaque (being non-surface apparent), it is wellformed.

not attested. Thus, the principle of Simplicity fails as well.

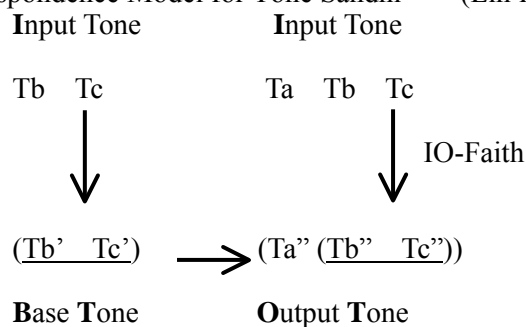
3. THEORIES AND ASSUMPTIONS ADOPTED IN THE PRESENT ANALYSIS OF TONE SANDHI

In this section, I discuss some theories and assumptions that are essential in the OT analysis of Boshan tone sandhi.

3.1 Prosodic Correspondence (Lin forthcoming)

Based on observations of tone sandhi in Mandarin and Sixian-Hakka, in Lin (forthcoming), I propose a prosodic correspondence model for the tone sandhi phenomena. The correspondence model requires identity between tonal outputs that stand in certain prosodic relationships. The model proposed is illustrated below:

(20) Correspondence Model for Tone Sandhi (Lin forthcoming)

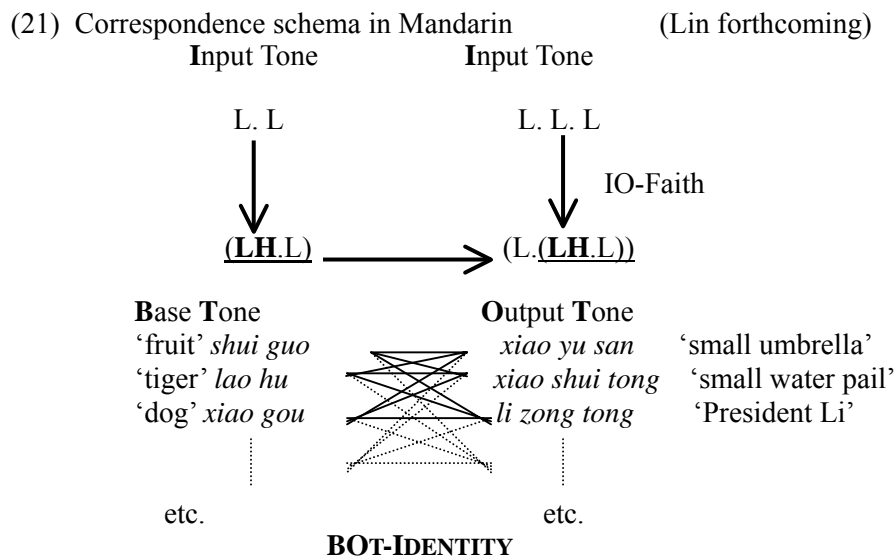


BOT-IDENTITY

(‘(...)’ = the left and the right edges of a prosodic constituent)

In the model, the base-tone-to-output-tone correspondence governs two freestanding tonal outputs that are compositionally related. Unlike the transderivational model proposed in Benua (1997), the two tonal outputs are related by the prosodic structures rather than by the morphosyntactic structures. Forms related in the prosodic structures are capable for correspondence evaluation. That is because prosodic units have long been observed to play crucial roles in speech production/comprehension

(Shattuk-Hufnagel 1996, Gerken 1996, Speer et al 1989) as well as in phonology (Selkirk 1984a, 1984b, 1986; Nespor and Vogel 1986; Shih 1986; Hsiao 1991, 1995) and thus are cognitively real units. In the correspondence relation, the tonal bases are freestanding tones that share underlying information with the tonal outputs and are minimally less prosodically complex than the tonal outputs. For example, in (20), the $Tb''.Tc''$ in $(Ta''.(Tb''.Tc''))$ and $Tb'.Tc'$ share the same underlying tones $Tb.Tc$. In addition, they are prosodically related. Thus, they are evaluated for correspondence. The tonal base and the tonal output are output tonal strings that can associate to any freestanding segments. For example, in the following correspondence schema, the tonal base is a freestanding tonal sequence that shares the input with the tonal output to which it prosodically relates. The segmental base to which the tonal base associates is a freestanding form as well, but it needs not be part of the segmental output to which the tonal output associates.



The correspondence relationship is captured by the constraint IDENT-BOT.

- (22) IDENT-BOT: Corresponding tones in the prosodically related bases and outputs must be identical. (*a gradient constraint*) (Lin forthcoming)

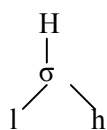
The prosodic correspondence model and the IDENT-BOT constraint capture the fact that in tone sandhi, prosodically related tonal sequences tend to be identical. Maximization of identity between prosodically related tonal outputs plays an important role in tone sandhi. A tonal output would strive to be more like the tonal base to which it prosodically relates, even though the maximization of identity would sometimes generate forms that are less transparent. This has been borne out in the tone sandhi phenomena of Mandarin and Sixian-Hakka (Lin forthcoming) as well as in Tianjin tone sandhi (Lin 2004). In this paper, I will show that this is also true in Boshan. The seemingly unpredictable directionalities of tonal operation in Boshan can be attributed to the desire of identity maximization between prosodically related outputs and are properly accounted for by the interaction of the IDENT-BOT constraint with other constraints.

3.2 The Internal Structure of Tone

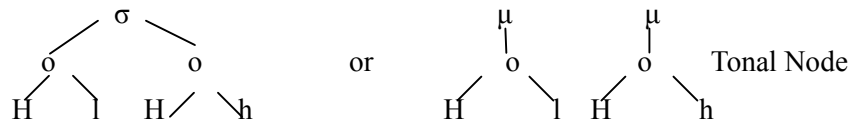
As summarized in Yip (2002a), there are four different models of tonal geometry for the internal structure of tone. They are listed below:

(Yip 2002a: 52-53)

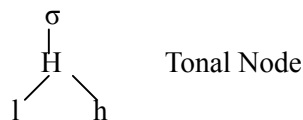
- (23) Models in which the features are entirely independent of each other, and there is no tonal node dominating them both: Yip 1980, also Hyman 1993:81 (8a)



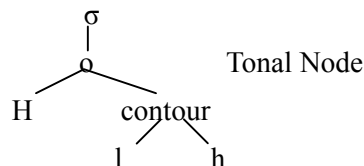
- (24) Models in which the two features are sisters under a Tonal Node, and each half of the contour tone is entirely independent: Duanmu 1990, 1994, Clements 1981, Snider 1990.



- (25) Models in which the register feature is the Tonal Node, dominating the Tone features: Yip 1989, also Hyman 1993: 81 (8d)



- (26) Models in which Tone features are dominated by a node of their own, called Contour, which is a sister to the Register feature, and where both are dominated by a Tonal Node: Bao 1990, Snider 1999.



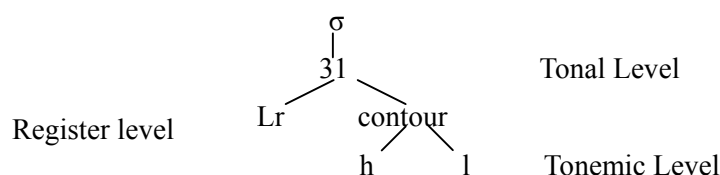
Among the four models of tonal geometry, Bao's model is the most powerful one. His model predicts that registers are free to spread alone, the whole tone is able to spread as a unit, contours are able to spread independent of registers, and that features dominated by the contour can spread alone. The other models cannot make the same predictions. Bao's model, though powerful, is proved to be necessary because all the patterns predicted in Bao do occur in natural languages.³ Therefore,

³ Please refer to Bao (1990), Chen (2000) and Yip (2002a) for detailed discussion/comparison of the different models of tonal geometry.

Bao's model is adopted here, but with some labeling differences.

In the present study, the tones, which are represented as 55, 214, 31, 24, 53, belong to the tonal level. The high and the low registers are represented as Hr, and Lr respectively. They belong to the register level. The features dominated by contours belong to the tonemic level and are represented as h and l.

