Identity Preservation in Hakha-Lai Tone Sandhi

哈卡倈語的變調對應性

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IDENTITY PRESERVATION IN HAKHA-LAI TONE SANDHI*

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ABSTRACT

This paper examines the tone sandhi phenomenon in the Tibeto-Berman language of Hakha-Lai, which is special for the complex interactions among its elementary rules. The rule interactions in Hakha-Lai lead to both left-to-right and right-to-left rule directionalities in sequences of three or more tones. The rule application directionalities, however, appear to be ungoverned, as none of the principles proposed to date that may contribute to determining directionalities can account for them. In this paper, I argue that the tone sandhi operation directionalities in Hakha-Lai are by no means ungoverned. Normally tone sandhi operates from right to left for identity reasons. This is forced by the IDENT-BOT constraint. The right-to-left direction is sacrificed only when such direction would result in output forms that contain marked sequences or tonal changes at the prominent position, which are forbidden by $_{U}$[AGREE-t and IDENT-IO-T-L respectively. Thus, the directionalities of tone sandhi operation in Hakha-Lai are naturally predicted by the interaction of the IDENT-BOT constraint, the $_{U}$[AGREE-t constraint, and the IDENT-IO-T-L constraint, where IDENT-BOT must be dominated by the latter two constraints.

1. INTRODUCTION

This paper examines the tone sandhi phenomenon in Hakha-Lai, which is a Kuki-Chin language spoken in Chin State, Burma, and parts

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of Mizoram State, India. Hakha-Lai tone sandhi was first thoroughly studied in Hyman and VanBik (2004) and was shown to pose great challenges to existing phonological theories, including the rule based derivational theory and the output-driven constraint based Optimality Theory (OT). The central problem of Hakha-Lai, according to Hyman and VanBik (2004), is rooted in the right-to-left directionality of one of its elementary rules in sequences of three or more tones. That the directionality is hard to predict is due to the fact that the outputs generated by such directionality would violate the very phonological constraint that motivates the tonal alternations in the language. In view of the failure of existing phonological theories in respect to Hakha-Lai tone sandhi, Hyman and VanBik (2004) proposed a Direct-Mapping analysis that crucially relies on three language specific rules which directly map specific inputs onto their corresponding outputs and are ranked in a way similar to OT constraints. This analysis, though quite simple, does not explain the motivation behind the problematic right-to-left rule application directionality.

In the present study, the tone sandhi phenomenon in Hakha-Lai is re-examined in depth, with the aim to uncover the conspiracy behind the directionality of rule application. Re-examination of Hakha-Lai tone sandhi shows that the interactions among the elementary rules in Hakha-Lai lead not only to right-to-left, but also to left-to-right rule application directionalities in sequences of three or more tones. The application directionalities seem to be ungoverned, as none of the principles proposed to date, such as Structure Affinity, Temporal Sequence, Derivational Economy, Transparency, Wellformedness and Simplicity (Chen 2004) that may contribute to determining directionalities could account for them (see discussions in §2). Nonetheless, I will show that an OT analysis not only accounts in a properly manner for the language data, but also discloses the conspiracy behind the seemingly unpredictable directionalities. I argue that the operation directionalities of tone sandhi in Hakha-Lai are triggered by an Identity Effect. In Hakha-Lai, tonal outputs tend to be identical to the tonal bases to which they prosodically correspond. This is captured by an Output-to-Output correspondence constraint. The satisfaction of the constraint causes tone sandhi to operate in a right-to-left direction. However, if the correspondence of the two forms (i.e. the output and the base) would result in highly marked forms, which is captured by the positional markedness constraint, or forms that involve tonal changes at the prominent position, which is captured by the positional faithfulness constraint, Identity Effect would be sacrificed and in that case, the operation directionality of tone sandhi would change. Thus, the directionalities are naturally predicted by the interaction of the Output-to-Output correspondence constraint, the positional markedness constraint, and the positional faithfulness constraint, where the Output-to-Output correspondence constraint must be outranked by the latter two constraints.

The paper is organized as below. After presenting the tonal facts of Hakha-Lai 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 Hakha-Lai tone sandhi where I show that the rule application directionalities in Hakha-Lai are highly correlated to the preservation of identity between prosodically related tonal outputs. §5 concludes this paper.

2. DATA AND GENERALIZATION

There are three tones in Hakha-Lai. They are falling (HL), rising (LH) and low (L). In Hakha-Lai, tone bearing units are bimoraic. Thus, mono moraic words such as *ka* 'my' are toneless.

Like many tonal languages, Hakha-Lai tones undergo tone sandhi in certain positions. In the phrase initial position, an underlying /LH/ tone is changed to [HL]. This can be shown in (1). In (1), the contrast between /LH/ and /HL/ is preserved when they occur after the toneless morpheme *ka* 'my', but is neutralized when they occur in the phrase initial position. (All examples of Hakha-Lai are from Hyman and VanBik (2002a, 2002b, 2004); sandhi tones are in boldface hereafter.)

(1)

a. /LH/:	*ka kee*[LH] 'my leg'	vs.	*kee*[**HL**] 'leg'
b. /HL/:	*ka hmaa*[HL] 'my wound'		*hmaa*[HL] 'wound'

Hyman and VanBik (2004) propose that there is a floating H tone (transcribed as %H) in the phrase initial position. The floating H tone causes the following LH tone to undergo tonal change. That is:

(2) Initial Rising

%H.LH → %H.**HL**

In addition to Initial Rising, tone sandhi occurs when tones are adjacent to certain concrete (as opposed to floating) tones. This can be exemplified by the bi-tonal combinations below. The combinations are given after the toneless *ka* ‘my’ below to avoid the application of the initial R rule.

(3) ‘my mountain beer’

	ka tlaaŋ.zuu
Base tone	HL.HL
Sandhi tone	HL.**L**

(4) ‘my corn beer’

	ka koom.zuu
Base tone	L.HL
Sandhi tone	L.**L**

(5) ‘my grave time’

	ka thlaan.tsaan
Base tone	LH.LH
Sandhi tone	LH.**HL**

(6) ‘my grave animal’

	ka thlaan.saa
Base tone	LH.L
Sandhi tone	**L**.L

The bi-tonal changes are summarized in the following table:

(7)

1st tone	2nd tone		
	HL	LH	L
HL	HL.**L**		
LH		LH.**HL**	**L**.L
L	L.**L**		

The tonal changes illustrated above can be captured by the following four derivational rules:

(8)

a. Initial R(ising) Rule: LH → HL/ %H__
b. FL rule: HL → L / {HL,L}__
c. RF rule: LH→HL/ LH __
d. RL rule: LH→L/ __ L

Notice that in Hakha-Lai, except for the /LH.L/ sequence, it is the right tone, rather than the left tone of a sequence that undergoes tone sandhi. This condition is very different from that in some Chinese dialects such as Beijing Mandarin, Southern Min, Tianjin, Sixian-Hakka, and Boshan, which tend to maintain the identity of the rightmost tone in tone sandhi while allowing tones to change in the other positions. In the literature, languages that tend to preserve the identity of the rightmost tone, while allowing various modifications on the non-final tones in sandhi contexts, are normally regarded as right prominent languages, and those that tend to preserve the leftmost tone, while allowing tones in other positions to change, are regarded as left prominent languages (Chen 2000, Yip 2002a, Hyman and VanBik 2004, among others). Thus, Hakha-Lai, unlike Beijing Mandarin, Southern Min, Sixian-Hakka, Tianjin and Boshan, is a left prominent language.

