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CONSTRUCTION SENSITIVITY IN PINGYAO TONE SANDHI*

Hui-shan Lin
National Taiwan Normal University

ABSTRACT

This paper investigates tone sandhi phenomena in Pingyao, a Jin dialect spoken in Shanxi province in China. Pingyao tone sandhi is special in that tone sandhi in bi-syllabic strings is construction sensitive, but tone sandhi in tri-syllabic strings is not fully conditioned by construction types. Based on Optimality Theory (OT), this paper proposes analyses for bi-tonal and tri-tonal sandhi in Pingyao. We show that while bi-tonal sandhi can be accounted for by assuming that there are different grammars associated with different construction types, the lack of construction sensitivity in certain tri-syllabic strings suggests that the association between construction types and phonological grammars can be sacrificed to comply with a higher demand. In Pingyao, the higher demand is to avoid having a tri-tonal string with marked tone sandhi domain from being associated with conflicting grammars.

Key words: Pingyao, construction sensitive tone sandhi, Optimality Theory, directionality

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1. INTRODUCTION

This study examines the tone sandhi phenomena in Pingyao, a Jin dialect spoken in Shanxi province in China. Pingyao tone sandhi is special in that bi-tonal and tri-tonal sandhi behave differently with respect to construction sensitivity. Pingyao bi-tonal sandhi is conditioned by construction types. In two-syllable subject-predicate or verb-object constructions (henceforth $\mathcal{A}$ construction), Type A tone sandhi takes place; In other two-syllable grammatical constructions such as modifier-head, conjunction, verb-complement construction or reduplicated noun (henceforth $\mathcal{B}$ construction), Type B tone sandhi applies (Hou 1980, 1982a, 1982b, 1999; Bao 1990; Tsai 1994; Chen 2000; and J. Zhang 1999). However, in tri-syllabic strings, the association between construction type and tone sandhi observed in bi-tonal sandhi disappears in certain cases—sometimes Type B tone sandhi occurs in an $\mathcal{A}$ construction and sometimes Type A tone sandhi occurs in a $\mathcal{B}$ construction (Shen 1988; H. Zhang 1992; Tsai 1994; and Chen 1990).

The present paper examines bi-tonal and tri-tonal sandhi in Pingyao in terms of Optimality Theory (OT; Prince and Smolensky 1993/2004, McCarthy and Prince 1993)). For bi-tonal sandhi, the paper proposes that construction $\mathcal{A}$ and construction $\mathcal{B}$ have their own associated phonologies that contain different rankings of certain constraints. The differences in the ranking result in the different tonal alternations in the different construction types. For tri-tonal sandhi, since the construction type fails to govern tone sandhi in certain cases, it is proposed that the association between constructions and construction-specific grammars should be considered as violable OT constraints. In Pingyao, the association can be sacrificed to comply with a higher demand; the higher demand is to prevent a tri-tonal string with a marked tone sandhi domain (i.e., a domain that fails to align with a morphosyntactic structure) from undergoing tone sandhi of different types.

The paper is organized as follows: Section 2 describes Pingyao bi-tonal and tri-tonal sandhi. Sections 3 and 4 offer analyses for bi-tonal and tri-tonal sandhi. Section 5 concludes this paper. All Pingyao data are drawn from Hou (1980, 1982a, 1982b) and Chen (1990). Due to space limits, this paper does not discuss tone sandhi beyond three syllables.

2. PINGYAO TONE SANDHI – SOME BASICS

2.1 Bi-tonal Sandhi

Pingyao has three lexical tones: *ping sheng* 13, *shang sheng* 53, and *qu sheng* 35.[1] Pingyao bi-tonal sandhi is sensitive to grammatical constructions. A tonal combination involving the construction (i.e., subject-predicate or verb-object) undergoes different tonal alternations from combinations involving the construction (i.e., other constructions such as modifier-head, conjunction, verb-complement, or reduplicated noun).

Given three lexical tones, nine (3^2) bi-tonal combinations can arise in Pingyao. For bi-tonal combinations of the construction, five undergo tone sandhi, as shown in (1). (In the examples below, tones are separated by '-', *T* represents base tone, and *T*' represents sandhi tone.)[2]

[1] In addition to 13, 35, and 53, there are two *ru* tones in Pingyao, *yinru* 23 and *yanru* 54. Bao (1999), Chen (2000), and J. Zhang (1999) treat the two *ru* tones 23 and 54 as variants of the two non-*ru* tones, 13 and 53, respectively because 23 and 13, and 54 and 53 are not only phonetically similar but also behave similarly in tone sandhi. The present paper follows these scholars and also considers the two *ru* tones as allotones rather than lexical tones. It is actually quite common to consider *ru* tones as variants of non-*ru* tones in phonological studies of Chinese dialects. For example, based on phonetic and phonological evidence, Duanmu (1997) considers the short HL of Shanghai to be an allotone of HL and, Chung (2008) and Lin (2011) consider the two *ru* tones 32 and 54 of Dongshi Hakka as the variants of the two non-*ru* tones 31 and 53.

[2] As the focus of the present paper is on tones rather than segments, the Pingyao examples are cited using the official pinyin transcription rather than phonetic transcription.

(1) *Tone sandhi in the $\mathcal{A}$ construction*

	Input	*Output*	*Example*
a.	13-35	31’-35	*jia bai* ‘the family is broken up’
b.	13-53	35’-53	*zheng yan* ‘eyes are open’
c.	35-13	13’-13	*yuan shen* ‘the yard is deep’
d.	35-35	31’-35	*shou qi* ‘to be bullied’
e.	53-53	35’-53	*er ruan* ‘easy to be persuaded’

A schematic summary of the changes is given in (2).

(2)

$\sigma_1 \backslash \sigma_2$	13	35	53[3]
13		31’-35	35’-53
35	13’-13	31’-35	
53			35’-53

(Key: The shaded areas contain tonal combinations that do not change.)

Bi-tonal combinations of the $\mathcal{B}$ construction also undergo tone sandhi, as shown in (3).

(3) *Tone sandhi in the $\mathcal{B}$ construction*

	Input	*Output*	*Examples*
a.	13-13	31’-35’	*kai kai* ‘can be opened’ [verb-complement]
b.	13-35	13-13’	*xiong di* ‘brothers’
c.	13-53	31’-53	*zhen jia* ‘true and false’
d.	35-13	35-53’	*da men* ‘main door’
e.	35-35	35-53’	*bing tong* ‘illness’

[3] The 53 tone in the word final position sounds like 423. This paper follows Chen (1996, 2000), Bao (1990), and Tsai (1994) and considers the final rise to be phonetic and of no phonological importance.

A schematic summary of the changes in (3) is given in (4).

(4)

$\sigma_1 \backslash \sigma_2$	13	35	53
13	31'-35'	13-13'	31'-53
35	35-53'	35-53'	
53			

The operation of tone sandhi on the ℬ construction is clearly different from that on the 𝒜 construction. As shown, a single combination might surface with different output forms depending on which construction is involved. Take /35-13/ for example, the combination surfaces with [35-53'] when it is of the ℬ construction (e.g., *da men* 'main gate') but as [13'-13] when it is of the 𝒜 construction (e.g., *yuan shen* 'the yard is deep').[4] It is worth noting that the sandhi site in the two construction types is different. In the 𝒜 construction, it is always the tones on the right that remain intact and the tones on the left that undergo tone sandhi. In the ℬ construction, it is generally the tones on the left that remain unchanged and tones on the right that undergo tone sandhi. /13/ is the only exception; it can change to [31']

[4] Pingyao tone sandhi does not distinguish between syntactic and morphological structures. For instance, the disyllabic string of a verb-object construction undergoes Type A tone sandhi no matter whether the disyllabic string is a phrase (e.g., *mo dao* 'sharpen a knife') or a compound (e.g., *cao xin* 'worry'). In addition, Pingyao tone sandhi does not distinguish different syntactic categories (except for reduplicated nouns and verbs [cf. fn. 6]). Consider the examples below; (a), (b) and (c), which belong to the ℬ construction, all undergo type B tone sandhi despite the fact they belong to different syntactic categories.

	Underlying tone	*Sandhi tone*	*Example*	*Syntactic category*
a.	13-13	31'-35'	*pei shang* 'sad'	Adj
b.			*yuan yang* 'mandarin ducks'	Noun
c.			*gen sui* 'to follow'	Verb

before /53/ or another /13/.[5] We hereafter refer to the tone sandhi pattern of the $\mathcal{A}$ construction summarized in (2) as TSA, and to that of the $\mathcal{B}$ construction summarized in (4) as TSB.[6]

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[5] J. Zhang (1999) proposes an insightful OT analysis of Pingyao bi-tonal sandhi. He attempts to explain the exceptional change of a left /13/ tone in TSB from the perspective of historical tone change. J. Zhang proposes that the sandhi form of a *yin* tone should fall and that of a *yang* tone should rise based on two assumptions: (1) voiceless onsets associated to *yinping* tones usually cause the following rimes to accompany with a falling tone while voiced onsets associated to *yangping* tones usually cause the following rime to accompany a rising tone; (2) sandhi tones are more conservative than base tones. J. Zhang proposes the *Yin/Yang* Preservation constraint below to capture the fact.

Yin/Yang Preservation: In sandhi forms, *yin* tones are falling and *yang* tones are rising.

J. Zhang considers the left-hand /13/ of TSB to be a *yinping* tone and claims that it should surface with a falling tone according to *Yin/Yang* Preservation. However, while *Yin/Yang* Preservation might explain the change of /13/ to [31'] before /53/ and /13/, it fails to explain why /13/ does not change before /35/ (i.e., /13-35/ → *[31'-13']).

[6] In addition to TSA and TSB, there is actually another kind of tone sandhi that applies in the case of reduplicated verbs. Reduplicated verbs are considered as Construction $\mathcal{C}$ in Hou (1980).

	Underlying tone	13-13	
Construction $\mathcal{A}$	Sandhi tone	13-13	[verb-object] *kai che* 'drive car'
Construction $\mathcal{B}$	Sandhi tone	31'-35'	[modifier-head] *cong hua* 'onion flower' [reduplicated N] *kai kai* 'idea'
Construction $\mathcal{C}$	Sandhi tone	35'-31'	[reduplicated V] *kai kai* 'to open a little'

Construction $\mathcal{C}$ represents a minority type in Pingyao tone sandhi and is seldom addressed/analyzed in the literature. Due to space limits, the present paper focuses on tone sandhi of the two dominant construction types (i.e., $\mathcal{A}$ & $\mathcal{B}$).

2.2 Tri-tonal Sandhi

Tri-syllabic tone sandhi in Pingyao is more intriguing. Grammatical construction in tri-syllabic strings is more complex. Take *ban jiao shi* 'stumbling block' as an example. The tri-syllabic word itself is of a modifier-head ($\mathcal{B}$) construction (i.e., [*ban jiao*]$_{\text{modifier}}$ + [shi]$_{\text{head}}$). In addition, it contains a left-branching verb-object ($\mathcal{A}$) construction (i.e., [*ban*]$_{\text{verb}}$ + [*jiao*]$_{\text{object}}$). Therefore, the tri-syllabic word has the structure $\{\{\mathcal{A}\}\mathcal{B}\}$. Another characteristic of Pingyao tri-syllabic tone sandhi is that it is based on bi-tonal sandhi. Therefore, each tri-syllabic string (e.g., XYZ) will have two bi-tonal windows (e.g., XY and YZ), as illustrated in (5) (cf. Chen et al. 2004):

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(5)      X          Y          Z
         |__________| |________|
              I           II      (bi-tonal windows)
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The directionality of the tone sandhi operation depends on whether the bi-tonal windows are scanned from I to II (rightwards) or from II to I (leftwards). Thus, two issues arise in tri-tonal sandhi. First, is tone sandhi still conditioned by construction types when hierarchical structures are involved? Second, how is the directionality of the operation of tone sandhi determined in tri-tonal sandhi?

Pingyao tri-tonal sandhi can be categorized into three types with respect to the traffic of tone sandhi and construction sensitivity. In the first type, the directionality of the operation of tone sandhi is conditioned by the morphosyntactic structure and tone sandhi is conditioned by the grammatical construction. For instance, in (6) tone sandhi applies left-to-right, following the morphosyntactic structure (as shown in 6a). Applying tone sandhi in the reverse direction would result in the wrong output (as shown in 6b). Tone sandhi is also sensitive to construction types. In *ban jiao shi* 'stumbling block', since the two words on the left involve a verb-object ($\mathcal{A}$) construction, TSA takes place. But for the two tones on the right, TSB applies because *shi* 'stone' and *ban jiao* 'to trip' before it belong to a modifier-head (ℬ) construction.