(27)



In Chengdu, unlike in Sixian-Hakka (Lin forthcoming) and Tianjin (Lin 2004), only information in the tonal level is significant and is considered in the markedness constraints. Informations in the register level and the tonemic level are left out for simplicity.⁴

3.3 Allotone Generation and Allotone Selection

Recently, it has been proposed that in dealing with phonological alternations, two mechanisms must be distinguished: one is allomorphic generation; the other is allomorph selection (Hayes 1990, Tsay and Myers 1996, Yip 2002a, b). Allomorph generation refers to the generation of the allomorph, while allomorph selection refers to the selection of the proper allomorph for a particular environment from a set of allomorph paradigm. For instance, in Boshan tone sandhi, tonal allomorph generation will generate the allotones 55, 53 and 24 for an input 55a, while the mechanism of tonal allomorph selection decides that the 53 tone will surface before 55, 24 will surface before 31, and 55 will occur elsewhere.

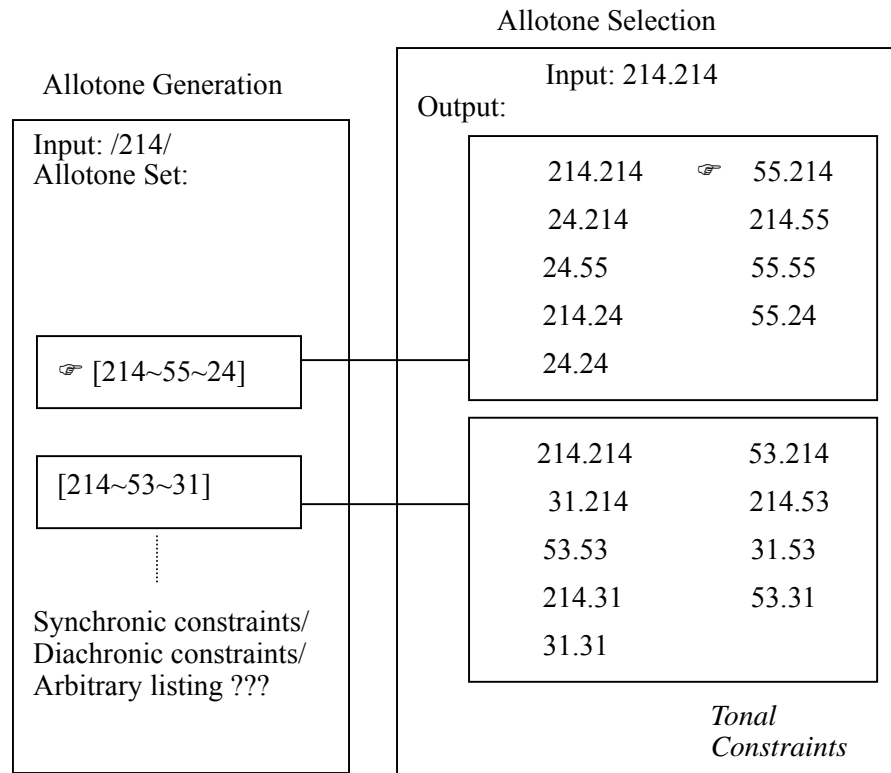
In tone sandhi, while it has generally been agreed that allotone selection can be controlled by phonological markedness, there are

⁴ In Bao's (1999) model, the contour node may have at most two branches. He proposes that concave and convex contours are surface phenomena. Therefore, the internal structure of the concave tone in Boshan 214, which is left out for simplicity in this paper, would be [Lr, lh].

different views regarding how allotones are generated. The different views can be categorized into two types. One is that the allotone pairings are phonologically determined, and thus can be predicted by rules, as in the derivational theory (Wang 1967, Yip 1980) or by constraint interactions, as in the Optimality Theory (Horwood 2000). The other view is that allotone pairings cannot be determined by synchronic phonological conditions. They are determined by information in historical tonal categories (Chen 2000) or are just arbitrarily decided and listed in the mental lexicon (Tsay and Myers 1996, Yip 2002a).

In the present study, due to the limit of time and space, the issue concerning how the allotones are generated will not be addressed. The present analysis presumes the results of allotone generation. Thus the constraints proposed in the paper would be to decide among all the possible combinations of the allotones. For instance, for a Boshan bi-tonal input /214.214/, the allotone set [214~55~24] predicted by the mechanism of allotone generation is presumed. Thus, the candidates considered for evaluation will be 214.214, 55.214, 24.214, 214.55, 24.55, 55.55, 214.24, 55.24 and 24.24.

(28) Allotone Generation and Allotone Selection (Boshan Tone Sandhi)



The allotone sets of Boshan generated by allotone generation are listed below:

(29) Allotone sets in Boshan

- a. [214~55~24]
- b. [55a~53~24]
- c. [55b~214~24]
- d. [31 ~24]

3.4 Prosodic Domain for Boshan

As shown in section 2, the operation of tone sandhi in Boshan is insensitive to the morphosyntactic structures. Thus, the tone sandhi domain cannot be determined based on the morphosyntactic structures. In Boshan, a decision must be made concerning whether the domain of the tri-tonal strings is $((\sigma\sigma)\sigma)$ or $(\sigma(\sigma\sigma))$. It is proposed that the tone sandhi domain of Boshan, like those of Sixian-Hakka and Tianjin tone sandhi, whose tone sandhi operations are also insensitive to the morphosyntactic structures, is the left branching $((\sigma\sigma)\sigma)$. Thus, the domain for Boshan tone sandhi can be accounted for by the prosodic constraint proposed for Sixian-Hakka (Lin forthcoming) and Tianjin (Lin 2004). The constraints and ranking are listed below:

- (30) ALLFTL: Every foot stands at the left edge of the utterance. (*a categorical constraint*)
- (31) PARSESYLL: Parse every syllable into higher prosodic levels. (*a categorical constraint*)
- (32) *MONOF: Avoid monosyllabic feet. (*categorical constraint*)
- (33) FTBIN: Foot must be binary under syllabic analysis. (*a gradient constraint*)
- (34) Prosodic constraint ranking: {PARSESYLL, *MONOF, ALLFTL} >> FTBIN

The tableaux below illustrate how the prosodic constraints predict the tonal domain $((\sigma\sigma)\sigma)$ for tri-tonal examples. (35) and (36) are examples with different morphosyntactic structures. It is shown that the prosodic constraints always select $((\sigma\sigma)\sigma)$ as the tonal domain, regardless of the morphosyntactic branching of the input.

(35)

$\{\sigma\{\sigma\sigma\}\}$	PARSESYLL	*MONOF	ALLFTL	FTBIN
a. $((\sigma\sigma)\sigma)$				*
b. $((\sigma)\sigma\sigma)$		*!		*
c. $(\sigma(\sigma\sigma))$			*!	*
d. $(\sigma\sigma)(\sigma)$		*!	*	*
e. $(\sigma\sigma)\sigma$	*!			
f. $\sigma(\sigma\sigma)$	*!		*	
g. $\sigma\sigma\sigma$	*!			

(36)

$\{\{\sigma\sigma\}\sigma\}$	PARSESYLL	*MONOF	ALLFTL	FTBIN
a. $((\sigma\sigma)\sigma)$				*
b. $((\sigma)\sigma\sigma)$		*!		*
c. $(\sigma(\sigma\sigma))$			*!	*
d. $(\sigma\sigma)(\sigma)$		*!	*	*
e. $(\sigma\sigma)\sigma$	*!			
f. $\sigma(\sigma\sigma)$	*!		*	
g. $\sigma\sigma\sigma$	*!			

4. THE ANALYSIS

In this section, an OT analysis is proposed to account for tone sandhi in bi-tonal and tri-tonal strings in Boshan. I start from proposing constraints for the simpler case of bi-tonal sequences and then move on to the more complex case of tri-tonal strings. Due to the fact that the tonal change of 31 before another 31 tone is optional, word strings that involve the 31.31 sequence, including the bi-tonal string /31.31/ and the tri-tonal combinations /T.31.31/ and /31.31.T/, are excluded from discussion.⁵ In addition, following Chen (2000), I do not discuss the

⁵ In OT, alternative readings could be derived by the re-ranking of the constraints. The optional reading where 31 remains unchanged before another 31 tone could be due to a faithfulness constraint that requires the 31 tone to be parsed. When it is ranked above the constraint that triggers tone sandhi in the 31.31 sequence (e.g. OCP-31), the optimal reading is derived. In the reading where 31 tone undergoes tonal change, the constraint that requires the 31 tone to be parsed is ranked below the markedness constraint that

following two types of tri-tonal combinations.⁶

- (37)
- (a) /214.55b.55/
 - (b) /55b.55.31/

(37a) is excluded because it has two possible outputs (38i) and (38ii) and there is no way to determine which of the two sandhi forms is the correct one due to the lack of appropriate instantiation in the source (Qian 1993).