(9) Hakha-Lai as a left prominent language

a.	left prominent T.T → T.**T**	Hakha-Lai, Chengdu
b.	right prominent T.T → **T**.T	Beijing Mandarin, Southern Min, Sixian-Hakka, Tianjin, Boshan

(Key: **T** = sandhi tone; T = base tone)

Consider now tone sandhi in multi-tonal combinations. In Hakha-Lai, tone sandhi in multi-tonal strings is based on tone sandhi in bi-tonal sequences. Thus, the question concerning which two tones in multi-tonal strings should be scanned first for tonal changes may be raised. 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. (10a). 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. (10b). In (10a), it appears as if tone sandhi has operated in the direction of left-to-right; in (10b), tone sandhi can be regarded as operating from right to left.

(10) Underlying Tone: /Ta.Tb.Tc/
Tone Sandhi Rule: Ta → **Ta**/ __ Tb
Tb → **Tb**/ __ Tc

Left-to-right ⇨	Right-to-left ⇦
(a) Ta.Tb.Tc | **Ta**.Tb.Tc | **Ta**.**Tb**.Tc	(b) Ta.Tb.Tc | 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

In multi-tonal strings of Hakha-Lai, both left-to-right and right-to-left operation directionalities are observed. As shown in (11), while the tonal outputs of (P1)-(P4) are derived by operating tone sandhi from right to left, those of (P5) and (P6) are derived by operating tone sandhi from left to right.

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

a. ⇦	(P1) %H.LH.LH → %H.LH.**HL** → %H.**HL.HL** (P2) %H.LH.HL (n/a) → %H.LH.HL → %H.**HL.**HL (P3) *ka* LH.LH.LH → *ka* LH.LH.**HL** → *ka* LH.**HL.HL** (P4) *ka* LH.LH.LH.LH →*ka* LH.LH.LH.**HL**→ *ka* LH.LH.**HL.HL** →*ka* LH.**HL.HL.HL**
b. ⇨	*(P1) %H.LH.LH → *%H.**HL**.LH* *(P2) %H.LH.HL →%H.**HL**.HL → *%H.**HL.L*** *(P3) ka LH.LH.LH → *ka LH.**HL**.LH* *(P4) ka LH.LH.LH.LH → ka LH.**HL.**LH.LH (n/a)→ka LH.**HL.**LH.LH* *→ *ka LH.**HL.**LH.**HL***

(12) Tone sandhi must apply left-to-right in (P5) and (P6)

a.	(P5) *ka* <u>LH.LH</u>.L → LH.**HL**.L
⇨	(P6) <u>%H.LH</u>.L → %H.**HL**.L
b.	*(P5) ka LH.<u>LH.L</u> → <u>LH.**L**</u>.L → *__L.L__.L*
⇦	*(P6) %H.<u>LH.L</u> → *%H.**L**.L*

Consider (P1) for instance. In (P1), the output must be derived by operating tone sandhi rules on /%H.LH.LH/ from right to left, as the resultant output of a left-to-right operation (i.e. %H.**HL**.LH) is unattested. Since both left-to-right and right-to-left directionalities are observed in Hakha-Lai, the question concerning what determines toward which direction tone sandhi should operate would naturally arise.

To date, there are six general principles that are proposed to be the possible criteria that govern the rule application directionalities. They are Temporal Sequence, Structure Affinity, Derivational Economy, Transparency, Simplicity, and Welformedness (Chen 2004). Temporal Sequence refers to the temporal sequence of speech organization and thus prefers the left-to-right directionality. Structure Affinity refers to cyclicity following syntactic bracketing. Derivational Economy refers to the choice of the shortest derivational path, and thus prefers bleeding and counterfeeding. Transparency, on the other hand, prefers feeding and bleeding. Simplicity prefers simple (level) to complex (contour) tones. Finally, Wellformedness prefers a derivation that yields unmarked tonal combinations. Here below, I show that none of them can predict the tone sandhi operation directionality in Hakha-Lai.

Consider first Temporal Sequence which prefers the left-to-right directionality. Obviously, the directionalities of rule application in Hakha-Lai cannot be governed by the principle of Temporal Sequence as both left-to-right and right-to-left rule application directionalities are observed in patterns (1) to (6).

Consider next the principle of Structure Affinity. In Hakha-Lai, directionality of rule application is insensitive to the morpho-syntactic structures of the utterance. For example, as shown above in (11), the output of a non-phrase initial LH.LH.LH string (i.e. P3) is derived by a right-to-left direction. However, as demonstrated below, the resultant output of a non-phrase initial LH.LH.LH is the same LH.**HL.HL,** no matter whether the morpho-syntactic bracketing is mixed, as in (13) or left branching, as in (14).

(13) ‘My night-time friend’
{*ka* {{*zaan tsaan*} *kooy*}}
LH. LH. LH → LH.**HL.HL**

(14) ‘if it isn’t (the case)’
it is NEG if
{{{ *ʔa* *sii*} *law*} *lee*}
LH. LH. LH → LH.**HL.HL**

Notice that the phenomena where the tone sandhi operation directionalities are unpredictable by the morpho-syntactic structures, though less common, are by no means unique to Hakha-Lai. They are also observed in some Chinese dialects such as Tianjin (Chen 2000, Lin 2003, 2005c), Boshan (Chen 2000, Lin 2004b), and Chengdu (Lin 2005a, 2005b). These languages/dialects are referred to as morphosyntactically insensitive languages in the present study.

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. Although it is true that the attested output of (P5) (i.e. (15a)) are derived by shorter derivational paths than the unattested outputs (i.e. (15a’)), the attested outputs of (P1) and (P3) (i.e. (15b’)) are derived by longer derivational paths.