(6) 'stumbling block'

a.

to trip		stone	
{{$_{\mathcal{A}}$ *ban*	*jiao*}	*shi* $_{\mathcal{B}}$}	
35	13	53	Input
<u>13'</u>	<u>13</u> $_A$		TSA
	<u>31'</u>	<u>53</u> $_B$	TSB
13'	31'	53	Output

b.

to trip		stone	
{{$_{\mathcal{A}}$ *ban*	*jiao*}	*shi* $_{\mathcal{B}}$}	
35	13	53	Input
	<u>31'</u>	<u>53</u> $_B$	TSB
<u>35</u>	<u>31'</u> $_A$		TSA (n.a.)
* 35	31'	53	Output (wrong!)

(Key: '{…}' = morphosyntactic structure; ' <u>….</u>$_{A/B}$ ' = application domain of TSA/TSB)

(7) '*thousand-layer insole'*

a.

thousand	layer	insole	
{$_{\mathcal{B}}$ {*qian*	*ceng*}	*di* $_{\mathcal{B}}$}	
13	13	53	Input
<u>31'</u>	<u>35'</u>$_B$		TSB
	<u>35'</u>	<u>53</u> $_B$	TSB (n.a.)
31'	35'	53	Output

b.

thousand	layer	insole	
{{$_{\mathcal{B}}$ *qian*	*ceng*}	*di* $_{\mathcal{B}}$}	
13	13	53	Input
	<u>31'</u>	<u>53</u>$_B$	TSB
<u>13</u>	<u>31'</u>$_B$		TSB (n.a.)
*13	31'	53	Output (wrong!)

In the second type, the directionality of the operation of tone sandhi is not sensitive to the morphosyntactic structure but tone sandhi is still conditioned by the grammatical constructions. For instance, although (8) is morphosyntactically right-branching, tone sandhi applies left-to-right (as shown in 8a). If tone sandhi applies right-to-left following the morphosyntactic structure (as shown in 8b), the wrong output is derived. Although the directionality of the operation of tone sandhi does not conform to the morphosyntactic structure, there is still a good correspondence between construction type and tone sandhi. Since (8) only involves the $\mathcal{B}$ construction, only TSB applies.

(8) ‘the west wing-room’

a.	west	wing-room		
	{$_{\mathcal{B}}$*xi*	{*xiang*	*fang* $_{\mathcal{B}}$} }	
	13	13	13	Input
	31’	35’ $_{B}$		TSB
		35’	53’ $_{B}$	TSB
	31’	35’	53’	Output
b.	west	wing-room		
	{$_{\mathcal{B}}$*xi*	{*xiang*	*fang* $_{\mathcal{B}}$} }	
	13	13	13	Input
		31’	35’ $_{B}$	TSB
	13	31’ $_{B}$		TSB (n.a.)
	*13	31’	35’	Output (wrong!)

The third type is the most intriguing; not only is tone sandhi operation directionality insensitive to morphosyntactic structure, tone sandhi is also not fully conditioned by the construction types. For instance, although (9) is morphosyntactically left-branching, tone sandhi applies right-to-left (compare 9a with 9b). In addition, although (9) is composed of both $\mathcal{B}$ and $\mathcal{A}$ constructions, only TSA takes place.

(9) ‘the journey is long’

a.

journey		long	
{{$_{\mathcal{B}}$ *lu* - *dao* }		*chang* $_{\mathcal{A}}$}	
35	35	13	Input
	13’	13_{A}	TSA
13’	$13’_{A}$		TSA
13’	13’	13	Output

b.

journey		long	
{{$_{\mathcal{B}}$ *lu* - *dao* }		*chang* $_{\mathcal{A}}$}	
35	35	13	Input
35	$53’_{B}$		TSB
	53’	13_{A}	TSA (n.a.)
*35	53’	13	Output (wrong!)

(10) ‘very lucrative’

a.

very	make	money	
{$_{\mathcal{B}}$ *hen*	{*zhuan*	*qian* $_{\mathcal{A}}$}}	
53	35	13	Input
53	35_{B}		TSB (n.a)
	35	$53’_{B}$	TSB
53	35	53’	Output

b.

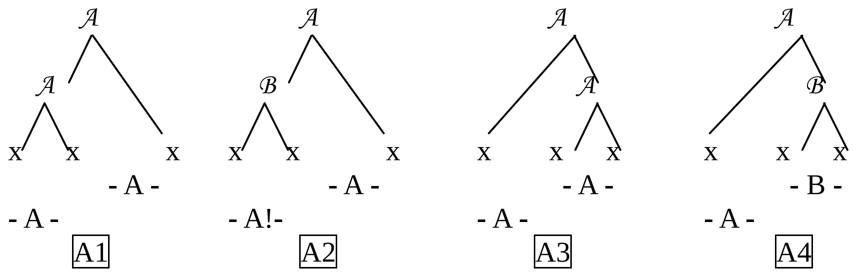
very	make	money	
{$_{\mathcal{B}}$ *hen*	{*zhuan*	*qian* $_{\mathcal{A}}$}}	
53	35	13	Input
	13’	13_{A}	TSA
53	$13’_{B}$		TSB (n.a.)
*53	13’	13	Output (wrong!)

Without citing further examples, in (11) we give the overall tri-syllabic tone sandhi pattern as laid out in the literature (Shen 1988, Chen 1990, H. Zhang 1992, Tsai 1994), where the tree represents the morphosyntactic structure, the node labels ‘$\mathcal{A}$’ and ‘$\mathcal{B}$’ indicate the construction type, x represents the syllable, ‘-A-’ and ‘-B-’ beneath the tree indicate which tone sandhi applies, and '!' signals tone sandhi applications that do not match the construction types. As shown in (11), for each trisyllabic string, there are two possible morphosyntactic structures, left branching and right branching, and each morphosyntactic structure can have four possible grammatical constructions, with the $\mathcal{A}$/$\mathcal{B}$ construction on the inner/outer cycle. In (11), A3, A4, B1, and B2 belong to the first interaction type; A1 and B4 belong to the second type; and, A2 and B3 belong to the third type.

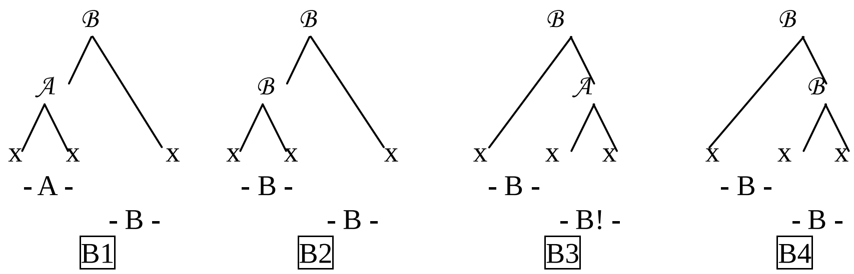
(11) *The overall tri-tonal sandhi pattern (Shen 1988, Chen 1990, H. Zhang 1992, Tsai 1994)*

(a) $\mathcal{A}$ *Type*

Left-branching *Right-branching*



(b) $\mathcal{B}$ *Type*



The pattern in (11) reveals two things. First, the directionality of the operation of tone sandhi is not governed by morphosyntactic structures.

Rather, it is governed by the construction type. As shown in (11a), tone sandhi operates right-to-left when the topmost construction belongs to Type $\mathcal{A}$ and (11b) shows that tone sandhi applies in the reverse direction when the topmost construction is of Type $\mathcal{B}$ (Shen 1988, Chen 1990).[7] Second, while tri-tonal sandhi is generally conditioned by construction type, a mismatch between construction type and tone sandhi occurs when the tri-syllabic string has a $\mathcal{BA}$ structure (i.e., A2 and B3). When the $\mathcal{BA}$ is morphosyntactically left-branching (i.e., {{$\mathcal{B}$}$\mathcal{A}$}), only TSA applies; when the $\mathcal{BA}$ is morphosyntactically right-branching (i.e., {$\mathcal{B}${$\mathcal{A}$}}), only TSB applies. These rules are summarized in (12):

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[7] Pingyao is not the only language whose tone sandhi operation directionality is insensitive to morphosyntactic structures. Tone sandhi in Chinese dialects such as Tianjin (Tan 1987; Z. Zhang 1987; Hung 1987; Chen 1986, 1987, 2000; Lin2004a, 2008, 2012; Wee 2004, 2010), Sixian-Hakka (K. Hsu 1996; Hsiao 2000; Lin2004a, 2005a), Boshan (Chen 2000; Lin2004a, 2004b), Chengdu (Lin 2004a, 2006), as well as in the Tibeto-Burman language of Hakha-Lai (Hyman and VanBik 2004; Lin 2004a, 2005c) is also insensitive to morphosyntactic structures. For instance, in Sixian-Hakka tone sandhi consistently applies left-to-right irrespective of the morphosyntactic structures; thus, both the morphosyntactically left branching utterance {{*tsu kon*}*thong*} 'pig liver soup' and the right branching utterance {*mai* {*tsu kon*}} 'buy pig liver' that are underlyingly /LH-LH-LH/ correspond to the same tonal output [L'-L'-LH] which is the result of left-to-right application (i.e., <u>LH-LH</u>-LH → L'-<u>LH-LH</u> → L'-L'-LH, not *LH-<u>LH-LH</u>* → **LH-L'-LH*). However, unlike Pingyao whose tone sandhi operation directionality is conditioned by grammatical constructions, tone sandhi in the morphosyntactically insensitive dialects/languages mentioned above is governed by the edge of prominence (Lin 2004a, 2004b, 2005a, 2005b, 2006, 2008). Tone sandhi applies left-to-right if a dialect/language is *right* prominent (e.g., Tianjin, Boshan, and Sixian-Hakka) and right-to-left if a dialect/language is *left* prominent (e.g., Chengdu and Hakha-Lai).

(12)

Topmost construction	*Construction*	*Directionality of tone sandhi operation*	*Tone sandhi matches construction type*
$\mathcal{A}$	$\{\{\mathcal{A}\}\mathcal{A}\}$	⇦	Yes
	$\{\mathcal{A}\{\mathcal{A}\}\}$		Yes
	$\{\mathcal{A}\{\mathcal{B}\}\}$		Yes
	$\{\{\mathcal{B}\}\mathcal{A}\}$		No (only TSA applies)
$\mathcal{B}$	$\{\{\mathcal{B}\}\mathcal{B}\}$	⇨	Yes
	$\{\mathcal{B}\{\mathcal{B}\}\}$		Yes
	$\{\{\mathcal{A}\}\mathcal{B}\}$		Yes
	$\{\mathcal{B}\{\mathcal{A}\}\}$		No (only TSB applies)

Thus, while bi-tonal sandhi is construction sensitive, tri-tonal sandhi is not entirely conditioned by construction types. Construction types fail to condition tri-tonal sandhi when a $\mathcal{BA}$ structure is involved. In addition, the direction of tone sandhi is not governed by the morphosyntactic structure but is conditioned by construction type. Tone sandhi applies right-to-left when the topmost construction belongs to Type $\mathcal{A}$ and left-to-right when the topmost construction belongs to Type $\mathcal{B}$.

3. OT ANALYSES TO BI-TONAL SANDHI

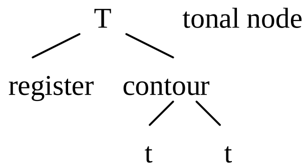
This section provides OT analyses of bi-tonal sandhi.[8] We propose that different construction types have their own associated phonologies. There are two cophonologies in Pingyao: an $\mathcal{A}$ construction-specific phonology (i.e., $\varphi\mathcal{A}$) and a $\mathcal{B}$ construction-specific phonology (i.e., $\varphi\mathcal{B}$). The two construction-specific phonologies will be treated in terms of OT constraints.