- (38)
- | | |
|--|---|
| \Rightarrow
(i) <u>214.55b.55</u> (n/a)
214. <u>55b.55</u>

214. 214 .55 | \Leftarrow
(ii) 214. <u>55b.55</u>

214. 214 .55

55.214 .55 |
|--|---|

(37b) is excluded because the attested output [**214**.55.31] can not be derived by applying the rules in either direction:

- | | |
|---|---|
| \Rightarrow
(i) <u>55b.55.31</u>

214.55.31

214.24.31 | \Leftarrow
(ii) 55b. <u>55.31</u>

55b. 24 .31 (n/a) |
|---|---|

4.1 Bi-tonal Sequences

Consider first the tonal fact in Boshan that identical tones cannot occur in juxtaposition. It is a common phenomena of OCP (Leben 1973, Goldsmith 1976) and thus can be captured by the OCP-T constraint below:

triggers tonal change in the 31.31 sequence; consequently, 31 tone undergoes tone sandhi before another 31 tone to satisfy the markedness constraint.

⁶ The two tonal combinations /T.31.31/ and /31.31.T/ are also excluded from discussion in Chen (2000) for the same reason that tonal change on the 31.31 substring is optional.

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(39) OCP-T: Avoid adjacent identical tones at the tonal level. (*a categorical constraint*)

There are five output tones in this dialect; therefore, the OCP-T constraint is assumed to be the cover constraint for the following constraints:

- (40) OCP-T(214): Avoid adjacent 214 tones at the tonal level.
- (41) OCP-T(55): Avoid adjacent 55 tones at the tonal level.
- (42) OCP-T(31): Avoid adjacent 31 tones at the tonal level.
- (43) OCP-T(53): Avoid adjacent 53 tones at the tonal level.
- (44) OCP-T(24): Avoid adjacent 24 tones at the tonal level.

In addition to the OCP-T constraints, two other markedness constraints are also needed. They are 24-31 and OCP-CONT.

(45) 24-31: 31 tones are preceded by 24 tones and 24 tones are followed by 31 tones. (*a categorical constraint*)

(46) OCP-CONT: Avoid adjacent contour tones. (e.g. * 214.31) (*a gradient constraint*).

The markedness constraint 24-31 is to capture the fact that tones immediately precede 31 are neutralized to 24 and that the derived (only) tone 24 surfaces before all and only 31. This constraint could be a reflection of the common phenomena of tonal polarity, which prefers neighboring tones to have opposite value.⁷ The constraint is never violated by the optimal candidate; therefore, it is proposed to be a categorical constraint and is dominant.

- (47) 24-31
Input: 214.31
Output: **24**.31 f 214.31

The OCP-CONT constraint prohibits adjacent contour tones. It is proposed to be a gradient constraint and it calculates every instance of adjacent contour sequences. For example, the tri-tonal string 214.214.214 would violate the OCP-CONT constraint twice. The

⁷ I am grateful for Yuchau Hsiao for leading me to this idea.

OCP-CONT constraint will be shown to be important in accounting for tri-tonal strings (see §4.2). The OCP-CONT constraint must rank below the 24-31 constraint to avoid the wrong prediction.

- (48) 24-31 >> OCP-CONT
Input: 55a.31
Output: **24**.31 f 55.31

Turning now to the faithfulness constraint, the following two faithfulness constraints are necessary.

- (49) IDENT-IO-T-R: The rightmost tone of an utterance (at the tonal level) is identical to its input correspondent.
(50) IDENT-IO-T: Input-Output corresponding tones (at the tonal level) are identical. (*a gradient constraint*)

The IDENT-IO-T constraint is a faithfulness constraint that requires identity between inputs and outputs. The IDENT-IO-T-R constraint belongs to the positional faithfulness constraints which state that "correspondent segments in a privileged position must have identical specification for [F]." (Beckman 1998) Tone sandhi can be divided into two systems according to the position of tonal preservation during tonal sandhi. Tone sandhi phenomena which tend to maintain the identity of the rightmost tone while allowing tones to change in the other positions belong to right prominent tone sandhi. For example, Mandarin, Southern Min, Tianjin, Sixian-Hakka and Boshan all belong to the right prominent system. For tone sandhi phenomena which tend to preserve the leftmost tone while allowing tones to change in the other positions, they are referred to as left prominent tone sandhi. Tone sandhi phenomena in Chengdu, Quiyang and Changsha, for instance, belong to the left prominent system. In the right prominent system, such as in Boshan, the positional faithfulness constraint IDENT-IO-T-R is essential to ensure that when two identical tones are adjacent, it is always the tone at the left edge of an utterance, but not at the right edge, that undergoes tonal change. And the constraint must be ranked high. For left prominent tone sandhi, the IDENT-IO-T-R constraint must be ranked very low. Instead, a positional faithfulness constraint which requires tones at the left edge to be preserved, i.e., IDENT-IO-T-L will be playing the key role.

In Boshan, there is no crucial ranking among the IDENT-IO-T-R

constraint, the OCP-T constraint and the 24-31 constraint. Thus they are proposed to be equally ranked. As for the IDENT-IO-T constraint, it is in conflict with the markedness constraints of OCP-T, and 24-31. The markedness constraints must dominate the faithfulness constraint to ensure that impermissible underlying tonal sequences will not surface without undergoing some changes.

- (51) OCP-T >> IDENT-IO-T
 Input: 214.214
 Output: **55**.214 f 214.214

The final ranking proposed for the tonal constraints is:

- (52) The tonal constraint ranking for Boshan tone sandhi:
 {IDENT-IO-T-R, 24-31, OCP-T} >> OCP-CONT >> IDENT-IO-T

The tableaux below demonstrate how the tonal constraints correctly predict the tonal outputs for bi-tonal examples:

- (53) 55a.55 → **53**.55

	55a.55	IDENT-IO-T-R	24-31	OCP-T	OCP-CONT	IDENT-IO-T
☞ a.	53.55					*
b.	24.55		*!			*
c.	55.55			*!		
d.	55.53	*!				*

- (54) 55b.55 → **214**.55

	55b.55	IDENT-IO-T-R	24-31	OCP-T	OCP-CONT	IDENT-IO-T
☞ a.	214.55					*
b.	55.55			*!		
c.	24.55		*!			*

(55) 214.214 → 55.214

	214.214	IDENT- IO-T-R	24-31	OCP-T	OCP- CONT	IDENT- IO-T
☞ a.	55.214					*
b.	214. 214			*!	*	
c.	24.214		*!		*	*

(56) 55.31 → 24.31

	55.31	IDENT- IO-T-R	24-31	OCP-T	OCP- CONT	IDENT- IO-T
☞ a.	24.31				*	*
b.	55. 31		*!			
c.	53.31		*!		*	*

(57) 31.214 → 31.214

	31.214	IDENT- IO-T-R	24-31	OCP-T	OCP- CONT	IDENT- IO-T
☞ a.	31.214				*	
b.	24. 214		*!		*	*

4.2 Tri-tonal Strings, Conflicting Directionality, and Normal, Over- vs. Underapplication

4.2.1 Direction-sensitive Patterns

Given four underlying tones, 64 (4^3) tri-tonal combinations can be yielded in Boshan; among them, nine tri-tonal combinations are direction-sensitive. The nine tri-tonal patterns are repeated below. As mentioned above, (P1)-(P4) must be derived with a left-to-right rule application directionality, while (P5)-(P9) must be derived with a right-to-left directionality.