(15)

More Economic		Less Economic	
a. ⇨	(P5) *ka* LH.LH.L → LH.**HL**.L	*a’.* ⇦	*(P5) ka LH.LH.L → LH.**L**.L → *L.L.L*
b. ⇦	*(P1) %H.LH.LH → *%H.**HL**.LH* *(P3) kaLH.LH.LH → *****kaLH.**HL**.LH*	b’. ⇨	(P1) %H.LH.LH → %H.LH.**HL** → %H.**HL.HL** (P3) *ka* LH.LH.LH → *ka* LH.LH.**HL** → *ka* LH.**HL.HL**

Transparency prefers transparent outputs to opaque outputs. Opaque outputs can be categorized into two types, outputs that are non-surface-true and outputs that are 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; in other words, there are impermissible forms at surface. On the other hand, a generalization is non-surface-apparent if the structure description of a rule application is not recoverable at the surface level; in other words, there are unconditioned changes at surface. Transparency also fails to predict the tonal changes in Hakha-Lai tone sandhi because as exemplified below, the attested outputs of (P1) and (P2), which are derived by a right-to-left directionality, are opaque. That is because both (P1) and (P2) contain the tonal sequence HL.HL, which is not a possible output in bi-tonal sequence (see §4.1 for more discussion on opacity).

(16)

	Opacity		Transparency	
	⇦		⇨	
	Input	*Output*	*Input*	*Output*
P1	%H.LH.LH	%H.**HL.HL**	*%H.LH.LH*	**%H.**HL**.LH*
P2	%H.LH.HL	%H.**HL.**HL	*%H.LH.HL*	**%H.**HL.L***

The impermissible sequences observed in (P1) and (P2) also automatically make the principle of Wellformedness, which prefers a derivation that yields unmarked tonal combinations, impossible to govern the tonal changes.[1]

Finally, consider the principle of Simplicity. Simplicity prefers level tones to contour tones. As shown below, the principle of Simplicity still fails because in (P5), the unattested output derived by a right-to-left directionality contains more level tones than the attested one.

(17)

	Less Level Tones		More Level Tones	
	⇨		⇦	
	Input	*Output*	*Input*	*Output*
P5	*ka* LH.LH.L	*ka* LH.**HL**.L	*ka* LH.LH.L	*****L.L****.L*

In sum, none of the six principles proposed to date that may contribute to determining directionalities can account for the rule

[1] Although there is an overlapping between the criteria of Transparency and Wellformedness, the two criteria should not be mixed. That is because although transparent outputs are always wellformed, wellformed outputs are not necessarily transparent. Some opaque outputs (particularly non-surface-apparent outputs) could be wellformed. (ref. Lin 2004b, Lin 2005b).

application directionalities in Hakha-Lai. The failure of the six principles seems to suggest that the directionalities in Hakha-Lai tone sandhi are unpredictable. Nonetheless, I will show in §4 that the seemingly unpredictable directionalities are naturally predicted by the interaction of a set of universal constraints.

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 Hakha-Lai tone sandhi.

3.1 Prosodic Correspondence (Lin 2005d)

Based on observations of tone sandhi in Beijing Mandarin and Sixian-Hakka, in Lin (2005d), 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 is illustrated below:

(18) Correspondence Model for Tone Sandhi (Lin 2005d)

Input Tone　　　**I**nput Tone

Tb　Tc　　　Ta　Tb　Tc

↓　　　　↓ IO-Faith

(<u>Tb’　Tc’</u>) ⟶ (Ta” (<u>Tb”　Tc”</u>))

Base **T**one　　　**O**utput **T**one

BOT-**I**DENTITY

Key: ‘(…)’ = 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 morpho-syntactic structures. Forms related in the prosodic structures are capable for correspondence evaluation because prosodic units are cognitively real units as they 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). 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 (18), the Tb".Tc" in (Ta".(Tb".Tc")) and the base 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 with any freestanding segments. For example, in the correspondence schema in (19), the tonal base is a freestanding tonal sequence that shares the tonal 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 need not be part of the segmental output to which the tonal output associates. Thus, while the tonal base **LH**.L may be associated with *shui.guo* 'fruit', the tonal output L.**LH**.L may be associated with *xiao.yu.san* 'small umbrella', even though the segmental information of 'fruit' and 'small umbrella' is completely different. Such claim has its basis on the autosegmental status of tone, as tonal processes are often observed to take place without paying respect to the information in the segmental level.[2]

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[2] Studies on tone sandhi in nonsense words also support this view. As shown below, tone sandhi takes place in nonsense words.

Tone sandhi in nonsense words

a. *huo*L.*qu*L → *huo***LH**.*qu*L
   fire get
b. *huo*L.*qu*L.*ji*L → *huo***LH**.*qu***LH**.*ji*L
   fire get self

Since nonsense words provide no information as to the lexicon, tone sandhi observed in nonsense words proves that tonal changes pay little or no attention to the lexical information.

In the speech perception experiment carried out by Speer, Shih, and Slowiaczek (1989), it is shown that listeners are able to predict tone sandhi even without input from lexical

(19) Correspondence schema in Beijing Mandarin (Lin 2005d)

Input Tone		**I**nput Tone	
L. **L**		**L**. **L**. **L**	IO-Faith
(**L**.**H**.**L**)	→	(**L**.(**L**.**H**.**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-**I**DENTITY

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

(20) IDENT-BOT: Corresponding tones in the prosodically related bases and outputs must be identical. (Lin 2005d)

The prosodic correspondence model and the IDENT-BOT constraint reflect 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 observed in the tone sandhi phenomena in Beijing Mandarin and Sixian-Hakka (Lin 2005d), in Boshan (Lin 2004b), in Chengdu (Lin 2005a, b), as well as in Tianjin (Lin 2003, 2005c). In this paper, I will show that identity preservation also plays an important role in Hakha-Lai. The seemingly unpredictable directionalities of tonal operation in Hakha-Lai can be attributed to the desire of identity maximization

words half of the times.

between prosodically related outputs and are properly accounted for by the interaction of the IDENT-BOT constraint and the markedness constraints.