The present paper adopts Bao's (1999) model and considers each tone to have an internal representation such as that in (13), in which tone features are dominated by a node called Contour, which is a sister of the Register feature; both Contour and Register are dominated by a Tonal Node.[9] Therefore, the three lexical tones (i.e., 13, 35, and 53) and the derived tone (i.e., 31) can be represented as in (14); besides TSA and TSB, as summarized in (2) and (4), can be represented in more detail in (15) and (16):

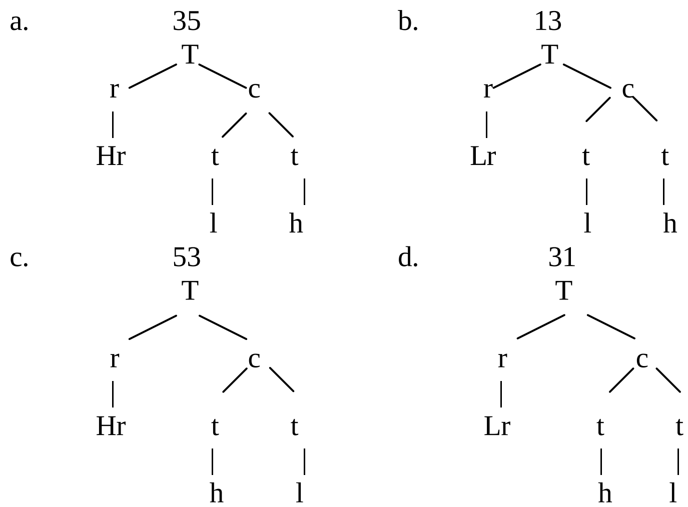
[8] A reviewer questions whether it is possible to account for Pingyao tone sandhi by Lexical Phonology. That Lexical Phonology cannot work to predict Pingyao tone sandhi is addressed clearly in Chen (1990:25) and Chen (2000:94). One of the reasons the model fails to work is that though it seems that the $\mathcal{A}$ construction (e.g., subject-predicate and verb-object) is more phrase-like while the $\mathcal{B}$ construction (e.g. modifier-head, conjunction) is more compound-like, it is wrong to equate TSA to a post-lexical rule and TSB to a lexical rule. That is because TSB can apply to phrase-like strings and TSA to lexical compounds. For instance, the subject-predicate sequence *tou teng*, which has the idiomatic meaning of 'troublesome', undergoes TSA even though it is highly lexicalized and has a meaning that is not derivable from its constituent parts 'head' + 'ache'. Besides, if TSA is considered as a post-lexical rule and TSB as a lexical rule, it will be difficult to explain why TSA, a post-lexical rule, can apply before TSB, which is a lexical rule (ref. 6).

[9] For a detailed discussion/comparison of the different models of tonal geometry, please refer to Bao (1999), Chen (2000), and Yip (2002).

(13) *Tonal geometry proposed in Bao (1999)*



(14)



[Hr= high register, Lr = low register]

(15) *TSA– represented with register and contour features*

$\sigma_1 \backslash \sigma_2$	13 Lr,lh	35 Hr,lh	53 Hr,hl
13 Lr,lh	13-13 Lr-Lr lh-lh	31’-35 Lr-Hr hl-lh	35’-53 Hr-Hr lh-hl
35 Hr,lh	13’-13 Lr-Lr lh-lh	31’-35 Lr-Hr hl-lh	35-53 Hr-Hr lh-hl
53 Hr,hl	53-13 Hr-Lr hl-lh	53-35 Hr-Hr hl-lh	35’-53 Hr-Hr lh-hl

(16) *TSB– represented with register and contour features*

$\sigma_1 \backslash \sigma_2$	13 Lr,lh	35 Hr,lh	53 Hr,hl
13 Lr,lh	31’-35’ Lr-Hr hl-lh	13-13’ Lr-Lr lh-lh	31’-53 Lr-Hr hl-hl
35 Hr,lh	35-53’ Hr-Hr lh-hl	35-53’ Hr-Hr lh-hl	35-53 Hr-Hr lh-hl
53 Hr,hl	53-13 Hr-Lr hl-lh	53-35 Hr-Hr hl-lh	53-53 Hr-Hr hl-hl

3.1 Edge of Prominence and Positional Faithfulness

A major difference between the $\mathcal{A}$ and $\mathcal{B}$ constructions is the position of the sandhi site. For the $\mathcal{A}$ construction, it is the tone on the left that undergoes a change in tone sandhi. The tone on the right never changes. On the contrary, the *ℬ* construction tends to preserve the tone on the right while allowing tones to change on the left when tone sandhi occurs.

In the literature (Yip 1980, 1999, 2002; Shih 1986; Duanmu 1993; Chen 2000; Hyman and VanBik 2004; Lin 2004, 2008; Wee 2004, 2010; among others), languages that tend to preserve the rightmost tone while allowing tones in other positions to change in tone sandhi are considered as *right prominent* (e.g., Beijing Mandarin, Tianjin, Sixian-Hakka, Southern Min) and languages that tend to maintain the left tone when tonal alternation takes place are considered as *left prominent* (e.g., Chengdu, Hakha-Lai). Therefore, the *𝒜* construction has the characteristics of a right prominent language and is right headed; in contrast, the *ℬ* construction has the characteristics of a left prominent language and is left headed.[10] In other words, *𝒜* and *ℬ* constructions have opposite head positions.

[10] Tsai (1994) attempts to explain edge of prominence in *𝒜* and *ℬ* constructions based on Duanmu's (1990) *non-head stress* (NHS), whereby in a syntactic head/non-head relation, the stress is assigned to the non-head. NHS correctly predicts the preservation of the right-hand tone in a subject-predicate and a verb-object (*𝒜*) construction, which are syntactically left-headed, and the preservation of the left-hand tone in a modifier-head (*ℬ*) construction, which is syntactically right-headed; however, it fails to make the correct prediction for tone sandhi in the rest of the constructions. For instance, as a verb-complement construction is syntactically left-headed, NHS would predict the preservation of the right-hand tone. But in reality, it is the left-hand tone that tends to be preserved in such a construction. Therefore, this paper judges the edge of prominence according to the stability of tone. That the edge where the underlying tone is retained is the edge of prominence is supported by acoustic studies. For instance, Lin et al. (1984), Peng (1996), and Chang (1995) have examined the phonetic properties of Beijing Mandarin, Taiwanese and Sixian-Hakka, respectively. The results show that in Beijing Mandarin and in Sixian Hakka, the tonal length of the second syllable of a di-syllabic word is longer than that of the first syllable, and in Taiwanese, a phrase final syllable is longer than a phrase internal syllable, supporting that Beijing Mandarin, Sixian-Hakka, and Taiwanese are right headed. In addition, H. Hsu (2006), based on the fact that rising tones are longer than level tones, which in turn are longer than falling tones (Ohala 1978), argues that Chengdu, which tends to retain the leftmost tone in tone sandhi, is left headed because in Chengdu tone sandhi, rising tones are avoided at the right edge (ref. i, ii, iii) and high level tones are preferred to falling tones at the left edge (ref. iv).

The stability of the right tone in the *𝒜* construction and of the left tone in the *ℬ* construction during tone sandhi can be captured by positional faithfulness constraints such as IDENT-IO-T-R and IDENT-IO-T-L, respectively. However, as both the right edge of the *𝒜* construction and the left edge of the *ℬ* construction are the edge of prominence in both constructions, the two constraints can more generally be referred to as IDENT-IO-T-HD.

(17) IDENT-IO-T-HD: The tone standing at the prominent position cannot be different from its corresponding tone in the output.

In the *ℬ* construction, although the tones at the head (left) position are generally preserved, /13/ before 53 and another 13 is allowed to change. Thus, IDENT-IO-T-HD will make a wrong prediction. But since /13/ is the only lexical tone that is low in register, a generalization can be made: at the head position Hr tones never change while Lr tones are allowed to change when properly conditioned. Thus, IDENT-IO-T-HD should be divided into two sub-constraints, one imposing a restriction on the change of Hr tones and the other on Lr tones.

(18) IDENT-IO-T-HD(Hr): The Hr tone standing at the head position cannot be different from its corresponding tone in the output.

(19) IDENT-IO-T-HD(Lr): The Lr tone standing at the head position cannot be different from its corresponding tone in the output.

In TSB, since at the head position Hr tones never change while Lr tones are allowed to alternate, IDENT-IO-T-HD(Hr) must be dominant while IDENT-IO-T-HD(Lr) must be outranked by markedness constraints (MC) that trigger tone sandhi. On the other hand, in TSA, since tones standing at the

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Chengdu tone sandhi rules:

i. LM → L/ T ___ ii. MH → M/{MH, ML}___

iii. MH → H/ LM ___ iv. HM → H/ ___ T

head position are always preserved, both IDENT-IO-T-HD(Hr) and IDENT-IO-T-HD(Lr) should be top-ranked.[11]

(20) φA IDENT-IO-T-HD(Hr), **IDENT-IO-T-HD(Lr) » MC**
φB IDENT-IO-T-HD(Hr), **MC » IDENT-IO-T-HD(Lr)**

The constraint rankings in (20) suggest that Hr tones are more stable than Lr tones at the head position. This actually conforms to de Lacy's (1999, 2002) observation about tone and prominence. De Lacy examines the interaction between tone and prominence and finds that different prosodic positions have different tonal preferences: a H tone is preferred over a M tone, which in turn is preferred over a L tone in prosodically prominent (i.e., head) positions; in prosodically weak (i.e., non-head) positions, the preference is the reverse, with L preferred over M, which in turn is preferred over H. The two fixed constraint rankings in (21) and (22) are proposed in de Lacy (2002) to capture the facts.

(21) *Tonal preference in the head position*
*HD/L » *HD/M
(22) *Tonal preference in the non-head position*
*NONHD/H » *NONHD/M

As Hr tones are higher in pitch than Lr tones, Hr tones should be preferred to Lr tones at the head position (cf. Lin 2011a). This preference properly explains why Hr tones are more stable than Lr tones at the head position in the *B* construction.[12] Nonetheless, though Lr tones are unstable at the head position of a *B* construction due to their marked status, the resultant

[11] IDENT-IO-T-HD(Hr) and IDENT-IO-T-HD(Lr), when equally ranked, is equivalent to IDENT-IO-T-HD.
[12] The preference for Hr tones in head position and Lr tones in non-head position is also reported in Dongshi Hakka (cf. Lin 2011a).

tonal output is still low in register. This suggests φB also contains a constraint prohibiting register alternation at the head position.

(23) IDENT-IO-REG-HD: The register of the head tone cannot be different from its corresponding tone in the output.

The two positional faithfulness constraints (18) and (23) together predict that in the *ℬ* construction, a /13/ tone at the head (left) position is allowed to change and that it can only turn to 31', which is the only tone in Pingyao that shares the register feature with 13.

While IDENT-IO-REG-HD plays an important role in TSB in ensuring that tones at the head position preserve their registers, this constraint is not decisive in TSA. However, since head tones never change in TSA, IDENT-IO-REG-HD is always respected in TSA and can also be considered as top-ranked.

(24) φA IDENT-IO-REG-HD, IDENT-IO-T-HD(Hr), **IDENT-IO-T-HD(Lr) » MC**
φB IDENT-IO-REG-HD, IDENT-IO-T-HD(Hr) » **MC »IDENT-IO-T-HD(Lr)**

3.2 Triggering of Tone Sandhi

This sub-section deals with tonal alternations in the two construction types. For the sake of simplicity, the discussion that follows will focus on what triggers the tonal alternations and ignore details such as how proper allotones are selected. Therefore, for each input combination, the candidate pull is limited to a totally faithful candidate and the candidates derivable by TSA and TSB.

Though (in addition to the location of sandhi site) the tonal alternations in the two construction types seem to differ considerably, careful examination of TSA and TSB shows that they actually share some characteristics. First, both TSA and TSB have a preference for a 35-53 sequence. Five out of the nine bi-tonal combinations of both *𝒜* and *ℬ* constructions undergo tone sandhi; of these, two change to $35^{(')}$-$53^{(')}$ (i.e., 25ai, 25aii, 25bi, 25bii). In addition, the alternations occurring to /35-13/ (25aiii) and /35-35/ (25aiv) can also be considered as sharing the same trigger. In both cases, the 35 tone, when not followed by a 53 tone, changes to a non-35 tone.

(25) *The preference for the 35-53 sequence*

$\boxed{\text{TSA}}$	*Input*		*Output*
ai.	/13-53/	→	[35’-53]
aii.	/53-53/	→	[35’-53]
aiii.	/35-13/	→	[13’-13]
aiv.	/35-35/	→	[31’-35]
$\boxed{\text{TSB}}$	*Input*		*Output*
bi.	/35-13/	→	[35-53’]
bii.	/35-35/	→	[35-53’]

Why is there a preference for a sequence of 35-53? It is proposed that the sequence is preferred because there is an agreement in pitch height (i.e., 5) across the syllable. Thus, the preference for the sequence is due to feature agreement at the intersyllabic position. There should be a constraint requiring a tone that ends/starts with a pitch height of 5 to be followed/preceded by another 5 at the intersyllabic position. In Bao’s model, the pitch height of 5 has Hr in the register tier and [h] in the contour tier. Therefore, the preference for the 35-53 sequence can be captured by the AGREE-[Hr,h] constraint in (26).[13]

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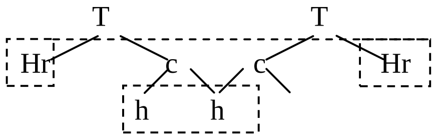
[13] The phenomenon can not be accounted for by a more general constraint like AGREE-t which requires intersyllabic tone segments to agree. For instance, in TSB there are three output forms that violate AGREE-t. They are 13(l$\boxed{\text{h-l}}$h)13’ (← /13(lh-lh)35/), 31’(h$\boxed{\text{l-h}}$l)53 (← /13(lh-hl)53/), and 53(h$\boxed{\text{l-h}}$l)53 (← /53(hl-hl)53/). In 31’-53 (← /13-53/), the unchanged form is even better than the sandhi form in terms of AGREE-t. Thus, AGREE-t will make a wrong prediction.