(58)

a. ⇒	(P1)	<u>55a.214.214</u> → 55.214.214 → 55. 55 .214
	(P2)	<u>55b.214.214</u> → 55.214.214 → 55. 55 .214
	(P3)	<u>214.214.214</u> → 55 .214.214 → 55.55 .214
	(P4)	<u>214.214.31</u> → 55 .214.31 → 55.24 .31
b. ⇐	(P5)	<u>55a.55a.55</u> → 55. 53 .55
	(P6)	<u>55b.55b.55</u> → 55. 214 .55
	(P7)	<u>55a.55.31</u> → 55. 24 .31
	(P8)	<u>55a.55b.55</u> → 55. 214 .55
	(P9)	<u>55b.55a.55</u> → 55. 53 .55

The rule application directionalities in which the outputs are derived, as discussed above, are not governed by the morphosyntactic structures nor principles such as Temporal Sequence, Derivational Economy, Transparency, Simplicity and Wellformedness. But is the rule application directionalities truly unpredictable? An intriguing phenomenon could be found when we look into the outputs derived by the different directionalities more closely. There is a correlation between the rule application directionalities and whether the output is transparent (i.e., showing normal application) or opaque (i.e. showing over- or underapplication). Normal application refer to output forms that are neither non-surface-true nor non-surface-apparent while over- and underapplication refer to forms that are non-surface-apparent and non-surface-true respectively. As shown in (59), while (P1)-(P4), which are generated by the left-to-right directionality, are opaque, (P5)-(P9), which are generated by the opposite directionality, are transparent.⁸

⁸ For the tri-tonal combinations that are direction insensitive, normal applications are observed.

(59)

	<i>Input</i>	<i>Output</i>	<i>Directionality</i>	<i>Application Mode</i>
P1	55a.214.214	55. 55 .214	⇒	Underapplication
P2	55b.214.214	55. 55 .214	⇒	Underapplication
P3	214.214.214	55.55 .214	⇒	Underapplication
P4	214.214.31	55.24 .31	⇒	Overapplication
P5	55a.55a.55	55. 53 .55	⇐	Normal Application
P6	55b.55b.55	55. 214 .55	⇐	Normal Application
P7	55a.55.31	55. 24 .31	⇐	Normal Application
P8	55a.55b.55	55. 214 .55	⇐	Normal Application
P9	55b.55a.55	55. 53 .55	⇐	Normal Application

Pattern (1), pattern (2) and pattern (3) involve underapplication of tone sandhi because impermissible tonal sequences are observed at surface (in other words, tone sandhi fails to apply even when the structure description is met). Pattern (4) shows overapplication, since the leftmost 214 changes to 55 even though it is not followed by another 214 at surface. Pattern (5)-(9) exhibit normal application of tone sandhi because they do not contain any impermissible sequences or outputs that are non-surface-apparent.⁹

4.2.1.1 Overapplication

Consider first overapplication in pattern (4), which is the resultant output of a left-to-right rule application directionality in the derivational theory.

(60)

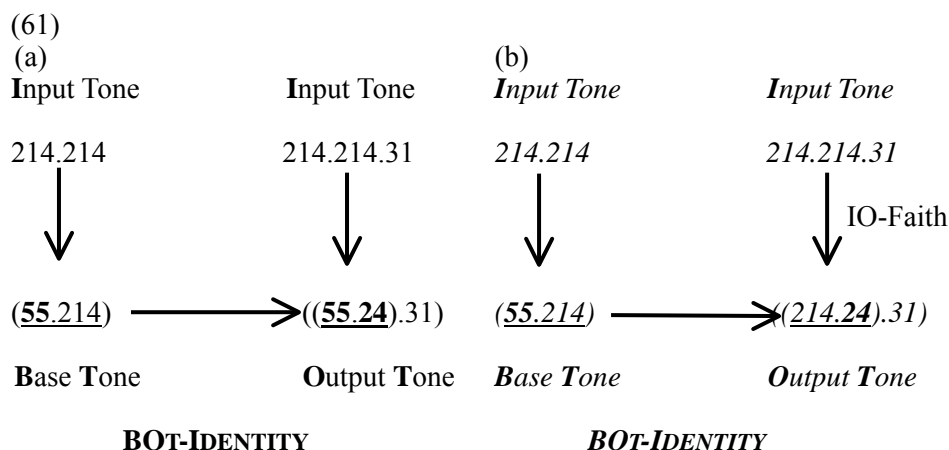
	<i>Input</i>	<i>Attested Output</i> (overapplication)	<i>Unattested Output</i> (normal application)
P4	214.214.31	55.24 .31	214. 24 .31

Normal application of tone sandhi would have yielded 214.**24**.31, which is perfectly wellformed and is more faithful to the input since there is only one tone that has undergone tone sandhi. The question is why tone

⁹ Similar observation of the correlation between rule application directionality and whether the output is transparent or opaque is also found in Tianjin (Lin 2004).

sandhi overapplies? In Lin (forthcoming, 2004), I propose that overapplications observed in Mandarin, in Sixian-Hakka and in Tianjin are identity effects caused the desire of maximizing identity between prosodically related tonal outputs. Here I propose that overapplication in Boshan is also caused by the same reason and are properly accounted for by the constraint requiring identity between prosodically related outputs.

Assuming the prosodic structure of Boshan tone sandhi for the tri-tonal strings is $((\sigma\sigma)\sigma)$, the generation of the overapplication output can be explained as owing to the fact that it helps a tri-tonal output to be more like its prosodically related tonal base. Compare the schema in (61a) for the attested overapplication output with the schema in (61b) for the unattested normal application output. It could be seen that the tonal output in the internal prosodic structure of (61a) (i.e., $((55.24).31)$) is more like the base (i.e., 55.214) than that of (61b) (i.e., $((214.24).31)$).



This can be captured by the IDENT-BOT constraint.

(62) IDENT-BOT: Corresponding tones in the prosodically related bases and the outputs must be identical. (*a gradient constraint*) (Lin forthcoming)

The IDENT-BOT constraint should rank below the structural constraints OCP-T and 24-31 and it should outrank the IDENT-IO-T constraint to account for overapplication in Boshan.

- (63) {OCP-T, 24-31} >> IDENT-BOT
 Input: 214.214.31 Base: **55.214** (←214.214)
 Output: ((**55.24**).31) f ((**55.214**).31)
 Key: Base: Output (← Input)
- (64) IDENT-BOT >> IDENT-IO-T
 Input: 214.214.31 Base: **55.214** (←214.214)
 Output: ((**55.24**).31) f ((**214.24**).31)

The modified tonal constraints and ranking proposed for Boshan is:

- (65) The tonal constraint ranking for Boshan tone sandhi:
 {IDENT-IO-T-R, 24-31, OCP-T} >> {OCP-CONT, IDENT-BOT} >>
 IDENT-IO-T

The tableau here below demonstrates how the overapplication output in (P4) is correctly predicted:

(66) (P4) 214.214.31 → ((**55.24**).31) Base: **55.214** (← 214.214)

((214.214).31)	IDENT- IO-T-R	24-31	OCP-T	OCP- CONT	IDENT- BOT	IDENT- IO-T
☞ a. ((55.24).31) (overappli.) ⇒				*	*	**
b. ((214.24).31) (normal appli.) ⇐				**	*!*	*
c. ((24.24).31)		*!	*	**	**	**
d. ((214.214).31)		*!	*	**	*	
e. ((214.55).31)		*!			**	*
f. ((55.214).31)		*!		*		*
g. ((55.55).31)		*!	*		*	**
h. ((24.214).31)		*!		**	*	*
i. ((24.55).31)		*!			**	**

4.2.1.2 Underapplication

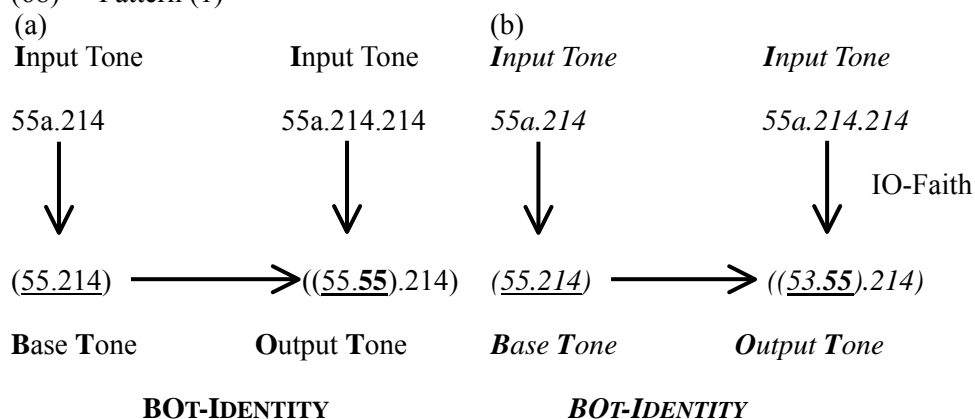
Within the nine tonal patterns, pattern (1), pattern (2) and pattern (3) involve underapplication. The underapplication patterns are also the resultant outputs of a left-to-right rule application directionality in the derivational theory. The outputs resulted from the opposite directionality (i.e., right-to-left) would have been the normal application outputs of **53.55.214**, **214.55.214** and **214.55.214** for pattern (1), (2) and (3) respectively. Why does tone sandhi choose to underapply in them?