3.2 Prosodic Domain for Hakha-Lai

In dealing with tone sandhi (no matter whether in a rule-based analysis or in a constraint-based analysis), one of the most important things is to determine the domain within which tone sandhi operates (Shih 1986, Chen 1987, Hsiao 1991, Lin 2000b, among others). Once the domain is determined, tone sandhi can be accounted for. In the literature, there are basically two approaches as to how the tone sandhi domain may be defined. One approach contends that tone sandhi directly operates on the morpho-syntactic structures (Chen 1987a, Lin J. 1994, among others). The other contends that tone sandhi should not operate directly on the morpho-syntactic structures and that the tone sandhi domain should be a kind of prosodic structure which mediates between syntax and phonology. (Shih 1986, Hsiao 1995, Lin 2000b, among others). As shown in §2, the operation of tone sandhi in Hakha-Lai is insensitive to the morpho-syntactic structures. Thus, the tone sandhi domain cannot be determined based on the morpho-syntactic structures. In Hakha-Lai, a decision has to be made concerning, for example, whether the domain of the tri-tonal strings is ((σσ)σ) or (σ(σσ)). It is proposed here that the tone sandhi domain of Hakha-Lai is the right branching (σ(σσ)), which is accounted for by the following prosodic constraints:

(21) ALLFTR: Every foot stands at the right edge of the utterance.
(22) PARSESYLL: Parse every syllable into higher prosodic levels.
(23) BINBRAN: Phonological structures are binary branching.
(24) Prosodic constraint ranking: {PARSESYLL, ALLFTL} >> BINBRAN

The tableaux below illustrate how the prosodic constraints predict the tonal domain (σ(σσ)) for tri-tonal examples. (25) and (26) are examples with different morphosyntactic structures. The prosodic constraints always select (σ(σσ)) as the tonal domain, regardless of the morphosyntactic branching of the input.

(25)

{σ{σσ}}	PARSESYLL	ALLFTR	BINBRAN
a. ((σσ)σ)		*!	
b. (σσ(σ))			*
☞ c. (σ(σσ))			
d. (σσ)(σ)		*!	*
f. σ(σσ)	*!		
g. (σσσ)			*!
h. σσσ	*!		

(26)

{{σσ}σ}	PARSESYLL	ALLFTR	BINBRAN
a. ((σσ)σ)		*!	
b. (σσ(σ))			*
☞ c. (σ(σσ))			
d. (σσ)(σ)		*!	*
f. σ(σσ)	*!		
g. (σσσ)			*!
h. σσσ	*!		

The claim for the domain might seem *ad hoc* at first glance. However, when we compare the domains proposed for other morphosyntactically insensitive languages in (27), a correlation between the prosodic domains and the position of prominence can be observed.[3] For *left*

[3] It is worth noting that all the morphosyntactically insensitive languages discussed here involve mutual tone sandhi. Mutual tone sandhi refers to the tone sandhi phenomena where the sandhi form is conditioned by the pitch value of both the sandhi tone and the neighboring tone (Liu 1987). Languages that involve purely independent and contextual tone sandhi are not discussed. Independent tone sandhi refers to the type of tone sandhi where the sandhi form is conditioned solely by the sandhi tone itself regardless of the pitch value of the adjacent tone, though the presence of the adjacent tone is crucial (Liu 1987). Taiwanese tone sandhi (Chen 1987, 2000; Hsiao 1995, 2000a; Lin 2000a; among others), for instance, belongs to independent tone sandhi. As illustrated in (1), the /H/ tone changes to **M** no matter whether it is followed by /M/ or /LM/. Contextual tone sandhi refers to the type of tone sandhi where the sandhi form is conditioned solely by the value of the adjacent tone regardless of the pitch value of the sandhi tone (Liu 1987). Shanghai tone sandhi (Chen 2000, Duanmu 1992, Selkirk and Shen 1990, among others),

prominent languages, the domain is *right* aligned (27a); while for *right* prominent languages, the domain is *left* aligned (27b). Thus, for dialects/languages whose tone sandhi is blind to morpho-syntactic structures, the prosodic domains can be independently defined by the

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for example, belongs to contextual tone sandhi. Shanghai is a left prominent Chinese dialect. In (2), /LH/ changes to **H** after /LH/ but **L** after /HL/.

(1) Taiwanese as independent tone sandhi
 a. H.M → **M**.M (e.g. *tang po* 'eastern')
 b. H.LM → **M**.LM (e.g. *tang ping* 'east side')

(2) Shanghai as contextual tone sandhi
 a. LH.LH → **L**.H (e.g. *ze' pẽ* 'Japan')
 b. HL.LH → **H**.L (e.g. *fe ga* 'tomato')

For both independent tone sandhi and contextual tone sandhi, since the tonal values of the neighboring tones do not matter, tonal changes in the non-prominent position simply take place simultaneously. Thus, the question of rule application directionalities would not exist. For example, in Taiwanese, a base tone changes to a sandhi tone in front of any tone, thus the tone sandhi rule will take place simultaneously and change all the non-final tones into sandhi tones.

(3) Taiwanese tone sandhi: change tones in the non-prominent (i.e. domain-final) position to sandhi tones

Underlying representation	$T_1.T_2.T_3.$
Tonal change	$\mathbf{T_1.T_2.}$
Surface presentation	$\mathbf{T_1.T_2.}T_3.$

Shanghai tone sandhi involves tonal deletion of old features in the non-prominent position and reassignment of new tonal features. Thus, the tonal deletion can take place simultaneously to delete the tonal features of the tones in the non-prominent position. Then, the reassignment process takes place and the toneless syllables are simultaneously filled with the feature of the prominent syllable.

(4) Shanghai tone sandhi: (a) deletion of the tonal features in the non-prominent (i.e. domain-initial) position; (b) reassignment of the tonal features from the tonal feature in the first syllable

Underlying representation	$HL_1.T_2.T_3$
Tonal deletion	$\emptyset_2.\emptyset_3$
Tonal filling	$L_2.L_3$
Surface presentation	$\mathbf{H_1.\ L_2.L_3}$

It is worth noting that both the independent and the contextual tone sandhi are categorized as the positional type of tone sandhi (that is, tone changes caused by purely positional factors) in Yip (1995), as oppose to tonal changes that are caused by a specific tonal environment, such as assimilation and dissimilation. Some languages would involve a mixture of different types of tone sandhi. For example, Chengdu (Lin 2005a, b) involves both mutual (the tonal changes of MH) and independent tone sandhi (the tonal changes of HM and LM). As long as mutual tone sandhi is involved, the question of tone sandhi operation directionality exists.

location of the prominence. The domains are aligned to the *non-prominent* edge.

(27) Correlation between the prosodic domains and the positions of prominence in morphosyntactically insensitive tone sandhi

Edge of Prominence	Prosodic Domain	Dialects/languages
a. left prominent T.T → $T_{TRI}.\mathbf{T}_{TAR}$	(σ(σσ))	Hakha-Lai Chengdu (Lin 2005a, b)
b. right prominent T.T → $\mathbf{T}_{TAR}.T_{TRI}$	((σσ)σ)	Tianjin (Lin 2003, 2005b) Boshan (Lin 2004b) Sixian-Hakka (Lin 2005d)

Key: T_{TRI} = triggering tone; T_{TAR} = target tone

The tonal domains also lead to another interesting observation. As operating tone sandhi in a right aligned domain (σ(σσ)) implies tone sandhi applies right-to-left and operating tone sandhi in a left aligned domain ((σσ)σ) implies a left-to-right tonal operation directionality, both the left aligned domain in right prominent languages and the right aligned domain in left prominent languages actually both entail a target-to-trigger tone sandhi operation directionality.