(26) AGREE-[Hr,h]: A tone that ends/starts with [Hr, h] must be followed/preceded by another [Hr, h] at the intersyllabic position.



Example (27) illustrates how AGREE-[Hr,h] predicts the tonal alternations in (25). As shown, there are two repair strategies for AGREE-[Hr,h] violations. One is to change the neighboring tone of a tone carrying [Hr,h] at the intersyllabic position to achieve agreement (i.e., 27ai, 27aii, 27bi, 27bii), the other is to change the tone carrying [Hr,h] at the intersyllabic position to *[Hr,h] when it is not adjacent to a tone carrying [Hr,h] (i.e., 27aiii, 27aiv).[14]

[14] AGREE-[Hr,h] is restricted to [Hr,h] and seems specific to Pingyao, but the constraint is actually also effective in the well-studied Beijing Mandarin. Bejing Mandarin has four tones, H(Hr,h), LH(Hr,lh), L(Lr,l), HL(Hr,hl). In this dialect, there is a so-called "second tone sandhi" that changes a second tone (LH) to a first tone (H) after the first or the second tone and before a non-neutral tone (Chao 1968, Duanmu 2000, among others). For example, *mei*LH *lan*LH *fang*H → *mei*LH *lan*H' *fang*H 'Mei, Lan-fang (a name)'. The phenomenon can be considered as a kind of assimilation; the second syllable is assimilated by the tone in the first syllable. The sequence $H_{\sigma1}$/$LH_{\sigma1}$-$LH_{\sigma2}$ is composed of two Hr tones. The first syllable tone, $H_{\sigma1}$/$LH_{\sigma1}$, in addition to being Hr, also ends with an h tone segment [i.e., H(Hr,h) and LH(Hr,lh)]. Before second tone sandhi takes place, the adjacent Hr tones do not agree in tone segment across syllable, violating AGREE-[Hr,h]; the violation is repaired after tone sandhi; that is, /H(Hr,h)-(lh,Hr)LH/ → [H(Hr,h)-(h,Hr)H'], /LH(Hr,lh)-(lh,Hr)LH/ → [LH(Hr,lh)-(h,Hr) LH']. Thus, Beijing Mandarin second tone sandhi can also be considered as triggered by AGREE-[Hr,h]. It is worth noting, however, that exactly how AGREE-[Hr,h] interacts with other constraints in Beijing Mandarin requires further investigation because not all output combinations respect the constraint. For instance, a L(Lr,l) or a HL(Hr,hl) does not change to H after H or LH. As L and HL tones in Beijing Mandarin never change to H tones, a possible analysis is to rank constraints of allotone generation above AGREE-[Hr,h].

(27) *The preference for the 35-53 sequence vs.* A*GREE-[Hr,h]*

$\boxed{\text{TSA}}$	A*GREE-[Hr,h] violated*		A*GREE-[Hr,h] violation repaired*
ai.	/13-53/ Lr,lh-hl,Hr	→	[35’-53] Hr,lh-hl,Hr
aii.	/53-53/ Hr,hl-hl,Hr	→	[35’-53] Hr,lh-hl,Hr
aiii.	/35-13/ Hr,lh-lh,Lr	→	[13’-13] Lr,lh-lh,Lr
aiv.	/35-35/ Hr,lh-lh,Hr	→	[31’-35] Lr,hl-lh,Hr
$\boxed{\text{TSB}}$	A*GREE-[Hr,h] violated*		A*GREE-[Hr,h] violation repaired*
bi.	/35-13/ Hr,lh-lh, Lr	→	[35-53’] Hr,lh-hl,Hr
bii.	/35-35/ Hr,lh-lh,Hr	→	[35-53’] Hr,lh-hl,Hr

Though both TSA and TSB are governed by AGREE-[Hr,h], the constraint has different effects on the two grammars. AGREE-[Hr,h] plays a dominant role in φA as no bi-tonal combination violates the constraint. On the other hand, AGREE-[Hr,h] is not always respected in φB. AGREE-[Hr,h] is violated in [31’(Lr,hl-hl,Hr)53] (← /13-53/) and [53(Hr,hl-hl,Hr)53] (←/53-53/). /13-53/ does not change to *[35’(Hr,lh-hl,Hr)53] to satisfy AGREE-[Hr,h] because the 13 → 35’ change at the head position violates IDENT-IO-REG-HD. This suggests the domination of IDENT-IO-REG-HD over AGREE-[Hr,h] in φB.

For /53-53/, the tone on the left could have changed to 35’ [i.e., *35’(Hr,lh-hl,Hr)53] or the tone on the right to a non-53 tone [e.g., *53(Hr,hl-lh,Hr)35’] to escape the violation of AGREE-[Hr,h]. But 53 never changes in a *B* construction. This suggests that IDENT-IO-53, or more generally IDENT-IO-FALL, is dominant in φB and that it outranks AGREE-[Hr,h].

(28) IDENT-IO-FALL: A falling tone must be faithfully preserved in the output.

In TSA, though 53 is also relatively more stable than the other two tones, a 53 tone is allowed to change before another 53 tone (i.e., /53(Hr,hl-hl,Hr)53/ → [35'(Hr,lh-hl,Hr)53]) to satisfy AGREE-[Hr,h]. This suggests that AGREE-[Hr,h] and IDENT-IO-FALL should be ranked in a reverse order in φA.

(29) φA **AGREE-[Hr,h] >> IDENT-IO-FALL**
φB IDENT-IO-REG-HD, **IDENT-IO-FALL >> AGREE-[Hr,h]**

The second property shared by TSA and TSB is that both of them require adjacent rising tones to agree in register. This explains the lack of adjacent rising contours that differ in register in TSA and TSB. It also explains why /13-35/ and /35-13/, which involve rising combinations of different registers, undergo tone sandhi in both $\mathcal{A}$ and $\mathcal{B}$ constructions. The phenomenon can be captured by AGREE-REG(RISE). The constraint is dominant in both TSA and TSB.

(30) AGREE-REG(RISE): Adjacent rising tones must agree in register.[15]

(31) φA
AGREE-REG(RISE), IDENT-IO-REG-HD, **AGREE-[Hr,h] >> IDENT-IO-FALL**
φB
AGREE-REG(RISE), IDENT-IO-REG-HD, **IDENT-IO-FALL >> AGREE-[Hr,h]**

We have examined several properties of TSA and TSB. These properties, which are captured by OT constraints, are shared by both TSA and TSB. The

[15] AGREE-REG(RISE) is equivalent to the conjoint constraint [OCP-RISE & AGREE-REG]$_{ADJ}$ (constraint conjunction; Smolensky 1993) which prohibits adjacent syllables from violating both OCP-RISE and AGREE-REG.

constraints play crucial roles in both tone sandhi types, though the effect they have on different constructions is not identical. This is reflected by the ranking difference between the two cophonologies.

Though TSA and TSB share some properties, there are also properties that exist in TSB but not in TSA. First, TSB tends to prohibit rising tones from occurring in an adjacent position; however, rising combinations can freely occur in TSA. In TSB, four out of the five bi-tonal combinations that undergo tone sandhi, i.e., /13-13/, /13-35/, /35-13/, and /35-35/, involve rising combinations in the underlying representation. Thus, the tonal alternations in the four pairs can be considered as being triggered by OCP-RISE. However, it is worth noting that the output form of the /13-35/ → [13-13'] change still surfaces with adjacent rising tones. As a matter of fact, it constitutes chainshift together with the /13-13/ → [31'-35'] change. That is, 13-35 → 13-13 → 31-35.

There are different approaches to chainshift. This paper adopts the Comparative Markedness model (McCarthy 2003). In this model, markedness constraints compare the output candidate under evaluation with another candidate that is fully faithful to the input. Markedness constraints are categorized into two types in this theory: those that penalize a marked structure that is also present in the fully faithful candidate ($*_{O}M$); and those that penalize a marked structure that is not present in the fully faithful candidate ($*_{N}M$).[16]

Adopting McCarthy's theory, this paper proposes the comparative markedness constraint $_{O}$OCP-RISE to account for the chainshift in Pingyao. $_{O}$OCP-RISE penalizes old, but not new, instances of adjacent rising tones. The constraint must outrank the general faithfulness constraint IDENT-IO-T to predict the alternations induced by adjacent rising tones in φB.

[16] McCarthy (2003) has shown that Comparative Markedness can account for the grandfather effect, the non-iterative process, and the derived environment effect. But see Yip (2003), Growhurst (2003), Blumenfeld (2003), and (B. Li 2005) for criticisms of the theory.

(32) $_{O}$OCP-RISE: Adjacent rising tones that are also present in the fully faithful candidate are prohibited. That is, no old violations of OCP-RISE.

$_{O}$OCP-RISE, on the other hand, has no effect in TSA. This can be proved by the lack of tone sandhi in /13-13/. Thus, the constraint must be dominated by IDENT-IO-T in φA.

(33) φA **IDENT-IO-T >> $_{O}$OCP-RISE**
φB **$_{O}$OCP-RISE >> IDENT-IO-T**

Second, the /13-53/ → [31'-53] change in TSB calls for a constraint that is important in TSB but not in TSA. In the change, the rising tone 13 on the left changes to a falling tone 31', which agrees in contour with its neighboring tone. Thus, the change is considered to be triggered by a constraint requiring contour agreement of adjacent tones.

(34) AGREE-CON: Adjacent tones must agree in contour.

Though AGREE-CON must outrank IDENT-IO-T to trigger the change in /13-53/, it cannot be ranked too high since not all output combinations in TSB agree in contour. The surface of the preferred sequence of 35-53[(')], which differs in contour but satisfies AGREE-[Hr,h], suggests that AGREE-[Hr,h] must outrank AGREE-CON. On the other hand, since AGREE-CON plays no role in TSA, it is proposed that it is outranked by IDENT-IO-T in φA.

(35) φA **IDENT-IO-T >> AGREE-CON**
φB AGREE-[Hr,h] >> **AGREE-CON >> IDENT-IO-T**

(36) and (37) are the final constraint rankings of φA and φB.

(36) *Ranking of φA*
IDENT-IO-T-HD(Hr), IDENT-IO-REG-HD, AGREE-REG(RISE),
IDENT-IO-T-HD(Lr), AGREE-[Hr,h]
>> IDENT-IO-FALL
>> IDENT-IO-T
>> $_{O}$OCP-RISE, AGREE-CON

(37) *Ranking of φB*
IDENT-IO-T-HD(Hr), IDENT-IO-REG-HD, AGREE-REG(RISE),
IDENT-IO-FALL, $_{O}$OCP-RISE
>> AGREE-[Hr,h]
>> AGREE-CON
>> IDENT-IO-T
>> IDENT-IO-T-HD(Lr)

In sum, tone sandhi in di-syllabic strings in Pingyao is construction sensitive. We propose that construction *𝒜* and construction *ℬ* have their own associated phonologies that are composed of the same set of constraints but differ in their relative ranking of certain constraints. The differences in the ranking of the constraints result in the different tonal alternations in the two construction types. The proposed analysis is consistent with the assumption of cophonology (Orgun 1996, Anttila 1997, Inkelas et al. 1997, Inkelas 1998, Yu 2000, among others) in which a single language can have different phonological grammars that are associated with different lexical classes, morphological categories, or morphological constructions, etc.[17]

[17] As will be shown in Section 4, the selection of one cophonology from the other in Pingyao is governed by the ASSOCIATION constraint (59) which associates the *𝒜* construction to φA and

(38) and (39) illustrate how the constraint rankings in (36) and (37) account for TSA and TSB, respectively. (The tones standing at the head position are double underlined.)

(38) *TSA*

Input: /13-35/ Output: [31’-35] (Fully faithful output: 13-35)[18]

13-35	Ident-IO-T-Hd(Hr/Lr)	Ident-IO-Reg-Hd	Agree-Reg(Rise)	Agree-[Hr,h]	Ident-IO-Fall	Ident-IO-T	Agree-Con	oOCP-Rise
a. 13-35 Lr-Hr lh-lh			*!					*
☞ b. 31’-35 Lr-Hr hl-lh						*	*	
c. 13-13’ Lr-Lr lh-lh	*!					*		

the ℬ construction to φB.