(67)

	Input	Attested Output (underapplication)	<i>Unattested Output</i> (normal application)
P1	55a.214.214	55. 55 .214	53.55.214
P2	55b.214.214	55. 55 .214	214.55.214
P3	214.214.214	55.55.214	214.55.214

It is proposed that underapplication, like overapplication, is caused by the desire to increase identity between the tri-tonal outputs and their prosodically related base tones. If not so, outputs of normal application would have been the better output candidates, since unlike the underapplication outputs, they do not violate the OCP-T constraint. Compare the schema in (68a) for the attested underapplication output with the schema in (68b) for the unattested normal application output.

(68) Pattern (1)



Thus, the IDENT-BOT constraint serves to pick out the underapplication outputs. Because underapplication entails the existence of impermissible tonal sequences; therefore, it seems that the IDENT-BOT constraint must be ranked above the markedness constraints OCP-T and 24-31 to allow underapplication candidates to surface.

- (69) IDENT-BOT >> {OCP-T, 24-31}
Input: 55a.214.214 Base: 55.214 (←55a.214)
Output: ((55.55).214) f ((53.55).214)

However, this ranking would wrongly rule out the output of overapplication discussed above because in overapplication, identity between the base and the output is sacrificed to satisfy the markedness constraints.

- (70) IDENT-BOT >> {OCP-T, 24-31}
(P4) Input: 214.214.31 Base: 55.214 (← 214.214)
Output: ((55.214).31) f ((55.24).31) (wrong prediction!)

In addition, even just focusing on (P1) to (P3) where underapplication is involved, the attested output would still fail to be selected. For example, in (P1), the output candidate that does not undergo any tonal change would be wrongly selected, because though both the unchanged form and the attested candidate violate the OCP-T constraint once, the former satisfies the IDENT-BOT constraint better than the attested output, as shown below:

- (71) IDENT-BOT >> OCP-T
(P1) Input: 55a.214.214 Base: 55.214 (←55a.214)
Output: ((55.214).214) f ((55.55).214) (wrong prediction!)

By observing the underapplication outputs in Boshan more closely, it could be found that the impermissible sequences occur always at the left (non-prominent) edge, but not at the right (prominent) edge of a string.

(72)

Dialect/Language	Underapplication	Location of marked sequence (underlined)
Boshan	<u>55.55</u> .214	Markedness sequences occur at the <i>left</i> edge of a string
	<u>55.55</u> .214	
	<u>55.55</u> .214	

Thus, if a markedness constraint (e.g. OCP-T) is divided into two constraints, one penalizes marked sequence at the prominent position (MC-POS) and the other penalizes marked sequence in general (MC-FREE), and if MC-POS ranks above the IDENT-BOT constraint while MC-FREE ranks below the IDENT-BOT constraint (i.e., MC-POS >> IDENT-BOT >> MC-FREE), impermissible tonal sequences at the non-prominent position that are caused by identity preservation would be tolerated.

The following two MC-POS constraints which prohibit marked strings to occur at the prominent position are proposed in addition to their MC-FREE counterparts in (39) and (45).

(73) OCP-T]_U: No identical tones can occur at the right edge of the utterance.¹⁰

(74) 24-31]_U: At the right edge of the utterance, 31 tones are preceded by 24 tones and 24 tones are followed by 31 tones.

The MC-POS constraints proposed here belong to the family of Positional markedness constraints (Ito and Mester 1994, Lombardi 2001, Zoll 1996, 1998, Steriade 1997) which state that certain marked structures either must (as in positive positional markedness constraints) or cannot (as in negative positional markedness constraints) occur in particular positions.¹¹

¹⁰ Like the positional faithfulness constraint (e.g. IDENT-IO-T-R), there is no need to postulate whether a positional markedness constraint is a gradient constraint or a categorical constraint because there will always be only one tonal sequence that is at the specific edge of the utterance. Thus the constraint can only be violated at most once.

¹¹ Relating the markedness position to the prominent position would seem to be strange as according to positional faithfulness constraint, the prominent position should be the

According to the schema MC-POS >> IDENT-BOT >> MC-FREE, the constraint ranking for the markedness constraints and the IDENT-BOT constraint is:

(75) { OCP-T]_U, 24-31]_U } >> IDENT-BOT >> { OCP-T, 24-31 }

(74) below demonstrates that the ranking could solve the dilemma observed in (67)-(69).

(76) OCP-T]_U >> IDENT-BOT
 Input: 55a.214.214 Base: 55.214 (← 55a.214)
 Output: ((55.55).214) f ((55.214).214)

(77) IDENT-BOT >> OCP-T
 Input: 55a.214.214 Base: 55.214 (← 55a.214)
 Output: ((55.55).214) f ((53.55).214)

The final ranking for underapplication of Boshan is:

(78) { IDENT-IO-T-R, 24-31]_U, OCP-T]_U } >> {OCP-CONT, IDENT-BOT} >> {24-31, OCP-T} >> IDENT-IO-T

The tableaux here below demonstrate how the ranking proposed predicts the outputs of pattern (1), (2) and (3) (some noncrucial constraints are omitted):

position that promotes more contrast. However, I argue that the status of the prominent position to promote more contrast is still maintained despite the positional markedness constraints proposed here. That is because the positional markedness constraints proposed in this paper refer to *sequences* (e.g. OCP-55 means *55.55). In other words, they are sequential markedness constraints. The sequential positional markedness constraints only require that the marked *sequence* cannot occur in the prominent position and that tonal changes need to take place to repair the marked structure. According to the positional faithfulness constraint proposed in this study, when marked structures appear, it is the tone on the non-prominent end of the sequence that undergoes tone sandhi. As a consequence, the tone in the prominent position remains unchanged and the prominent position would still promote more contrast.

(79) (P1) 55a.214.214 → ((55.55).214) Base: 55.214 (← 55a.214)

((55a.214).214)	OCP-T] _U	24-31] _U	OCP- CONT	IDENT- BOT	OCP-T	24-31	IDENT- IO-T
☞ a. ((55.55).214) (underappli.) ⇒				*	*		*
b. ((53.55).214) (normal appli.) ⇐				**!			**
c. ((55.214).214)	*!		*		*		
d. ((53.214).214)	*!		**	*	*		*
e. ((24.214).214)	*!		**	*	*	*	*
f. ((55.24).214)		*!	*	*			*
g. ((53.24).214)		*!	**	**			**
h. ((24.24).214)		*!	**	**	*	*	**
i. ((24.55).214)				**!			**

(80) (P2) 55b.214.214 → ((55.55).214) Base: 55.214 (← 55b.214)

((55b.214).214)	OCP-T] _U	24-31] _U	OCP- CONT	IDENT- BOT	OCP- T	24-31	IDENT- IO-T
☞ a. ((55.55).214) (underappli.) ⇒				*	*		*
b. ((214.55).214) (normal appli.) ⇐				**!			**
c. ((55.214).214)	*!		*		*		
d. ((214.214).214)	*!		**	*	**		*
e. ((24.214).214)	*!		**	*	*	*	*
f. ((55.24).214)		*!	*	*			*
g. ((214.24).214)		*!	**	**			**
h. ((24.55).214)				**!		*	**
i. ((24.24).214)		*!	**	**	*		**

(81) (P3) 214.214.214 → ((55.55).214) Base: 55.214 (← 214.214)

((214.214).214)	OCP-T] _U	24-31] _U	OCP- CONT	IDENT- BOT	OCP- T	24-31	IDENT- IO-T
a. ((55.55).214) (underappli.) ⇒				*	*		**
b. ((214.55).214) (normal appli.) ⇐				**!			*
c. ((214.214).214)	*!		**	*	*		
d. ((55.214).214)	*!		*		*		*
e. ((24.214).214)	*!		**	*	*	*	*
f. ((214.24).214)		*!	**	**			*
g. ((55.24).214)		*!	*	*			**
h. ((24.55).214)				**!		*	**
i. ((24.24).214)		*!	**	**	*		**