4. THE ANALYSIS

In this section, an OT analysis is proposed to account for tone sandhi in bi-tonal and multi-tonal strings in Hakha-Lai. I start from proposing constraints for the tone sandhi phenomenon in the bi-tonal sequences which is rather simple and poses no problem in the literature and I then move on to the more complex case of multi-tonal sandhi.

4.1 Bi-tonal Sequences

What triggers tone sandhi in Hakha-Lai? As pointed out in Hyman and VanBik (2004), tone sandhi in Hakha-Lai takes place to avoid the change of tone level at the intersyllabic position. This is quite evident when we look at the following table. In column (b), but not in column (a), the end tone of the first syllable does not agree with the beginning tone of the second one. That is why tonal sequences in the former, but not the latter, undergo tone sandhi and change to the tonal sequences in column (c).

(28) (Hyman and VanBik 2004: 826)

	Inputs which do not change		*Inputs which do change*		*Outputs they change to*	
a.	LH-HL	b.	HL-HL	c.	→	HL-L
	HL-LH		LH-LH		→	LH-HL
	L-LH		LH-L		→	L-L
	HL-L		L-HL		→	L-L
	L-L					

In other words, neighboring tones tend to agree in features at the intersyllabic tonemic level. This tonal fact can be captured by the markedness constraint AGREE-t[4].

[4] The AGREE-t constraint resembles the NoJump constraint proposed in Hyman and VanBik (2004)

(Hyman and VanBik 2004: 826)

No Jumping Principle (NoJump): $* \begin{array}{cc} \sigma & \sigma \\ | & | \\ \alpha H & -\alpha H \end{array}$

(i.e. Hakha-Lai, a contour language, likes tone changes to take place <u>within</u> syllables.)

Here the AGREE-t constraint is proposed instead to highlight that tone sandhi in Hakha-Lai is an assimilatory process, as opposed to the dissimilatory processes observed in the Chinese dialects such as Beijing Mandarin, Tianjin, Boshan, and Chengdu.

(29) AGREE-t: The features at inter-syllabic tonemic level must agree.

e.g. σ σ TBU

L HL tonal level

* l h l

tonemic level

The AGREE-t constraint explains why underlying sequences of HL.HL, LH.LH, LH.L and L.HL, as well as phrase initial LH tone (i.e. %H LH), should undergo tone sandhi.

In addition to AGREE-t, the following two markedness constraints are needed.

(30) MARKEDNESS: No output tone is more marked than its corresponding input tone.[5]

(31) LINEARITY: No tonemic feature reversal in input and output tones (i.e. no metathesis).

The MARKEDNESS constraint requires that an output tone can not be more marked than its corresponding input tone. We all know that the universal markedness scale for tone is: *Rising tones >> *Falling tones >> * Level tones. Thus, according to the constraint, no falling tones should change to rising tones, and no level tones should change to either falling or rising tones. This constraint captures the tonal alternations in Hakha-Lai. In the language, when one tone has to change, it never changes to a tone that is more marked. Thus, an underlying HL tone has two possible surface forms (i.e. allotones), HL and L; and an underlying LH tone has three possible allotones, LH, HL, and L. L is the least

[5] This constraint is adopted from Hyman and VanBik (2004). Nonetheless, the present analysis has a different opinion concerning how the MARKEDNESS constraint is ranked with the constraint demanding input-output correspondence. While Hyman and VanBik (2004) propose that the *MARKEDNESS constraint must be ranked below the input-output correspondence constraint to ensure that the constraint will not have an effect unless a tone has to change, the present analysis proposes that the MARKEDNESS constraint should be ranked higher than the input-output correspondence constraint. As shown in (36), MARKEDNESS must dominate IDENT-IO-T-L, which ranks higher than IDENT-IO-T that requires input-output correspondence.

marked tone in Hakha-Lai and it has only one surface form, L. Thus, the MARKEDNESS constraint can be regarded as the key constraint for deciding the allotones for an input tone.

The LINEARITY constraint requires that tonemes within a tone should not metathesize. Hence, no LH tones may change to HL tones, and *vice versa*. As will be shown below [in (41)], this constraint plays a crucial role in predicting whether a LH tone changes to a HL tone or an L tone in sandhi positions. Everything being equal, a LH tone would change to an L tone rather than a HL tone since the latter would violate the LINEARITY constraint.

To ensure that tonal changes would occur to repair forms that do not agree in inter-syllabic position, the AGREE-t constraints must outrank the faithfulness constraint that requires input-output identity.

(32) IDENT-IO-T: Input-Output corresponding tones are identical.
(33) AGREE-t >> IDENT-IO-T
Input: HL.HL
Output: HL.**L** >> HL.HL

In addition to the general faithfulness constraint, a positional faithfulness constraint IDENT-IO-T-L, which states that the tone at the left (prominent) edge of an utterance, must be faithful to its input correspondent, is proposed to capture the fact that Hakha-Lai is a left prominent language.

(34) IDENT-IO-T-L: The leftmost tone of an utterance is identical to its input correspondent.

Nonetheless, although Hakha-Lai is a left prominent language, it contains one tone sandhi rule (i.e. the RL rule) that has the tone on the left to undergo tone sandhi (i.e. LH.L → **L**.L). For the input /LH.L/, a non-changed output form [LH.L] would actually better satisfy the IDENT-IO-T-L than the attested output [**L**.L]. To predict the attested output [**L**.L], the AGREE-t constraint has to outrank the IDENT-IO-T-L constraint.

(35) AGREE-t >> IDENT-IO-T-L
Input: LH.L
Output: **L**.L >> LH.L

Notice that [LH.L] and [**L**.L] are not the only two possible outputs for /LH.L/; there is another possible output form [LH.**HL**]. [LH.**HL**] satisfies AGREE-t in a way similar to [**L**.L]; but unlike [**L**.L], it does not incur any violations in the IDENT-IO-T-L constraint. The output [LH.**HL**], however, violates MARKEDNESS because HL is more marked than its corresponding input tone /L/ and thus is not a possible allotone for /L/. [LH.**HL**] can be ruled out if we rank MARKEDNESS above IDENT-IO-T-L.