[18] For the sake of simplicity, we focus on what triggers the tonal alternations and ignore details such as how proper allotones are selected. Therefore, for each input combination, the candidate pull is limited to a totally faithful candidate and the candidates derivable by TSA and TSB.

(39) *TSB*

Input: 13-35 Output: 13-13’ (Fully faithful output: 13-35)

13-35	Ident-IO-T-Hd(Hr)	Ident-IO-Reg-Hd	Ident-IO-Fall	$_{O}$OCP-Rise	Agree-Reg(Rise)	Agree-[Hr,h]	Agree-Con	Ident-IO-T	Ident-IO-T-Hd(Lr)
a. 13-35 Lr-Hr lh-lh				*!	*				
b. 31’-35 Lr-Hr hl-lh							*!	*	*
☞ c. 13-13’ Lr-Lr lh-lh								*	

4. AN OT ANALYSIS TO TRI-TONAL SANDHI

This section provides an account for tri-syllabic tone sandhi. This section starts by discussing how tone sandhi operation directionality is predicted, followed by discussion of construction sensitivity in tri-tonal sandhi.

4.1 Directionality in Tri-tonal Sandhi

As mentioned in §2.2, morphosyntactic structures play no role in determining the directionality of tri-tonal sandhi.[19] Rather, the traffic of tone sandhi is governed by the construction type of the topmost constituent (i.e., the tri-syllabic string). When the topmost construction belongs to type $\mathcal{A}$, tone sandhi operates right-to-left; and when the topmost construction is of type $\mathcal{B}$, tone sandhi operates left-to-right.

How do we explain the correlation between the construction type and directionality? Howard (1972), based on the examination of a large number of phonological rules in a wide variety of languages, offers an objective way to determine the directionality of rule application. In his theory, the rule

[19] Chen (2004: 806) proposes six general principles as the possible criteria that govern the directionality of the operation of tone sandhi. They are Structure Affinity, Temporal Sequence, Derivational Economy, Transparency, Simplicity, and Welformedness. None of the principles governs the directionality of Pingyao tri-tonal sandhi. Structure Affinity refers to cyclicity following the syntactic bracketing. Temporal Sequence refers to the temporal sequence of speech organization thus prefers left-to-right directionality. Derivational Economy chooses the shortest derivational path, and 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. The fact that rule application directionality in Pingyao tri-tonal strings is insensitive to morphosyntactic structures quickly rules out Structure Affinity as the governing factor. Similarly, tone sandhi operation directionality is not governed by the principle of Temporal Sequence because tone sandhi also operates right-to-left. Derivational Economy also fails to predict the directionality because by comparing (6a), which is the attested output, with (6b), which is unattested, it can be seen that, while both TSA and TSB apply in the former, only TSB applies in the latter. In other words, the unattested output is derived by the shorter derivational path. Next, Transparency also fails. Consider (6) again. The attested output (6a) is opaque because 35 changes to 13' even though it is not followed by 13 at the surface. Besides, even though (6a) is opaque while (6b) is transparent, neither contains impermissible tonal combinations; therefore, Wellformedness can not work, either. Finally, the principle of Simplicity also fails because all Pingyao tones are contour tones.

application directionality is predicted from the location of the trigger (i.e., determinant) and the target (i.e., focus).

(Howard 1972:30)

> A rule is applied across a string from the side corresponding to the location of the determinant to the side corresponding to the focus.

(40) *Howard's directional rule application theory*

Phonological Rule	*Rule Application Directionality*
a. X → Y/ __ Z	Right-to-left ⇦
b. X → Y/ Z __	Left-to-right ⇨

In other words, rules should apply from the direction of the prominent edge towards the non-prominent edge. Thus, for a right prominent language, the phonological rule should apply right-to-left and for a left prominent language, the rule should apply left-to-right.

The directionality as predicted in Howard's theory has the advantage of predicting transparent outputs. Consider a hypothetical language with the two phonological rules listed in (41). Given that the phonological rules are right headed, Howard's theory predicts that the rules should apply right-to-left. (42) illustrates that a right-to-left directionality results in an output (42a) that is transparent (there is neither an unconditioned change nor an impermissible string in the output) while a left-to-right directionality results in an output (42b) that is opaque. The output in (42b) is opaque because X changes to Y even though it is not followed by Z at the surface.

(41) Phonological rules: X → Y/ __ Z
Z → A/ __ B

(42)

	Input	*Output*	*Derivation*
a.	/X-Z-B/	[X-A'-B]	X-$\underline{\text{Z-B}}$ → X-A'-B ⇦
b.	/X-Z-B/	[Y'-A'-B]	$\underline{\text{X-Z-B}}$ → Y'-$\underline{\text{Z-B}}$ → Y'-A'-B ⇨

(Key: $\underline{\text{x.x}}$ = current two-tone window scanned for possible rule application)

In Pingyao tone sandhi, since the $\mathcal{A}$ construction is right headed while the $\mathcal{B}$ construction is left headed, Howard's theory correctly predicts the right-to-left directionality for a tri-syllabic string in an $\mathcal{A}$ construction and the left-to-right directionality for a tri-syllabic string in a $\mathcal{B}$ construction.[20]

The right-to-left directionality suggests that the domain is right aligned (σ(σσ)); on the other hand, the left-to-right directionality suggests a left aligned domain ((σσ)σ). Since an $\mathcal{A}$ construction is right headed while a $\mathcal{B}$ construction is left headed, no matter whether the domain is right-aligned in a tri-syllabic $\mathcal{A}$ construction or left-aligned in a tri-syllabic $\mathcal{B}$ construction, the domain is aligned to the prominent/head position, as illustrated in (43).

[20] Although Howard's (1972) theory can explain the directionality in Pingyao tone sandhi and a variety of phonological phenomena examined in his work, it fails in predicting the tone sandhi operation directionalities in Hakha-Lai and Chinese dialects such as Tianjin, Chengdu, Sixian-Hakka, etc. (Hyman and VanBik 2004; Lin 2004a, 2004b, 2005a, 2005c, 2006, 2008; cf. fn. 7).

(43)

Topmost construction [head]	*Construction*	*Rule application directionality*	*Tone sandhi domain*
$\mathcal{A}$ [right headed]	{{$\mathcal{A}$}$\mathcal{A}$}	⇦	(σ(σσ))
	{$\mathcal{A}${$\mathcal{A}$}}		(σ(σσ))
	{$\mathcal{A}${$\mathcal{B}$}}		(σ(σσ))
	{{$\mathcal{B}$}$\mathcal{A}$}		(σ(σσ))
$\mathcal{B}$ [left headed]	{{$\mathcal{B}$}$\mathcal{B}$}	⇨	((σσ)σ)
	{$\mathcal{B}${$\mathcal{B}$}}		((σσ)σ)
	{{$\mathcal{A}$}$\mathcal{B}$}		((σσ)σ)
	{$\mathcal{B}${$\mathcal{A}$}}		((σσ)σ)

Pierrehumbert (1994) examines a number of phonological phenomena involving alignment to a head position and proposes that headness can be treated as a location in the same way as the left/right edges. In other words, alignment constraints can also refer to head positions. Therefore, in this paper, instead of proposing ALLFTR for the $\mathcal{B}$ construction and ALLFTL for the $\mathcal{A}$ construction, the more general constraint ALLFTHD is proposed.

(44) ALLFTHD: Every foot (Ft) stands at the head position of the utterance.

ALLFTHD must outrank the ALIGNFT/MS constraint in (45), which encourages the alignment of the foot and morphosyntactic structure. In addition to ALLFTHD and ALIGNFT/MS, two other constraints are needed.

PARSESYLL (46) helps rule out foot structures that satisfy ALLFTHD but have unparsed syllables [e.g., (σσ)σ]. BINBRAN (47) helps rule out foot structures that satisfy both ALLFTHD and PARSESYLL but are not binary branching [e.g., (σσσ)].

(45) ALIGNFT/MS: The edges of every foot are aligned with the corresponding edges of some morphosyntactic structures (MS).
(46) PARSESYLL: Parse every syllable into higher prosodic levels.
(47) BINBRAN: Phonological structures are binary branching.

(48) and (49) illustrate how ||{PARSESYLL, ALLFTHD, BINBRAN } >> ALIGNPS/MS|| predicts the (σ(σσ)) domain for the tri-syllabic string in the $\mathcal{A}$ construction and the ((σσ)σ) domain for the tri-syllabic string in the $\mathcal{B}$ construction, irrespective of the morphosyntactic structures of the strings.

(48) *Tri-syllabic 𝒜 construction (right headed)*

	{σ{σσ}}	PARSESYLL	ALLFTHD	BINBRAN	ALIGNPS/MS
	a. σ(σσ)	*!			
	b. σσσ	*!**			
	c. (σσ)(σ)		*!	*	**
	d. ((σσ)σ)		*!		*
	e. (σσ(σ))			*!	*
	f. (σσσ)			*!	
☞	g. (σ(σσ))				
	{{σσ}σ}				
	a. σ(σσ)	*!			*
	b. σσσ	*!**			
	c. (σσ)(σ)		*!	*	*
	d. ((σσ)σ)		*!		
	e. (σσ(σ))			*!	*
	f. (σσσ)			*!	
☞	g. (σ(σσ))				*

(49) *Tri-syllabic ℬ construction (left headed)*

{σ{σσ}}	PARSESYLL	ALLFTHD	BINBRAN	ALIGNPS/MS
a. σ(σσ)	*!	*		
b. σσσ	*!**			
c. (σ(σσ))		*!		
d. (σσ)(σ)		*!*	*	**
e. (σσ(σ))		*!*	*	*
f. (σσσ)			*!	
☞ g. ((σσ)σ)				*

{{σσ}σ}	PARSESYLL	ALLFTHD	BINBRAN	ALIGNPS/MS
a. σ(σσ)	*!	*		*
b. σσσ	*!**			
c. (σ(σσ))		*!		*
d. (σσ)(σ)		*!*	*	*
e. (σσ(σ))		*!*	*	*
f. (σσσ)			*!	
☞ g. ((σσ)σ)				

In a derivational theory, directionality is the result of cyclic rule application from the innermost tone sandhi domain outwards. In Optimality Theory, cyclicity, which involves the protection of structures built on previous cycles, can be properly captured by Output-to-Output (OO) correspondence (Benua 1997, Duanmu 1997). The traditional OO correspondence model (Benua 1997) requires the output forms in OO correspondence to be morphosyntactically related. Since Pingyao tone sandhi domain is not governed by morphosyntactic structures, cyclicity in tone sandhi can not be properly captured by the traditional model. Lin (2004) proposes a Prosodic Correspondence Model for tone sandhi. In this model, tonal outputs standing in prosodic relations can be evaluated for correspondence.

(50) *Correspondence Model for Tone Sandhi* (Lin 2004:30)

Input Tone　　　**I**nput Tone
Tb Tc　　　Ta Tb Tc
↓　　　↓　　　IO-Faith
(Tb' Tc') ⟶ (Ta" (Tb" Tc"))
Base **T**one　　　**O**utput **T**one
BOT-IDENTITY

(Key: '(…)' = the left and the right edges of a prosodic constituent)

In this model, the base-tone-to-output-tone correspondence (BOT-IDENTITY) governs two freestanding tonal outputs that are compositionally related. The two tonal outputs, unlike the outputs in the transderivational model (Benua 1997), are related by prosodic structure rather than by morphosyntactic structure. In correspondence relations, 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 (50), (Ta"-(Tb"-Tc")) and (Tb'-Tc') are prosodically related, and the Tb"-Tc" in (Ta"-(Tb"-Tc")) and the base (Tb'-Tc') share the same underlying tones Tb-Tc. Thus, (Ta"-(Tb"-Tc")) and (Tb'-Tc') are capable for correspondence evaluation. Based on the autosegmental status of tone, only tonal information is considered significant in the correspondence model; information in the segmental tier is of no importance. In the correspondence model, the tonal base and the tonal output are output tonal strings that can associate with any freestanding segments. This can be illustrated by the correspondence schema in Beijing Mandarin in (51). In (51), the tonal base is a freestanding tonal sequence [i.e., (LH'-L)] that shares the tonal input (i.e., /L-L/) with the tonal output with which it prosodically relates [i.e., (L-(LH'-L))].[21] The segmental base with which the tonal base associates is a freestanding form as well, but it need not be part of the segmental output with which the tonal output associates. Thus, while the tonal base LH'-L could be associated with *shui guo* 'fruit', the tonal output L-LH'-L could be associated with *xiao yu san* 'small umbrella', even though the segmental information of 'fruit' and 'small umbrella' is completely different. The correspondence relationship is captured by the constraint IDENT-BOT in (52).