The inclusion of the MC-POS constraints (i.e., 24-31]_U, OCP-T]_U) will not influence the analysis for overapplication in (P4) because overapplication outputs never contain impermissible tonal sequences. Thus, the MC-POS constraint has the exact function as the MC-FREE constraint to overapplication since both the MC-POS constraint and the MC-FREE constraint will be fully satisfied by the overapplication outputs. Thus, the inclusion of the MC-POS constraint will not wrongly reject the overapplication output in (P4). This can be illustrated more clearly below:

(82) (P4) 214.214.31 → ((55.24).31) Base: 55.214 (← 214.214)

((214.214).31)	OCP-T] _U	24-31] _U	OCP- CONT	IDENT- BOT	OCP-T	24-31	IDENT- IO-T
a. ((55.24).31) (overappli.) ⇒			*	*			**
b. ((214.24).31) (normal appli.) ⇐			**	*!*			*

4.2.1.3 Normal Application

Finally, consider the normal application outputs. The normal application outputs are the resultant outputs of a right-to-left rule application directionality.

(83)

a.	(P5) $55a.55a.55 \rightarrow 55.53.55$
↔	(P6) $55b.55b.55 \rightarrow 55.214.55$
	(P7) $55a.55.31 \rightarrow 55.24.31$
	(P8) $55a.55b.55 \rightarrow 55.214.55$
	(P9) $55b.55a.55 \rightarrow 55.53.55$
b.	(P5) $55a.55a.55 \rightarrow 53.55a.55 \rightarrow *53.53.55$
⇒	(P6) $55b.55b.55 \rightarrow 214.55b.55 \rightarrow *214.214.55$
	(P7) $55a.55.31 \rightarrow 53.55.31 \rightarrow *53.24.31$
	(P8) $55a.55b.55 \rightarrow 53.55b.55 \rightarrow *53.214.55$
	(P9) $55b.55a.55 \rightarrow 214.55a.55 \rightarrow *214.53.55$

The reason why tone sandhi applies from right to left in (P5)–(P9) is that the reverse directionality would generate marked outputs that contain adjacent contour tones (e.g. $53.53.55$). In other words, tone sandhi applies from right to left to minimize adjacent contour tones. Thus, tone sandhi tends to apply from left to right to maximize identity between prosodically related outputs unless the resultant outputs would contain highly marked forms (i.e., adjacent contour tones). The tableaux below demonstrate that the ranking in (78) for misapplication (i.e., over- and underapplication) can account for normal application as well.¹²

¹² In the tableaux for P(5)–P(9), the attested normal application candidates clearly incur less violations in the OCP-CONT constraint than the misapplication outputs. However, because the OCP-CONT constraint is equally ranked with the IDENT-BOT constraint, the effect of the markedness constraint OCP-CONT that functions as the crucial constraint for the directionality to reverse is somehow weakened. The effect of OCP-CONT can be shown more clearly if the OCP-CONT constraint is proposed to dominate the IDENT-BOT constraint. The domination of the OCP-CONT over the IDENT-BOT constraint could actually work well in accounting for the 9 tri-tonal patterns that are direction-sensitive. However, they do not work for the rest of the tri-tonal patterns that are direction-neutral. The tableau below exemplifies that the OCP-CONT constraint must be equally ranked with the IDENT-BOT constraint, as the domination of the OCP-CONT constraint over the

(84) (P5) 55a.55a.55 → ((55.53).55) Base: 53.55 (← 55a.55a)

((55a.55a).55)	24-31] _U	OCP-T] _U	OCP- CONT	IDENT- BOT	OCP-T	24-31	IDENT- IO-T
☞ a. ((55.53).55) (normal appli.) ⇐				**			*
b. ((53.53).55) (underappli.) ⇒			*	*	*!		**
c. ((55.55).55)		*!		*	*		
d. ((55.24).55)	*!			**			*
e. ((53.55).55)		*!			*		*
f. ((53.24).55)	*!		*	*			**
g. ((24.55).55)		*!		*	*	*	*
h. ((24.53).55)			*	**!		*	**
i. ((24.24).55)	*!		*	**	*	*	**

IDENT-BOT constraint would predict the wrong output.

214.55a.55 → 214.53.55 Base: 214.55 (← 214.55)

214.55a.55	24-31] _U	OCP-T] _U	OCP- CONT	IDENT- BOT	OCP-T	24-31	IDENT-IO -T
☞ a. ((214.53).55)			*!	*			*
☛ b. ((55.53).55)				**			**

Key: a pointing hand outside the tableau points out the attested output fails to be selected by the constraints

☛ = unattested output wrongly selected by the constraints

(85) (P6) 55b.55b.55 → ((55.214).55) Base: 214.55 (← 55b.55b)

(55b.55b.)55)	24-31] _U	OCP-T] _U	OCP- CONT	IDENT- BOT	OCP-T	24-31	IDENT- IO-T
☞ a. ((55.214).55) (normal appli.) ↔				**			*
b. ((214.214).55) (underappli.) ⇒			*	*	*!		**
c. ((55.55).55))		*!		*	*		
d. ((55.24).55)	*!			**			*
e. ((214.55).55)		*!			*		*
f. ((214.24).55)	*!		*	*			**
g. ((24.55).55)		*!		*	*	*	*
h. ((24.214).55)			*	**!		*	**
i. ((24.24).55)	*!		*	**	*	*	**

(86) (P7) 55a.55.31 → ((55.24).31) Base: 53.55 (← 55a.55)

(55a.55).31)	24-31] _U	OCP-T] _U	OCP- CONT	IDENT- BOT	OCP- T	24-31	IDENT- IO-T
☞ a. ((55.24).31) (normal appli.) ↔			*	**			*
b. ((53.24).31) (overappli.) ⇒			**	*			**!
c. ((55.55).31)	*!			*	*		
d. ((55.53).31)	*!		*	**			*
e. ((55.214).31)	*!		*	**			*
f. ((53.55).31)	*!						*
g. ((53.53).31)	*!		**	*	*		**
h. ((53.214).31)	*!		**	*			**
i. ((24.55).31)	*!			**		*	*
j. ((24.24).31)			**	**!	*	*	**
k. ((24.53).31)	*!		**	**		*	**
l. ((24.214).31)	*!		**	**		*	**

(87) (P8) 55a.55b.55 → ((55a.214).55) Base: 53.55 (← 55a.55b)

((55a.55b).55)	24-31] _U	OCP-T] _U	OCP- CONT	IDENT- BOT	OCP- -T	24-31	IDENT- IO-T
☞ a. ((55.214).55) (normal appli.) ↔				**			*
b. ((53.214).55) (overappli.) ⇒			*	*			**!
c. ((55.24).55)	*!			**			*
d. ((55.55).55)		*!			*		
e. ((53.55).55)		*!			*		*
f. ((53.24).55)	*!		*	*			**
g. ((24.55).55)		*!			*	*	*
h. ((24.214).55)			*	**!		*	**
i. ((24.24).55)	*!		*	**	*	*	**

(88) (P9) 55b.55a.55 → ((55.53).55) Base: 214.55 (← 55b.55a)

((55b.55a).55)	24-31] _U	OCP-T] _U	OCP- CONT	IDENT- BOT	OCP- T	24-31	IDENT- IO-T
☞ a. ((55.53).55) (normal appli.) ↔				**			*
b. ((214.53).55) (overappli.) ⇒			*	*			**!
c. ((55.55).55)		*!		*	*		
d. ((55.24).55)	*!			**			*
e. ((214.55).55)		*!			*		*
f. ((214.24).55)	*!		*	*			**
g. ((24.55).55)		*!		*	*	*	*
h. ((24.53).55)			*	**!		*	**
i. ((24.24).55)	*!		*	**	*	*	**

In sum, in Boshan, tone sandhi applies from left to right to maximize identity between outputs that stand in prosodic relations, unless the resultant outputs would contain forms that are highly marked, in that

case, tone sandhi applies in the reverse direction.

4.2.2 Direction-Neutral Patterns

So far, the identity effect in Boshan tone sandhi has been born out by the direction-sensitive type of tone sandhi. Here below I demonstrate that identity preservation is also highly respected in the direction-neutral type of tone sandhi.