(36) MARKEDNESS >> IDENT-IO-T-L
Input: LH.L
Output: **L**.L >> LH.**HL**

We propose the following ranking for the current tonal constraints:

(37) Tonal constraint ranking of Hakha-Lai tone sandhi
{AGREE-t, MARKEDNESS} >> IDENT-IO-T-L >> IDENT-IO-T >> LINEARITY

The tableaux below demonstrate how the constraint ranking correctly accounts for the bi-tonal sequences in Hakha-Lai. In (38), for instance, both (a) and (b) violate AGREE-t because the tonemic features do not agree in inter-syllabic positions in both candidates. Candidate (c), although not violating AGREE-t, incurs a violation in MARKEDNESS because LH is more marked than its corresponding input /HL/ and thus is not a possible allotone for /HL/. Candidate (d), satisfies both AGREE-t and MARKEDNESS, but it violates IDENT-IO-T-L because the HL at the left edge of the bi-tonal strings undergoes change. Thus, candidate (e) is correctly selected as the optimal output.

(38) *ka* HL.HL → HL.**L**

HL.HL	AGREE-t	MARKEDNESS	IDENT-IO-T-L	IDENT-IO-T	LINEARITY
a. HL.HL	*!				
b. **L**.HL	*!		*	*	
c. HL.**LH**		*!		*	*
d. **L**.**L**			*!	**	
☞ e. HL.**L**				*	

(39) *ka* L.HL → L.**L**

L.HL	AGREE-t	MARKEDNESS	IDENT-IO-T-L	IDENT-IO-T	LINEARITY
a. L.HL	*!				
b. L.**LH**		*!		*	*
c. **LH**.HL		*!	*	*	
☞ d. L.**L**				*	

(40) *ka* LH.LH → LH.**HL**

LH.LH	AGREE-t	MARKEDNESS	IDENT-IO-T-L	IDENT-IO-T	LINEARITY
a. LH.**L**	*!			*	
b. **L**.LH			*!	*	
☞ c. LH.**HL**				*	*

(41) *ka* LH.L → **L**.L

LH.L	AGREE-t	MARKEDNESS	IDENT-IO-T-L	IDENT-IO-T	LINEARITY
a. LH.L	*!				
b. LH.**HL**		*!		*	
c. **HL**.L			*	*	*!
☞ d. **L**.L			*	*	

(42) %H.LH → %H.**HL**

%H.LH	AGREE-t	MARKEDNESS	IDENT-IO-T-L	IDENT-IO-T	LINEARITY
a. %H.LH	*!				
b. %H.**L**	*!			*	
☞ c. %H.**HL**				*	*

(43) *ka* L.LH → L.LH

L.LH	AGREE-t	MARKEDNESS	IDENT-IO-T-L	IDENT-IO-T	LINEARITY
a. L.**HL**	*!			*	*
b. **HL**.LH		*!	*	*	
c. L.**L**				*!	
☞ d. L.LH					

Here above, we have seen how the constraints work to predict bi-tonal sandhi. Here below we continue to see how tone sandhi in multi-tonal strings is accounted for. For the sake of clarity, in the following discussion, we eliminate the MARKEDNESS constraint, whose key role is to predict the allotones for an input tone, and the output candidates considered for evaluation are all and only the possible combinations of the allotones of a tonal input. Thus, for the tri-tonal string /%H.LH.HL/, the output candidates considered for evaluation would be [%H.LH.HL], [%H.**HL**.HL], [%H.**L**.HL], [%H.LH.**L**], [%H.**HL**.**L**], and [%H.**L**.**L**], but not, for instance, [%H.**L**.**LH**], since LH, which is more marked than HL, is not a possible allotone of /HL/. Candidates that are not composed of the allotones can be readily ruled out by the top-ranked MARKEDNESS constraint.

4.2 Multi-tonal Strings, Normal Application and Underapplication

The rule application directionalities, in which the outputs are derived, as discussed above, are not governed by the morpho-syntactic structures or principles such as Temporal Sequence, Derivational Economy, Transparency, Simplicity and Wellformedness. But are the rule application directionalities truly unpredictable? An intriguing phenomenon could be found when we look more closely into the outputs derived by the different directionalities. 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 refers 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 (44), while (P1)-(P4), which are generated by the right-to-left directionality, are opaque, (P5)-(P6), which are generated by the opposite directionality, are transparent. (P1)-(P4) belong to underapplication because impermissible sequences are observed at surface.[6]

(44)	***Input***	***Output***	***Directionality***	***Application Mode***
P1	%H.LH.LH	%H.**HL.HL**	⇦	Underapplication
P2	%H.LH.HL	%H.**HL**.HL	⇦	Underapplication
P3	*ka* LH.LH.LH	*ka* LH.**HL.HL**	⇦	Underapplication
P4	*ka* LH.LH.LH.LH	*ka* LH.**HL.HL.HL**	⇦	Underapplication
P5	*ka* LH.LH.L	*ka* LH.**HL**.L	⇨	Normal application
P6	%H.LH.L	%H.**HL**.L	⇨	Normal application

Take pattern (1) for instance. The resultant output %H.**HL.HL** contains the impermissible tonal sequence **HL.HL** because there is a change of tone levels in the intersyllabic position. The resultant output clearly violates the AGREE-t constraint. (P5) and (P6) belong to normal application. They contain neither an impermissible sequence at surface nor unconditioned changes.[7]

4.2.1.1 Underapplication

Consider underapplication again. Patterns (1)-(4), which are derived by the right-to-left directionality, involve underapplication of tone sandhi since the outputs are non-surface-true.

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[6] Notice that the outputs of (P1), (P3) and (P4) also have the characteristic of overapplication. Take (P1) for instance, the rightmost LH changes to **HL** even though at surface it is not preceded by either %H or LH. In the present study, if a tonal output exhibits the characteristics of both over- and underapplication, it will be regarded as underapplication for two reasons. First, underapplications are more marked than overapplications. Second, the characteristic of underapplication, i.e. containing impermissible output sequences, is easier to detect at surface than that of overapplications which often require reference to information in the input.

[7] The correlation between the conflicting directionalities and the different application modes observed in Hakha-Lai is also reported in the tone sandhi phenomena in Boshan (Lin 2004b), in Chengdu (2005a, b) and in Tianjin (2003, 2005c).