(51) *Correspondence schema in Beijing Mandarin* (Lin 2004:35)

Input Tone		**I**nput Tone
L- L		L- L- L
↓		↓ IO-Faith
(LH'-L)	→	(L-(LH'-L))
Base **T**one		**O**utput **T**one
'fruit' *shui guo*		*xiao yu san* 'small umbrella'
'tiger' *lao hu*		*xiao shui tong* 'small water pail'
'dog' *xiao gou*		*li zong tong* 'President Li'
etc.		etc.
	BOT-IDENTITY	

(52) IDENT-BOT: Corresponding tones in the prosodically related bases and outputs must be identical. (Lin 2004:93)

[21] In Beijing Mandarin, all bi-tonal combinations other than L.L are legal tonal sequences permitted to occur at the surface.

The maximization of identity between prosodically related tonal outputs plays an important role in the tone sandhi phenomena of various languages such as Beijing Mandarin and Sixian Hakka (Lin 2005a), Boshan (Lin 2004b), Hakha-Lai (Lin 2005b), Chengdu (Lin 2006), and Tianjin (Lin 2008). In those languages, tonal outputs tend to be more like the tonal bases with which they prosodically relate, even though the maximization of identity sometimes generates forms that are opaque. In Pingyao, IDENT-BOT also plays a role in preserving the tonal output of the previous cycle and predicting the traffic of tone sandhi, as illustrated in (53).

(53)

a.

Input Tone 13-13 → (31'-35') **B**ase Tone

Input Tone 13-13-13 → (IO-Faith) → ((31'-35').53') **O**utput **T**one

(31'-35') → ((31'-35').53')

BOT-IDENTITY

b.

***I**nput **T**one* 13-13 → *(31'-35')* ***B**ase **T**one*

***I**nput **T**one* 13-13-13 → (*IO-Faith*) → **((13-31')-35')* ***O**utput **T**one*

(31'-35') → **((13-31')-35')*

BOT-IDENTITY

In (53), the diagram on the left is the diagram of the attested output resulting from left-to-right directionality while the diagram on the right is that of the unattested output resulting from the reverse direction. As clearly shown, the tonal output in the internal prosodic structure (underlined) of the attested output ((<u>31’-35’</u>)-53’) is more like that of the base <u>31’-35’</u> than that of the unattested output *((<u>13-31’</u>)-35’). IDENT-BOT must outrank IDENT-IO-T to predict the directionality, as illustrated in (54).

(54) Construction: {*B*{*B*}}；tone sandhi domain: ((σσ)σ)
{$_{B}$ 13-{13-13 $_{B}$}} → ((31’-35’)-53’) RO: 31’-35’（← $_{B}$ /13-13/）
Example: *xi xiang fang* ‘‘the west wing-room’

((13-13)-13)	IDENT-BOT	IDENT-IO-T
a. ((13-<u>31’</u>)-35’) B B ⇦	**!	**
☞ b. ((<u>31’-35’</u>)-53’) B B ⇨	*	***

Notice that IDENT-BOT, in turn, must be dominated by markedness constraints that trigger tone sandhi to rule out candidates that fully satisfy IDENT-BOT but contain an impermissible tonal sequence, as illustrated in (55).

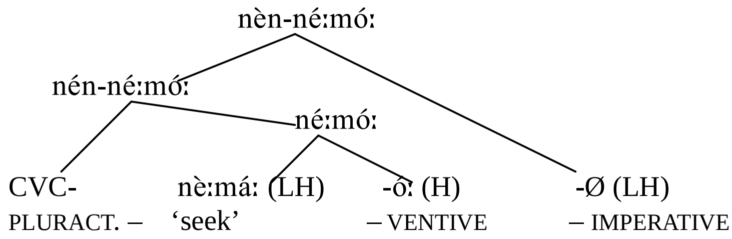
(55) Construction: {*B*{*B*}}；tone sandhi domain: ((σσ)σ)
{$_{B}$ 13-{13-13 $_{B}$}} → ((31’-35’)-53’) RO: 31’-35’（← $_{B}$ /13-13/）
Example: *xi xiang fang* ‘the west wing-room’

((13-13)-13)	MC	IDENT-BOT	IDENT-IO-T
a. ((<u>31’-35’</u>)-13) B B	*! (35’-13 violates AGREE[Hr,h])		**
☞ b. ((<u>31’-35’</u>)-53’) B B		*	***

4.2 Construction Sensitivity in Tri-tonal Sandhi

We shall now consider the issue of construction sensitivity in tri-tonal sandhi. As shown, bi-tonal sandhi is construction sensitive—an $\mathcal{A}$ construction is associated to φA and undergoes TSA while a $\mathcal{B}$ construction is associated to φB and undergoes TSB. In other words, there is a perfect construction type-tone sandhi (CONS-TS) match in di-syllabic sequences. In tri-syllabic strings, however, though the CONS-TS match generally holds, a mismatch occurs when the tri-syllabic string contains $\mathcal{B}$ + $\mathcal{A}$ in sequence. When a tri-syllabic $\mathcal{A}$ construction contains a left-branching $\mathcal{B}$ construction (i.e., $\{\{\mathcal{B}\}\mathcal{A}\}$), only TSA applies. On the other hand, when a tri-syllabic $\mathcal{B}$ construction contains a right-branching $\mathcal{A}$ construction (i.e., $\{\mathcal{B}\{\mathcal{A}\}\}$), only TSB takes place. Clearly, in both $\{\{\mathcal{B}\}\mathcal{A}\}$ and $\{\mathcal{B}\{\mathcal{A}\}\}$, the topmost construction determines which tone sandhi to apply; the embedded construction, on the other hand, plays no role. Thus, one might attempt to attribute the insensitivity of tone sandhi to the embedded construction observed in $\mathcal{BA}$ to Bracket Erasure. Bracket Erasure refers to the generalization that the phonology applying in the mother node does not make reference to that in the embedded daughter nodes. Therefore, when there are two phonological grammars in a string, the phonology that subscribes to the outer construction has the last say. The effect of Bracket Erasure can be illustrated by the Hausa example given in Inkelas (2008). (56) contains two tone-replacing constructions; the ventive construction imposes H while the imperative construction imposes LH. In the word, the ventive construction is embedded within the imperative construction. The word surfaces with a LH contour, showing that the inner ventive stem, which is imposed H by the ventive cophonology, is replaced by LH by the cophonology of the outer (imperative) construction.

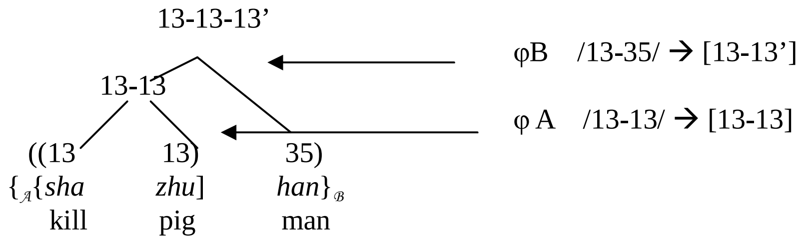
(56) ‘Seek repeatedly ! ’ (Inkelas 2008)



However, Bracket Erasure cannot account for Pingyao tri-tonal sandhi. Bracket Erasure can explain tone sandhi in a $\mathcal{BA}$ structure, which is solely conditioned by the topmost construction, but it fails to predict tone sandhi in an $\mathcal{AB}$ structure, which is sensitive to the construction type of the embedded structure. This can be illustrated by (57) in which an $\mathcal{A}$ construction is embedded within a $\mathcal{B}$ construction. In the inner construction ($\mathcal{A}$), /13-13/ surfaces unchanged according to φA. When it comes to the outer construction ($\mathcal{B}$), φB only targets the right bi-tonal window containing 13-35, leaving the first 13 unaffected. Had the topmost construction overwritten the tones generated by the grammar of the embedded construction, the output would have be *31’-35’-53’ ($\leftarrow_B$ 31’-<u>35’-35</u> $\leftarrow_B$ <u>13-13</u>-35). In other words, Bracket Erasure cannot explain Pingyao tri-tonal sandhi because the topmost construction determines the tonal pattern of $\mathcal{BA}$ but not that of $\mathcal{AB}$.[22]

[22] Tone sandhi in $\mathcal{AA}$ and $\mathcal{BB}$, which respectively involve a single type of construction, can be considered as conditioned by the topmost construction and predictable by Bracket Erasure.

(57) 'butcher'



It is interesting to note that Pingyao is not the only language that simultaneously involves CONS-TS matches and mismatches. Changsha, a Xiang dialect spoken in Hunan, also has two construction sensitive tone sandhi patterns (cf. Lin 2011b). Like Pingyao, a bi-tonal sequence in Changsha has a perfect CONS-TS match: TSA applies in the $\mathcal{A}$ construction (including subject-predicate, verb-object, and verb-complement) and TSB applies in the $\mathcal{B}$ construction (including modifier-head and conjunction). And, as in Pingyao, CONS-TS mismatches also occur in tri-tonal strings. They occur when the structure of the tri-tonal string is {{$\mathcal{B}$}$\mathcal{A}$} or {$\mathcal{A}${$\mathcal{B}$}}. The CONS-TS correspondence in Changsha tri-tonal sandhi, as summarized in Lin (2011b), is given below.

(58) *Changsha tri-tonal sandhi Lin (2011b)*

Construction	*CONS-TS matching*
{{𝒜}𝒜}	yes
{𝒜{𝒜}}	
{{ℬ}ℬ}	yes
{ℬ{ℬ}}	
{{ℬ}𝒜}	yes
{ℬ{𝒜}}	No (only TSA applies)
{{𝒜}ℬ}	No (only TSB applies)
{𝒜{ℬ}}	Yes

Bracket Erasure also fails to capture Changsha tri-tonal sandhi. Otherwise, {{ℬ}𝒜} and {𝒜{ℬ}} should have undergone only TSA and {ℬ{𝒜}} and{{𝒜}ℬ} only TSB.

When dealing with phenomena that are construction sensitive, the association between construction and construction-specific grammar is generally assumed to be automatic and exceptionless (Anttila 2002, Inkelas and Orgun 1995, Inkelas 2008, Inkelas and Zoll 2007, Orgun and Inkelas 2002, Orgun 1996, Yu 2000, among others). However, the changes in construction sensitivity observed in Pingyao tri-tonal sandhi suggest that the association between construction and construction-specific grammar can be sacrificed at some point to comply with certain higher demands. In other words, the association should be considered as a violable OT constraint that can be violated to satisfy higher ranked constraints. In this paper, the ASSOCIATION constraint in (59) is proposed to capture the general matching between tone sandhi and construction type. In Pingyao, ASSOCIATION functions to ensure the association of the $\mathcal{A}$ construction to φA and the $\mathcal{B}$ construction to φB.

(59) ASSOCIATION: Tone sandhi should match the construction type.

For languages that have only one type of tone sandhi, the ASSOCIATION constraint is always satisfied because there is only one phonological grammar in the language. But for languages that have two or more construction-sensitive tone sandhi and exhibit CONS-TS mismatches, constraints encouraging the matching (i.e., ASSOCIATION) must be dominated by constraints that invite the mismatch. What is the cause of the mismatch in Pingyao? To attain better tonal output in terms of markedness or faithfulness are logical possibilities. However, the possibility of markedness can be dispensed with quickly by comparing the two tonal outputs of $\mathcal{BA}$ in (60), as neither (60b), which is derived by tone sandhi rules matching the construction type, nor (60a), which is derived by a single type of tone sandhi rule and thus involves the CONS-TS mismatch, contain any impermissible tonal combinations.

(60) ‘wide shoulders’

a.	shoulder		wide	
	{{$_{\mathcal{B}}$*jian* -	*bang* }	*kuan* $_{\mathcal{A}}$}	
	13	53	13	Input
		53	13_A	TSA (n.a.)
	35’	53_A		TSA
	35’	53’	13	Output
b.	shoulder		wide	
	{{$_{\mathcal{B}}$*jian* -	*bang* }	*kuan* $_{\mathcal{A}}$}	
	13	53	13	Input
	31’	53_B		TSB
		53	13_A	TSA (n.a.)
	*31’	53	13	Output (wrong!)