For the direction-neutral patterns, only one tone sandhi process is involved, and the optimal outputs always show normal applications but never over- or underapplications. That is because over- and underapplication are the results of the interactions of more than one tone sandhi processes. In direction-neutral patterns, the sandhi site would be either at the left edge Ta-Tb.Tc (‘-‘ specifies the sandhi site) or at the right edge Ta.Tb-Tc. The tableaux below clearly show that in both cases, the optimal candidate is always the candidate that is most identical to the base. For clarity, MC-POS and MC-FREE are used to stand for the positional markedness constraints 24-31]_U, OCP-T]_U and the general markedness constraints 24-31, OCP-T respectively.

(89) Ta-Tb.Tc → ((Ta .Tb).Tc)		Base: Ta .Tb (← Ta.Tb)		
((Ta-Tb).Tc)	MC-POS	IDENT-BOT	MC-FREE	IDENT-IO-T
☞ a. ((Ta .Tb).Tc)				*
b. ((Ta. Tb).Tc)		*!*		*
c. ((Ta.Tb).Tc)		*!	* (Ta.Tb)	

e.g.:

Input: 55a.55a.214 Base: **53**.55 (← 55a.55)
 Output: ((**53**.55).214) f ((55.**53**).214)
 f ((55.55).214)

(90) Ta.Tb-Tc \rightarrow ((Ta.**Tb**).Tc) Base: Ta.Tb (\leftarrow Ta.Tb)
 (Tb.Tc being an impermissible sequence)

((Ta.Tb)-Tc)	MC-POS	IDENT-BOT	MC-FREE	IDENT-IO-T
a. ((Ta. Tb).Tc)		*		*
b. ((Ta.Tb).Tc)	*! (Tb.Tc)		* (Tb.Tc)	*
c. ((Ta.Tb).Tc)		**!		**

e.g.:

Input: 214.55a.55 Base: 214.55 (\leftarrow 214.55)
 Output: ((214.**53**).55) f ((214.55).55)
 f ((**55.53**).55)

For the patterns that involve tonal changes at the left edge (e.g. (89)), the attested outputs would fully satisfy the IDENT-BOT constraint. On the other hand, for the tonal patterns that involve tonal changes at the right edge (e.g. (90)), the attested output will not completely satisfy the IDENT-BOT constraint (e.g. (90a)). However, since the candidate that fully satisfies the IDENT-BOT constraint (e.g. (90b)) is doomed to violate the top-ranked markedness constraint, the attested output will be the wellformed candidate that maximally satisfies the IDENT-BOT constraint.

5. PROBLEMS OF THE RULE-BASED ANALYSIS AND THE DERIVATIONAL CONSTRAINT ANALYSIS (CHEN 2000)

In this section, I consider two alternative analyses to Boshan tone sandhi. They are the rule-based analysis and the Derivational Constraint Analysis (Chen 2000). I will show that neither of them can capture the tone sandhi phenomena as naturally as the present analysis.

5.1 Problem of the Rule-based Analysis

In the rule-based analysis of tone sandhi (actually also in the constraint-based analysis), one of the most important things is to determine the domain within which tone sandhi should apply. Once the domain is determined, tone sandhi can be accounted for. Therefore, most effort the researchers made was to define the tone sandhi domains. For

example, in accounting for Beijing Mandarin, Shih (1986) proposes that the tone sandhi domain for Beijing Mandarin is a prosodic foot, which is defined by the following rule:

- (91) Foot Formation Rule (FFR) (Shih 1986: 110)
- Foot (f) Construction
- a. IC: Link immediate constituents into disyllabic feet.
 - b. DM: Scanning from left to right, string together unpaired syllables into binary feet, unless they branch to the opposite direction.
- Super-foot (f') Construction
- Join any leftover monosyllable to a neighboring binary foot according to the direction of syntactic branching.

According to the FFR rule, the domains for the following two morphosyntactically distinct tri-tonal examples are different. As a consequence, the difference between the tonal outputs is correctly predicted.

(92)

	<i>mai hao jiu</i> 'buy good wine'	<i>mai hao jiu</i> 'have bought wine'
Immediate Constituency	{σ{σσ}}	{{σσ}σ}
Prosodic Foot Structure	(σ(σσ))	((σσ)σ)
Derivation:		
Input:	(L.(L.L))	((L.L)L)
Cycle 1	LH	LH
Cycle 2	n/a	LH
Output:	L. LH .L	LH . LH .L

Rule-based analysis seems to work in accounting for Beijing Mandarin tone sandhi.¹³ However, when it comes to the tone sandhi phenomenon where the morphosyntactic structures seem to play no role such as that observed in Boshan, a rule-based analysis fails to work. The major problem is that in Boshan, tone sandhi would operate left-to-right in

¹³ There are still some residual problems left unresolved in the rule-based analysis for Beijing Mandarin tone sandhi. Please refer to Shih (1986), Zhang N. (1997) and Lin (2000) for discussion.

some patterns and right-to-left in others, regardless of the information in the morphosyntactic structures. Left-to-right application directionality implies that tone sandhi operates cyclically in the domain $((\sigma\sigma)\sigma)$ and right-to-left application directionality implies that tone sandhi applies cyclically in the domain $(\sigma(\sigma\sigma))$. Since there is no objective way to determine the rule application directionalities, there is no objective way to determine the tone sandhi domain within which tone sandhi operates as well. Thus stipulations of the directionalities in which the tone sandhi rules should apply are indispensable.

Though it has been proposed in the present study that the tonal domain for Boshan is $((\sigma\sigma)\sigma)$, the domain proposed under the OT framework cannot be directly incorporated in the rule-based analysis. That is because tone sandhi does not always apply left-to-right in Boshan even though the domain is $((\sigma\sigma)\sigma)$. The domain $((\sigma\sigma)\sigma)$ merely reflects the fact that left-to-right rule application directionality is the norm in Boshan tone sandhi. Recall that in (P5)-(P9) of the nine tonal patterns actually have the tone sandhi rules apply from right to left. In OT, the domain proposed for Boshan tone sandhi works because in the framework constraints are violable. The conflicting directionalities are resulted from the interaction of the constraints, especially the markedness constraints and the constraints requiring output-to-output correspondence, i.e., IDENT-BOT. The domination of the markedness constraints over the output-to-output correspondence constraint predicts that tone sandhi applies from left to right to achieve identity between prosodically related outputs, unless such rule directionality would produce outputs that contain highly marked sequences. In that case, tone sandhi applies from right to left.

However, in the rule-based analysis, the conflicting directionalities cannot be accounted for by a single tone sandhi domain. For example, if the tone sandhi domain for Boshan is assumed to be $((\sigma\sigma)\sigma)$, then only the tonal patterns that are derived by the left-to-right directionality (i.e., (P1)-(P4)) can be accounted for. The tonal patterns that are derived by the right-to-left directionality (i.e., (P5)-(P9)) can never be accounted for by the same domain.

(93) The domain $((\sigma\sigma)\sigma)$ accounts for (P1) and (P3) but not (P5) and (P7)

	(P1) 55a.214.214 → 55.55.214	(P3) 214.214.214 → 55.55.214
Input:	((55a. 214).214)	((214. 214).214)
Cycle 1	n.a.	55
Cycle 2	55	55
Output:	55. 55. 214	55. 55. 214
	(P5) 55a.55a.55 → 55.53.55	(P4) 55a.55.31 → 55.24.31
Input:	((55a. 55a). 55)	((55a. 55). 31)
Cycle 1	53	53
Cycle 2	53	24
Output:	* 53. 53. 55	* 53. 24. 31

Thus, the conflicting directionalities observed in tone sandhi can only be resorted to stipulations. For instance, stipulations like those listed below need to be made for tri-tonal strings in Boshan.

- (94) Stipulations necessary for tri-tonal sandhi in Boshan
- For inputs /55a.214.214/, /55b.214.214/, /214.214.214/ and /214.214.31/, tone sandhi should apply from left to right.
 - For inputs /55a.55a.55/, /55b.55b.55/, /55a.55.31/, /55a.55b.55/ and /55b.55a.55/, tone sandhi should apply from right to left.