(45)

	Input	Attested Output (underapplication) ⇦	*Unattested Output (normal application)* ⇨
(P1)	%H.LH.LH	%H.**HL.HL**	*%H.**HL**.LH*
(P2)	%H.LH.HL	%H.**HL**.HL	*%H.**HL.L***
(P3)	*ka* LH.LH.LH	*ka* LH.**HL.HL**	*ka LH.**HL**.LH*
(P4)	*ka* LH.LH.LH.LH	*ka* LH.**HL.HL.HL**	*ka LH.**HL**.LH.**HL***

A left-to-right directionality could have yielded normal application outputs for patterns (1) to (4), i.e. %H.**HL**.LH, %H.**HL.L**, *ka* LH.**HL**.LH, and *ka* LH.**HL**.LH.**HL**, respectively. Normal application outputs are supposed to be the better candidates than the underapplication counterparts because underapplication itself implies the violation of some phonological constraints. In Hakha-Lai, the constraint violated by the attested underapplication outputs is the AGREE-t constraint. As shown in the following tableau, based on the current constraint ranking, the unattested normal application counterparts would be selected and the attested underapplication outputs ruled out due to the AGREE-t constraint.

(46) (P3) *ka* (LH.(LH.LH))→ *ka* (LH.(**HL.HL**))

	(LH.(LH.LH))	AGREE-t	IDENT-IO-T-L	IDENT-IO-T	LINEARITY
☞	a. (LH.(**HL.HL**)) (underapplication) ⇦	*!		**	**
	💣 b. (LH.(**HL**.LH)) (normal application) ⇨			*	*

Key: The pointing hand outside the tableau points out the attested candidate that is failed to be picked out by the constraints set; 💣 points out the unattested output that is wrongly selected by the current constraints set.

So why does tone sandhi choose to underapply in (P1)-(P4) in Hakha-Lai? It is proposed that underapplication is caused by the desire to increase identity between the prosodically related output tones.

Compare the schema in (47a) for the attested underapplication output with the schema in (47b) for the unattested normal application output. It can be seen that the tonal output in the internal prosodic structure of (47a) (i.e. (LH.(**HL.HL**)) is more like the base (i.e. LH.**HL**) than that of (47b) (i.e. (LH.(**HL.**LH))

(47) (P3)

(a) **I**nput Tone	**I**nput Tone	(b) ***I**nput Tone*	***I**nput Tone*
ka LH.LH	*ka* LH.LH.LH	*ka LH.LH*	*ka LH.LH.LH*
↓ IO-Faith	↓	↓	↓
ka (LH.**HL**) →	*ka* (LH.(**HL.HL**))	*ka (LH.**HL**)* →	*ka (LH.(**HL.**LH))*
Base **T**one	**O**utput **T**one	***B**ase **T**one*	***O**utput **T**one*
BOT-IDENTITY		***BOT-IDENTITY***	

In other words, outputs of underapplication are driven by the need to satisfy the IDENT-BOT constraint.[8]

(48) IDENT-BOT: Corresponding tones in the prosodically related bases and outputs must be identical.

Thus, the IDENT-BOT constraint serves to pick out the underapplication outputs.

(49) (P3) *ka* (LH.(LH.LH))→ *ka* (LH.(**HL.HL**))
Base: LH.**HL** (←LH.LH)

(LH.(LH.LH))	IDENT-BOT
☞ a. (LH.(**HL.HL**))	*
b. (LH.(**HL**.LH))	**!

Because underapplication entails the existence of impermissible tonal sequences; therefore, it seems that the IDENT-BOT constraint must rank above the markedness constraint AGREE-t to enable the surface of the underapplication candidates.

[8] The same is attested in Boshan tone sandhi (Lin 2004b), in Chengdu tone sandhi (Lin 2005a, b), and in Tianjin tone sandhi (Lin 2003, 2005c).

(50) IDENT-BOT >> AGREE-t
Input: *ka* (LH.(LH.LH)) Base: LH.**HL** (←LH.LH)
Output: *ka* (LH.(**HL.HL**)) > *ka* (LH.(**HL.**LH))

However, this ranking does not suffice to reject (LH.(LH.**HL**)) which is also one of the possible candidates for the input *ka* (LH.(LH.LH)).

(51) (P3) *ka* (LH.(LH.LH))→ *ka* (LH.(**HL.HL**))
Base: LH.**HL** (←LH.LH)

	(LH.(LH.LH))	IDENT-BOT	AGREE-t
☞	a. (LH.(<u>**HL**.**HL**</u>))	*!	* (HL.HL)
💣	b. (<u>LH.(LH</u>.**HL**))		* (LH.LH)

As shown above, the attested output (LH.(**HL**.**HL**)) violates the IDENT-BOT constraint once because the internal foot of the candidate contains one tone that is different from the tonal base; however, the unattested output (LH.(LH.**HL**)) fully satisfies the constraint because its internal foot is identical to the base. As for the AGREE-t constraint, both (LH.(**HL**.**HL**)) and (LH.(LH.**HL**)) incur a violation in the constraint because the two-tone-sequence at the *right* edge of the tri-tonal string in the former (underlined) and the two-tone-sequence at the *left* edge of the tri-tonal string in the latter (underlined) do not conform to the AGREE-t constraint.

How may this problem be solved? By observing the underapplication outputs (i.e. (P1)-(P4)) more closely, we may find that the impermissible sequences in the attested underapplication outputs occur always at the non-prominent edge, but not at the prominent left edge of a string.

(impermissible sequences are underlined)

(52)

Dialect/Language	Underapplication	Location of marked sequence
Hakha-Lai (left-prominent)	LH.<u>**HL**.**HL**</u> LH.<u>**HL**.**HL**</u>.L LH.<u>**HL.HL.HL**</u> %H.<u>**HL**.**HL**</u> %H.<u>**HL**.HL</u>	*non-prominent* edge

Interestingly, the same phenomena is also observed in the attested underapplication outputs in Chengdu (Lin 2005a, b) and Boshan (Lin

2004b). In Chengdu, which is also a left prominent language, it is found that the impermissible sequences occur always at the right (non-prominent) edge, but not at the left (prominent) edge of a string. On the other hand, in Boshan, which is a right prominent language, it is found that the impermissible sequences occur always at the left (non-prominent) edge, but not at the right (prominent) edge of a string.

(53)

Dialect/Language	Underapplication	Location of marked sequence
Chengdu (left-prominent)	MH.**M.M** ML.**M.M** HM.**M.M**	*non-prominent* edge

(54)

Dialect/Language	Underapplication	Location of marked sequence
Boshan (right-prominent)	55.**55**.214 55.**55**.214 **55.55**.214	*non-prominent* edge

In the case of Boshan (Lin 2004b) and of Chengdu (Lin 2005a, b), I proposed that the markedness constraint should be divided into two constraints, one penalizing marked sequence at the prominent position (MC-POS) and the other penalizing marked sequence in general (MC-FREE). When MC-POS outranks the IDENT-BOT constraint which in turn outranks MC-FREE (i.e. MC-POS >> IDENT-BOT >> MC-FREE), impermissible tonal sequences at the non-prominent position that are caused by identity preservation are tolerated. I propose here that underapplication in Hakha-Lai also requires the division of the markedness constraints into the MC-POS and the MC-FREE constraints. Since Hakha-Lai is a left prominent language, the MC-POS constraint will penalize the impermissible sequence at the left edge. The following constraint is proposed.