How about faithfulness? IDENT-BOT seems to be capable of predicting the CONS-TS matches and mismatches. Consider the {{$\mathcal{B}$}$\mathcal{A}$} structure first. Why does all and only TSA apply? Recall that the tone sandhi domain of {{$\mathcal{B}$}$\mathcal{A}$} is (σ(σσ)). Because the tones standing in the inner bracket belong to the $\mathcal{A}$ construction, the tonal base should result from the application of TSA. Because TSA tends to change a left-hand tone when tone sandhi takes place (i.e., Tb-Tc → Tb’-Tc), to satisfy IDENT-BOT, it is better for the two tones on the left to undergo TSA. This is because TSB tends to change a right-hand tone in tone sandhi (i.e., Ta-Tb → Ta-Tb”), if the two tones on the left undergo TSB, the correspondence between the tonal base and the tonal output will be destroyed. (61) illustrates that the attested output derived by applying TSA only (e.g., 61b) is better than that derived by applying rules matching the construction types. In other words, it seems to be the maximization of tonal identity between prosodically related outputs that has caused the CONS-TS mismatch in the {{$\mathcal{B}$}$\mathcal{A}$} structure.

(61) Construction: {{$\mathcal{B}$}$\mathcal{A}$}; tone sandhi domain: (σ(σσ))

{{$_{\mathcal{B}}$ Ta-Tb }-Tc $_{\mathcal{A}}$} → (Ta”-(Tb’-Tc)) RO: Tb’-Tc（←$_{A}$ Tb-Tc）

(Ta-(Tb-Tc))	IDENT-BOT	ASSOCIATION
a. (Ta-(Tb”-Tc)) A B	*!	
☞ b. (Ta”-(Tb’-Tc)) A A		*

Example: *lu-dao chang* ‘the journey is long’

Input: {{$_{\mathcal{B}}$ 35-35 }-13 $_{\mathcal{A}}$} RO: 13’-13（←$_{A}$ /35-13/）

Output: (13’-(13’-13)) A A > (35-(53’-13)) A B

The reason why {$\mathcal{B}${$\mathcal{A}$}} involves TSB only may be explained in the same fashion. The tone sandhi domain of {B{A}} is ((σσ)σ). Because the tones standing in the inner bracket belong to the $\mathcal{B}$ construction, the tonal base should be the result of TSB. Since TSB tends to change a right-hand tone (i.e., Ta-Tb → Ta-Tb’), to satisfy IDENT-BOT, it is better for the two tones on the right to undergo TSB. If the two tones on the right undergo TSA, which tends to change a left-hand tone (i.e., Tb-Tc → Tb”-Tc) in tone sandhi, the correspondence between the tonal base and the tonal output will be destroyed. (62) illustrates that the attested output derived by applying TSB only (i.e., 62b) is better than the output derived by rules which match the construction types (i.e., 62a).

(62) Construction: {$\mathcal{B}${$\mathcal{A}$}}；tone sandhi domain: ((σσ)σ)
{$_{\mathcal{B}}$ Ta-{Tb -Tc $_{\mathcal{A}}$}} → ((Ta-Tb’)-Tc”) RO: Ta-Tb’（←$_B$ /Ta-Tb/）

((Ta-Tb)-Tc)	IDENT-BOT	ASSOCIATION
a. ((<u>Ta-Tb”</u>)-Tc) B A	*!	
☞ b. ((<u>Ta-Tb’</u>)-Tc”) B B		*

Example: *hen zhuan qian* ‘very lucrative’
Input: {$_{\mathcal{B}}$53-{35-13$_{\mathcal{A}}$}} RO: 53-35（←$_B$ /53-35/）
Output: ((<u>53-35</u>)-53’) > ((<u>53-13’</u>)-13)
B B B A

IDENT-BOT seems to work to explain the cases which exhibit a CONS-TS match as well. Take {{$\mathcal{A}$}$\mathcal{B}$} for example. Since the tone sandhi domain of {{$\mathcal{A}$}$\mathcal{B}$} is ((σσ)σ) and since the tones standing in the inner bracket belong to the $\mathcal{A}$ construction, the tonal base is derived by applying TSA. As TSA tends to change a left-hand tone, to satisfy IDENT-BOT, it is better for the two tones on the right to undergo TSB, as illustrated in (63).

(63) Construction: {{$\mathcal{A}$}$\mathcal{B}$}；tone sandhi domain: ((σσ)σ)

{{$_{\mathcal{A}}$ Ta-Tb}-Tc $_{\mathcal{B}}$} → Ta'-Tb-Tc''   RO: Ta'-Tb（←$_{A}$ /Ta-Tb/）

((Ta-Tb)-Tc)	IDENT-BOT	ASSOCIATION
a. $\underbrace{((\underbrace{\text{Ta'-Tb''}}_{A})\text{-Tc})}_{A}$	*!	*
☞ b. $\underbrace{((\underbrace{\text{Ta'-Tb}}_{A})\text{-Tc''})}_{B}$		

Example: *sha-zhu han* 'butcher'

Input: {{$_{\mathcal{A}}$ 13-13 }-35 $_{\mathcal{B}}$}   RO: 13-13（←$_{A}$ /13-13/）

Output: $\underbrace{((\underbrace{\text{13-13}}_{A})\text{- 13'})}_{B}$ > $\underbrace{((\underbrace{\text{13-31'}}_{A})\text{-35})}_{A}$

A summary of how IDENT-BOT may serve to predict the CONS-TS matches/mismatches is given in (64). The analysis presented so far suggests that tonal outputs tend to be more like the tonal bases with which they prosodically relate, even though the maximization of identity would lead to a CONS-TS mismatch.

(64)

Structure	*Tone sandhi domain & Reference Output*	*Output*	IDENT-BOT	ASSOCIATION
{{𝒜}𝒜}	(σ(σσ)) RO: Tb’-Tc（← A /Tb-Tc/）	☞a. (Ta”-(Tb’-Tc)) A A		
		b. (Ta-(Tb”-Tc)) B A	* !	
{𝒜{𝒜}}	(σ(σσ)) RO: Tb’-Tc（← A /Tb-Tc/）	☞a. (Ta”-(Tb’-Tc)) A A		
		b. (Ta-(Tb”-Tc)) B A	* !	
{{ℬ}ℬ}	((σσ)σ) RO: Ta-Tb’（← B /Ta-Tb/）	☞a. ((Ta-Tb’)-Tc”) B B		
		b. ((Ta-Tb”)-Tc) B A	* !	
{ℬ{ℬ}}	((σσ)σ) RO: Ta-Tb’（← B /Ta-Tb/）	☞a. ((Ta-Tb’)-Tc”) B B		
		b. ((Ta-Tb”)-Tc) B A	* !	
{{𝒜}ℬ}	((σσ)σ) RO: Ta’-Tb（← A /Ta-Tb/）	☞a. ((Ta’-Tb)-Tc”) A B		
		b. ((Ta’-Tb”)-Tc) A A	*!	
{𝒜{ℬ}}	(σ(σσ)) RO: Tb-Tc’（← B /Tb-Tc/）	☞a. (Ta”-(Tb-Tc’)) A B		
		b. (Ta-(Tb”-Tc’)) B B	* !	

{{ℬ}𝒜}	(σ(σσ)) RO: Tb'-Tc（← A /Tb-Tc/）	☞a. (Ta"-(Tb'-Tc)) A A		*
		b. (Ta-(Tb"-Tc)) B A	* !	
{ℬ{𝒜}}	((σσ)σ) RO: Ta-Tb'（← B /Ta-Tb/）	☞a. ((Ta-Tb')-Tc") B B		*
		b. ((Ta-Tb")-Tc) B A	* !	

Though the account based on Prosodic Correspondence seems rather straight forward, it has some limitations. First, the analysis presented above assumes that tones undergoing changes are on the left in TSA and on the right in TSB. Though the assumption generally holds, there are exceptions in TSB. As mentioned, a left-hand 13 tone is allowed to change before 53 and 13 in TSB. Thus, IDENT-BOT may fail to make the correct prediction when a tri-syllabic string involves a 13-13 or 13-53 combination in a ℬ construction. This can be illustrated by the example in (65).

(65) Construction: {{ℬ}𝒜}；tone sandhi domain: (σ(σσ))
{{ℬ 13-53 }-13 𝒜} → (35'-(53-13)) RO: 53-13（← A /53-13/）

Example: *jian-bang kuan* 'wide shoulders'

(13-(53-13))	IDENT-BOT	ASSOCIATION
💣 a. (31'-(53-13)) B A		
b. (35'-(53-13)) A A		*!

In (65), both candidates (a) and (b) fully satisfy IDENT-BOT. Candidate (a) does not violate IDENT-BOT because the two tones on the left (i.e., /13-53/) which undergo TSB involve an unusual alternation of a left-hand tone. Thus, candidates (a) and (b) tie in the IDENT-BOT constraint. Nonetheless, when it comes to ASSOCIATION, the attested output (b) is incorrectly ruled out because the two tones on the left, which belong to the $\mathcal{B}$ construction, undergo TSA.

In addition, there is another potential problem with an analysis that attributes the mismatches to IDENT-BOT. In Pingyao, a tonal combination of different construction types may surface with different sandhi forms. Sometimes, the outputs may even be different in that one involves tone sandhi while the other does not. (For instance, /13-13/ undergoes tone sandhi [changes to 31’-35’] when it is of a $\mathcal{B}$ construction but remains unchanged [i.e., 13-13] when it is of an $\mathcal{A}$ construction.) These combinations are also potentially problematic to the proposed analysis because the IDENT-BOT >> ASSOCIATION predicts that CONS-TS match can be sacrificed to maximize the tonal correspondence between the tonal bases and the tonal outputs. Thus, the best way to satisfy IDENT-BOT is for the tri-tonal string to undergo as few tonal alternations as possible. Let us consider tone sandhi in $\{\mathcal{B}\{\mathcal{B}\}\}$. As mentioned, when the structure is $\{\mathcal{B}\{\mathcal{B}\}\}$, there is a perfect CONS-TS match; in other words, only TSB will take place in the tri-tonal sequence of such a construction. However, as shown in (66), given an input of /53-13-13/, IDENT-BOT will favor the /13-13/ sequence to undergo TSA because /13-13/ does not change any of its tones when undergoing TSA and changes both of the tones when undergoing TSB. The change of a left-hand tone will violate IDENT-BOT.

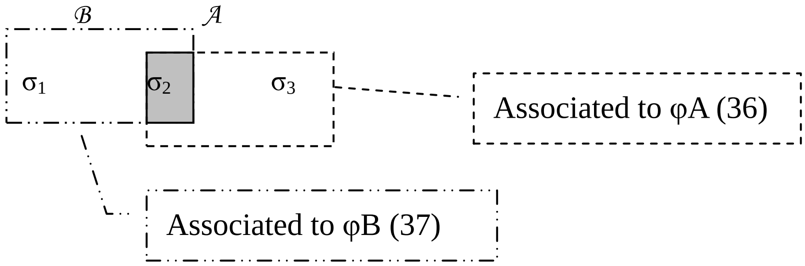
(66) Construction: {$\mathcal{B}${$\mathcal{B}$}}；tone sandhi domain: ((σσ)σ)
{$_{\mathcal{B}}$ 53-{13-13 $_{\mathcal{B}}$}} → ((53-31')-35') RO: 53-13（←$_B$ /53-13/）
Example: *yan jie-mao* 'eyelashes'

((53-13)-13)	IDENT-BOT	ASSOCIATION
a. $((\underline{53\text{-}13})_B\text{-}13)$ with $(53\text{-}13)\text{-}13$ underlined as A		*
💣 b. $((\underline{53\text{-}31'})_B\text{-}35')$ with $(53\text{-}31')\text{-}35'$ underlined as B	*!	

The discussion above shows that while IDENT-BOT can correctly predict some cases, it can also result in wrong predictions in others. Therefore, IDENT-BOT can not be the cause of the mismatches and it must rank lower than ASSOCIATION to avoid wrong predictions (e.g., 66).

Attaining better tonal output in terms of markedness or faithfulness is shown not to be the cause of the CONS-TS mismatch. As the CONS-TS mismatch is restricted to $\mathcal{BA}$ constructions, it could be some properties rooted in the $\mathcal{BA}$ construction that result in the mismatch. It is proposed that the mismatch occurs because the $\mathcal{BA}$ construction is marked in two respects. First, it is composed of two construction types, the $\mathcal{A}$ construction and the $\mathcal{B}$ construction; if a tri-syllabic string of such construction applied tone sandhi according to its construction types, the string would undergo two different types of tone sandhi, TSA and TSB. As mentioned, each Pingyao tri-syllabic string has two bi-tonal windows; if a tri-syllabic string undergoes two types of tone sandhi, the syllable in the middle (i.e., σ_2) will be evaluated by the constraint hierarchies of both φA and φB. Since φA and φB are different grammars that exhibit conflict rankings among certain constraints, it would be a marked situation if a single syllable were to be associated to different grammars and to be evaluated by conflicting rankings. The *MULTIPLE constraint in (68) is thus proposed to prohibit such a situation.