5.2 Problem of the Derivational Constraint Analysis (Chen 2000)

Chen (2000) proposes a constraint analysis to account for Boshan. The constraints proposed in Chen is different from those accepted by OT. Valid OT constraints are supposed to be output-driven. However, two out of the three constraints Chen proposes for Boshan are derivational in nature. The three constraints Chen proposes are Temporal Sequence, (derivational) Economy, and *Complex. The Temporal Sequence constraint requires tone sandhi to apply from left to right and the Economy constraint penalizes derivational steps. The *Complex constraint is a markedness constraint that penalizes the branching tone 214.

Needless to say, the Temporal Sequence constraint and the (derivational) Economy constraint are derivational in nature as they refer to the direction and the process of derivations.

The constraints are ranked in the order of *Complex >> Economy >> Temp. Here below are two of the examples Chen uses to demonstrate how the constraints work. It should be noted that in Chen's analysis, the candidates under evaluations are limited to the tonal sequence derived by the left-to-right and the right-to-left rule application directionalities.¹⁴

(95) 55a.214.214 → 55a.**55**.214 (Chen 2000:168)

			*Complex	Derivational Economy	Temporal Sequence
☞	a	⇒	55a.214.214	*	*
			(n/a)		
			55a.214.214		
			55. 55 .214		
	b	⇐	55a.214.214	*	**!
			55a. 55 .214		
			53 .55.214		

(96) 55b.55a.55 → 55b.**53**.55 (Chen 2000:169)

			*Complex	Derivational Economy	Temporal Sequence
	a	⇒	55b.55a.55	*	**
			214.55a.55		
			214 .53.55		
☞	b	⇐	55b.55a.55	*	*
			55b. 53 .55		
			(n/a)		

Chen's analysis, though seems to be able to account for tone sandhi in Boshan, has conceptual as well as technical problems. Conceptually, since Chen's analysis incorporates both rules and constraints, as pointed

¹⁴ An additional candidate that is derived by the persistent rule application would be considered in Chen's (2000) Derivational Constraint Analysis, if available.

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out by Bao (2003), there is a significant problem of duplication of both the rules and the constraints:

(Bao 2003:151)

Duplication of this type is one of the primary motivations for Optimality Theory (Prince and Smolensky 1993). Since it makes use of OT-like constraints, the derivational analysis converts easily to a pure OT analysis, by letting GEN(erator) assume the role of (6) [(6) refers to the four elementary rules of Tianjin tone sandhi] and dropping or reformulating derivation-related constraints. Chen attempts two OT analyses, with parallel and serial constraint evaluation.

Technically, the derivational constraint analysis proposed fails to provide a complete account for the tone sandhi phenomena because the candidates evaluated are limited to those derived by different derivational paths, but GEN in OT is not so restricted. (cf. Bao 2003).

As a matter of fact, even if the candidate pool can be limited to the candidates generated by different derivational paths, the derivational constraint analysis still fails to predict the attested tonal output. In Chen's analysis, no wellformedness constraint (WFC) that penalizes impermissible sequences (such as 55.55 and 214.214) is proposed. However, WFC is truly in need to ensure that the impermissible sequence 55.55 would undergo tonal change. Because though *Complex can cause 214.214, which is composed of purely complex tones, to undergo tonal change, the constraint cannot trigger tone sandhi in the sequence 55.55 which is composed of merely level tones. As shown below, without WFC, the unchanged 55.55.55 will be wrongly selected as the output for /55.55.55/.

(97) 55a. 55a.55 → 55.53.55

			*Complex	Economy	Temporal
☛	⇒	a. 55a. 55a.55 (n/a) 55a.55a.55 (n/a) 55.55.55			
	⇐	b. 55a. 55a.55 (n/a) 55a.55a.55 (n/a) 55.55.55			*!

☛ = unattested outputs wrongly selected by the constraints set

Thus, the WFC must be introduced into Chen's constraint ranking and it must rank above the *Complex constraint, as illustrated below:

(98) WFC >> *Complex >> Economy >> Temporal

Input: 55a.55a.55

Output: 55.53.55 f 55.55.55

As shown above, WFC is essential in predicting the correct output for /55a.55a.55/ whose output exhibits normal application. However, the WFC constraint, if truly introduced into Chen's ranking, would make the wrong prediction for tone sandhi that involves outputs that are non-surface-true (e.g. (P1)), as the undominated position of WFC would block any impermissible sequences from happening.

(99) The ranking WFC >> *Complex >> Economy >> Temporal would make the wrong prediction for (P1)

55a.214.214 → 55.55.214

			WFC	*Complex	Economy	Temporal
☞	⇒	a. <u>55a.214.214</u> (n/a) 55a.214.214 55.55.214	*!	*	*	
☛	⇐	b. <u>55a.214.214</u> <u>55a.55.214</u> 53.55.214		*	**	*

Key: A pointing hand outside the tableau points out the attested output failed to be selected by the constraint set.

5.3 Summary

To summarize, the Derivational Constraint analysis, aside from the problems of duplication and limited candidate pool, fails to account for data of normal and misapplication observed in Boshan at the same time. In the analysis proposed in the present study, both normal application and misapplication can be accounted for at the same time with a single constraint ranking.

As for the rule-based analysis, thought it can account for different types of application modes, ad hoc stipulations are indispensable. In the present analysis, the ad hoc stipulations in the rule application are successfully avoided. The conflicting directionalities are the results of constraint interactions, especially the interaction between the markedness constraints and the IDENT-BOT constraint.

6. CONCLUSION

In the preceding sections, I have presented the basic phenomena and the challenges of Boshan tone sandhi. The challenge Boshan tone sandhi has raised is the seemingly unpredictable rule application directionalities

observed in the tri-tonal strings. However, based on the constraint-based theory of OT, the factor governing the conflicting rule application directionalities and the conspiracy behind them are uncovered. It has been shown that there is an intriguing correlation between the directionalities of rule application and normal vs. misapplications. In tonal patterns that are direction-sensitive, the left-to-right directionality would produce misapplications while the right-to-left directionality would produce normal applications. Misapplications observed in tone sandhi have been shown in the present study to be forced by the desire for a tonal output to be more like a prosodically related base (captured by the IDENT-BOT constraint). Thus, achieving identity is the motivation lying behind the left-to-right directionality. Maximizing identity between prosodically related tonal outputs is important in Boshan tone sandhi. However, maximization of identity is not always fulfilled. When achieving identity would produce tonal outputs that are highly marked (captured by markedness constraints), identity preservation would be sacrificed. And the result would be normal applications. Thus, the motivation of the right-to-left directionality is to prevent highly marked sequences from happening. The selections between the different directionalities fall naturally from the interaction of the IDENT-BOT constraint and the markedness constraints. The domination of the markedness constraint over IDENT-BOT predicts that the IDENT-BOT constraint is satisfied unless the satisfaction of it would generate forms that violate the markedness constraints. The phenomena observed above are by no means unique to Boshan tone sandhi. The same is also reported in Mandarin, Sixian-Hakka (Lin forthcoming) and Tianjin tone sandhi (Lin 2004). In these dialects, achieving identity between prosodically related forms plays important roles, unless highly marked forms would be resulted. If that occurs, the identity between prosodically related forms are sacrificed. Therefore, the phenomena observed in Boshan is an universal tendency which deserve attention. The intriguing phenomena are revealed by the relative ranking of the markedness constraint and the constraint requiring identity between prosodically related forms.

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博山方言的連讀變調現象

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本篇論文的主旨在於討論漢語方言中，博山方言的連讀變調現象。深究的重點是博山方言連讀變調現象中難以預測的變調方向性及變調方向性背後之意義。本篇論文所採用的理論模式是優選理論。本文認為，博山變調的方向性基本上是由左而右。因為這個方向性可以使得輸出聲調和其參考的聲調(base)比較相同。當這個方向性會衍生出高度有標(highly marked)的形式時，連讀變調規則就會轉而由右而左運作。變調的方向性可以由音韻制約(markedness constraint)和輸出一輸出信實制約(OO-faithfulness constraint)之間的排列順序而得到預測。變調方向性背後的動機最主要是為了促成輸出聲調和其參考聲調之間的對應性。為了達成這個對應關係，變調規則必須由左而右運作。不過，這個對應性的達成並非全然無條件的。當連讀變調現象中更高的準則會因對應性的達成而受到違反時，變調的規則就會由相反的方向運行。