(67) ℬ𝒜 structure



(68) *MULTIPLE: A syllable cannot be associated to two cophonologies.

It is worth noting that the 𝒜ℬ construction is also composed of two construction types and intrinsically violates *MULTIPLE. However, it does not have the second marked property of a ℬ𝒜 construction. As (43) shows, when the construction is ℬ𝒜, there is a misalignment between tone sandhi domain and the morphosyntactic structure: when ℬ𝒜 is morphosyntactically left-branching (i.e., {{ℬ}𝒜}), the tone sandhi domain is right-branching [i.e., (ℬ(𝒜))] ; when ℬ𝒜 is morphosyntactically right-branching (i.e., {ℬ{𝒜}}), the tone sandhi domain is left-branching [i.e., ((ℬ)𝒜)]. In other words, ℬ𝒜 construction violates ALIGNPS/MS. The tone sandhi domain in 𝒜ℬ constructions, on the other hand, perfectly aligns with the morphosyntactic structure: when it is morphosyntactically left-branching (i.e., {{𝒜}ℬ}), the tone sandhi domain is also left-branching [i.e., ((𝒜)ℬ)] ; when it is morphosyntactically right-branching (i.e., {𝒜{ℬ}}), the tone sandhi domain is right-branching [i.e., (𝒜(ℬ))]. Prosodic structures that misalign with morphosyntactic structures are certainly marked. However, ALIGNPS/MS is violable in Pingyao (it is violated in {{𝒜}𝒜} and {ℬ{ℬ}}). It turns out that the individual violation of *MULTI and ALIGNPS/MS is not severe enough to cause the CONS-TS mismatch. 𝒜ℬ violates *MULTI and {{𝒜}𝒜} and {ℬ{ℬ}} violate ALIGNPS/MS, yet they all have a perfect CONS-TS match. It is the violation of both constraints that is fatal. The conjoint constraint in (69) is proposed (constraint conjunction; Smolensky 1993).

(69) [*MULTI & ALIGNPS/MS]$_{FT}$: *MULTI and ALIGNPS/MS cannot be both violated in a foot.

Thus, the reason tone sandhi in *BA* chooses not to fully follow the construction type is to avoid violating [*MULTI & ALIGNPS/MS]$_{FT}$.

It is interesting to know that it is also the need to satisfy [*MULTI & ALIGNPS/MS]$_{FT}$ that causes the CONS-TS mismatch in Changsha tri-tonal sandhi (cf. 58). Just as in Pingyao, the directionality in Changsha tri-tonal sandhi is also insensitive to morphosyntactic structures. In *AA* and *BA* constructions, tone sandhi applies left-to-right, and in *BB* and *AB* constructions, tone sandhi applies right-to-left. In other words, the tone sandhi domain is left aligned in *AA* and *BA* and right aligned in *BB* and *AB*, as summarized in (70). (70) also shows that CONS-TS mismatches occur only when the construction is {*B*{*A*}} or {{*A*}*B*}; these two constructions are the only constructions that violate both *MULTI and ALIGNPS/MS.

(70) *Construction sensitivity in Changsha tri-tonal sandhi vs.* *MULTI *and* ALIGNPS/MS

Construction	*Directionality*	*TS domain*	*CONS-TS matching*	*Violate* *MULTI	*Violate* ALIGNPS /MS
$\{\{\mathcal{A}\}\mathcal{A}\}$	⇨	((σσ)σ)	yes		
$\{\mathcal{A}\{\mathcal{A}\}\}$			yes		✓
$\{\{\mathcal{B}\}\mathcal{B}\}$	⇦	(σ(σσ))	yes		✓
$\{\mathcal{B}\{\mathcal{B}\}\}$			yes		
$\{\{\mathcal{B}\}\mathcal{A}\}$	⇨	((σσ)σ)	yes	✓	
$\{\mathcal{B}\{\mathcal{A}\}\}$			No (only TSA applies)	✓	✓
$\{\{\mathcal{A}\}\mathcal{B}\}$	⇦	(σ(σσ))	No (only TSB applies)	✓	✓
$\{\mathcal{A}\{\mathcal{B}\}\}$			yes	✓	

Moving back to Pingyao, there are two possible ways for a $\mathcal{BA}$ construction to escape the violation of [*MULTI & ALIGNPS/MS]$_{\text{FT}}$: one is to modify the tone sandhi domain to make it match the morphosyntactic structure, the other is to apply only one type of tone sandhi. It is the second option that is adopted. This suggests that the three constraints that are crucial in predicting the tone sandhi domain (i.e., ||{PARSESYLL, ALLFTHD, BINBRAN}||) must still rank high and ASSOCIATION must be outranked by

[*MULTI & ALIGNPS/MS]$_{Ft}$ to predict the CONS-TS mismatch. Further, *MULTI must be dominated by ASSOCIATION to capture the fact that tone sandhi in $\mathcal{AB}$ constructions is still fully conditioned by the construction type.

One last point worth discussing is how the choice of which tone sandhi rule to apply is made when there is a CONS-TS mismatch. In other words, which bi-tonal window is tolerated the CONS-TS mismatch? In {{$\mathcal{B}$}$\mathcal{A}$}, since only TSA applies, the CONS-TS match is bad in the left bi-tonal window but good in the right bi-tonal window. {$\mathcal{B}${$\mathcal{A}$}} is the mirror image of {{$\mathcal{B}$}$\mathcal{A}$}. In {$\mathcal{B}${$\mathcal{A}$}}, though the CONS-TS match fails in the right bi-tonal window because only TSB applies, the two-tone window on the left actually has a good CONS-TS match. The tone sandhi domain of {{$\mathcal{B}$}$\mathcal{A}$} is right aligned [i.e., ($\mathcal{B}$($\mathcal{A}$))], and that of {$\mathcal{B}${$\mathcal{A}$}} is left aligned [i.e., (($\mathcal{B}$)$\mathcal{A}$)]. In both cases, there is a good CONS-TS match in the inner prosodic foot. This suggests the CONS-TS association in the base is preserved in the output, as illustrated in (71a) and (71b) below:

(71)

(a) {{$\mathcal{B}$}$\mathcal{A}$} structure

(**G**rammatical construction)

(**B**i-tonal window)

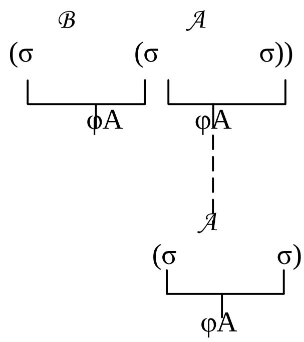
(**T**ype of tone sandhi)

Reference Output

(**G**rammatical construction)

(**B**i-tonal window)

(**T**ype of tone sandhi)



(b) {{ℬ}𝒜} structure

(**G**rammatical construction) ℬ 𝒜
((σ σ) σ)
(**B**i-tonal window)
(**T**ype of tone sandhi) φB φB

Reference Output
(**G**rammatical construction) ℬ
(σ σ)
(**B**i-tonal window)
(**T**ype of tone sandhi) φB

This can be captured by the IDENT-BOA constraint in (71).

(72) IDENT-BOA: The CONS-TS association in the prosodically related bases and outputs must be identical.

For other grammatical constructions such as 𝒜𝒜, ℬℬ, and 𝒜ℬ, since they obey ASSOCIATION, they automatically obey IDENT-BOA.

(73) and (74) illustrate how ||{PARSESYLL, ALLFTHD, BINBRAN} >> { [*MULTI & ALIGNPS/MS]$_{FT}$, IDENT-BOA } >> ASSOCIATION >> *MULTI|| accounts for tone sandhi in ℬ𝒜 and 𝒜ℬ. For simplicity, the three dominant constraints ||PARSESYLL, ALLFTHD, BINBRAN|| are omitted and only output candidates with correct tone sandhi domains are considered.

(73) $\mathcal{B}\mathcal{A}$

{{$\mathcal{B}$}$\mathcal{A}$} Domain: (σ(σσ)) RO: (<u>σσ</u>) | φA	[*MULTI & ALIGNPS/ MS]$_{Ft}$	IDENT-BOA	ASSOCIA-TION	*MULTI
a. (σ (σ σ)) A B	*!			*
b. (σ (σ σ)) B A	*!	*	**	*
c. (σ (σ σ)) B B		*!	*	
☞ d. (σ (σ σ)) A A			*	
{$\mathcal{B}${$\mathcal{A}$}} Domain: ((σσ)σ) RO: (<u>σσ</u>) | φB				
a. ((σ σ) σ) B A	*!			*
b. ((σ σ) σ) A B	*!	*	**	*
c. ((σ σ) σ) A A		*!	*	
☞ d. ((σ σ) σ) B B			*	

(74) 𝒜ℬ

{{𝒜}ℬ} Domain: ((σσ)σ) RO: (σσ) | φA	[*MULTI & ALIGNPS /MS]$_{Ft}$	IDENT-BOA	ASSOCIA-TION	*MULTI
a. ((σ σ) σ) B A		*!	**	*
b. ((σ σ) σ) B B		*!	*	
c. ((σ σ) σ) A A			*!	
☞ d. ((σ σ) σ) A B				*

{𝒜{ℬ}} Domain: (σ(σσ)) RO: (σσ) | φB	[*MULTI & ALIGNPS /MS]$_{Ft}$	IDENT-BOA	ASSOCIA-TION	*MULTI
a. (σ (σ σ)) A B		*!	**	*
b. (σ (σ σ)) A A		*!	*	
c. (σ (σ σ)) B B			*!	
☞ d. (σ (σ σ)) B A				*

5. CONCLUSION

This paper examines tone sandhi in Pingyao which is special in having differing construction sensitivity in bi-tonal and tri-tonal sandhi. Bi-tonal sandhi is construction sensitive; thus, it is proposed that the two main construction types, construction *A* and construction *B*, have their own associated phonologies that differ in the relative ranking of certain constraints. The differences in the constraint ranking between positional faithfulness constraints and the markedness constraint, for instance, result in the different tonal alternations in the different construction types. The domination of both positional faithfulness constraints (i.e., IDENT-IO-T-HD(Hr), IDENT-IO-T-HD(Lr)) over the markedness constraints in φA predicts the absolute stability of a head tone in the *A* construction while the domination of markedness constraints over IDENT-IO-T-HD(Lr) in φB predicts the stability of a Hr, but not a Lr, tone at the head position of a *B* construction.

While tone sandhi always matches the construction type in bi-tonal sandhi, tone sandhi is not conditioned by the construction type in tri-syllabic strings in a *BA* construction. The mismatch as observed in the *BA* construction suggests that the association between construction type and construction-specific grammar, which is generally assumed to be automatic and exceptionless in the literature, should be considered as a violable OT constraint which may be sacrificed to achieve a higher goal. It is argued that the mismatch occurs in the *BA* construction because a *BA* constructions is marked in two respects—it invites tone sandhi of a different nature to apply on overlapping sequences (violating *MULTI) and it has a marked tone sandhi domain, a domain that is not morphosyntactically conditioned (violating ALIGNPS/MS). As the combination of the two marked properties is too severe, the *BA* structure chooses to repair it by operating only one type of tone sandhi, resulting in the mismatch between tone sandhi and construction type (violating ASSOCIATION). The CONS-TS mismatch is thus properly captured by the domination of [*MULTI & ALIGNPS/MS]$_{FT}$ over ASSOCIATION.

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Hui-shan Lin
Department of English
National Taiwan Normal University
hslin@ntnu.edu.tw

平遙方言的連讀變調現象：優選理論的分析

林蕙珊
國立臺灣師範大學

本文從音韻學的觀點來分析平遙方言的連讀變調現象。平遙方言連讀變調有兩大特點：（一）在二字組部份，平遙方言連讀變調深受詞法關係（grammatical relation）影響。（二）在三字組部份，平遙方言連讀變調仍受詞法關係影響，只是詞法關係和變調規則時有不搭配的狀況；此外，三字組連讀變調方向和構詞句法結構（morpho-syntactic structure）關聯不大，而主要受到詞法關係規範。本文以優選理論（Optimality Theory）來分析平遙方言的連讀變調。在二字組部份，本文提出兩組並存音韻理論（co-phonology）來處理不同詞法關係的連讀變調。在三字組部份，本文指出，造成詞法關係和變調規則不搭配的主要原因，是為了避免變調範疇已不受構詞句法結構規範的詞組又同時對應到不同的並存音韻理論。

關鍵字：平遙方言，連讀變調，優選理論，詞法關係，變調方向