(55) $_{U}$[AGREE-t: At the left edge of an utterance, the features in inter-syllabic tonemic level must agree.

The MC-POS constraint proposed here belongs to the family of Positional Markedness Constraints (Lombardi 2001, Zoll 1998, Steriade 1997) which states that certain marked structures either must (as in the positive positional markedness constraints) or cannot (as in the negative positional markedness constraints) occur in particular positions.[9]

Following the schema MC-POS >> IDENT-BOT >> MC-FREE, the $_U$[AGREE-t constraint must outrank the IDENT-BOT constraint which in turn must outrank the AGREE-t constraint.

(56)

a. $_U$[AGREE-t >> IDENT-BOT
  Input: LH.LH.LH Base: LH.**HL** (← LH.LH)
  Output: (LH.(**HL.HL**)) > (LH.(LH.**HL**))

b. IDENT-BOT >> AGREE-t
  Input: LH.LH.LH Base: LH.**HL** (← LH.LH)
  Output: (LH.(**HL.HL**)) > (LH.(**HL**.LH))

The final constraint ranking proposed for Hakha-Lai is:

(57) {$_U$[AGREE-t, MARKEDNESS} >> IDENT-IO-T-L >> IDENT-BOT >> AGREE-t >> IDENT-IO-T >> LINEARITY

The tableaux below demonstrate how the ranking predicts the outputs that involve underapplication:

[9] Relating the markedness position to the prominent position would seem to be strange as according to the positional faithfulness constraint, the prominent position should be the 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 constraint proposed in this paper refers to *sequences* (e.g. $_U$[AGREE-T means the bi-tonal sequence at the left edge of an utterance must have the same feature in the intersyllabic position.). In other words, it is a sequential markedness constraint. The sequential positional markedness constraints only require that the marked *sequence* may not occur in the prominent position and that tonal changes are required 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.

(58) %H.LH.LH → (%H.(**HL.HL))**

Base: LH.**HL** (← LH.LH)

(%H.(LH.LH))	$_U$[AGREE-t	IDENT-IO-T-L	IDENT-BOT	AGREE-t	IDENT-IO-T	LINE
☞ a. (%H.(**HL**.**HL**)) ⇦ (underapplication)			*	*	**	**
b. (%H.(**HL**.LH)) ⇨ (normal application)			**!		*	*
c. (%H.(LH.**HL**))	*!			*	*	*
d. (%H.(**HL**.**L**))			**!		**	*
e. (%H.(**L**.**LH**))	*!		**	*	*	

(59) %H.LH.HL → (%H.(**HL**.HL))

Base: LH.HL (← LH.HL)

(%H.(LH.HL))	$_U$[AGREE-t	IDENT-IO-T-L	IDENT-BOT	AGREE-t	IDENT-IO-T	LINE
☞ a. (%H.(**HL**.HL)) ⇦ (underapplication)			*	*	*	*
b. (%H.(**HL**.**L**)) ⇨ (normal application)			**!		**	*
c. (%H.(LH.HL))	*!			*		
d. (%H.(LH.**L**))	*!		*	**	*	
e. (%H.(**L**.HL))	*!		*	**	*	
f. (%H.(**L**.**L**))	*!		**	*	**	

(60) *ka* LH.LH.LH → (LH.(**HL.HL))**
Base: LH.**HL** (← LH.LH)

(LH.(LH.LH))	U[AGREE-t	IDENT-IO-T-L	IDENT-BOT	AGREE-t	IDENT-IO-T	LINE
☞ a. (LH.(**HL**.**HL**)) ⇦ (underapplication)			*	*	**	**
b. (LH.(**HL**.LH)) ⇨ (normal application)			**!		*	*
c. (LH.(**HL**.**L**))			**!		**	*
d. (LH.(LH.**HL**))	*!			*	*	*
e. (LH.(LH.LH))	*!		*	**		
f. (LH.(LH.**L**))	*!		*	**	*	
g. (LH.(**L**.**HL**))	*!		*	**	**	*
h. (LH.(**L**.LH))	*!		**	*	*	
i. (LH.(**L**.**L**))	*!		**	*	**	

(61) *ka* LH.LH.LH.LH → (LH.(**HL.HL.HL))**
Base: LH.**HL.HL** (← LH.LH.LH)

(LH.(LH.LH.LH)	U[AGREE-t	IDENT-IO-T-L	IDENT-BOT	AGREE-t	IDENT-IO-T	LINE
☞ a. (LH.(**HL**.**HL**.**HL**)) ⇦ (underapplication)			*	**	***	***
b. (LH.(**HL**.LH.**HL**)) ⇨ (normal application)			**!		**	**
c. (LH.(LH.LH.LH))	*!		**	***		
d. (LH.(**HL**.**HL**.**L**))			**!	*	***	**
e. (LH.(**HL**.**HL**.LH))			**!	*	**	**
f. (LH.(**HL**.LH.**L**))			**!*	*	**	*
g. (LH.(**HL**.LH.LH))			**!*	*	*	*
h. (LH.(**HL**.**L**.**HL**))			**!	*	***	**
i. (LH.(**HL**.**L**.**L**))			**!*		***	*
j. (LH.(**HL**.**L**.LH))			**!*		**	*

In sum, tone sandhi generally operates from right to left to increase identity between prosodically related tonal outputs in Hakha-Lai. Preserving identity between prosodically related outputs is important in tone sandhi. It may even 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.

4.2.1.2 Normal Application

Consider the normal application patterns (P5) and (P6), which are derived by the left-to-right rule application directionality. As shown above, increasing identity between prosodically related outputs is important in Hakha-Lai tone sandhi. Identity preservation is the reason that causes tone sandhi to apply from right to left in (P1) to (P4) and that results in underapplication outputs. However, if preserving identity is so important in Hakha-Lai tone sandhi, what prevents tone sandhi from applying right-to-left in (P5)-(P6)? As shown below, the outputs derived by a right-to-left directionality would be more identical to their corresponding bases than the attested normal application outputs derived by a left-to-right directionality.

(62)

	Input	Base	Attested Output (normal application) Less identical ⇨	*Unattested Output* *More identical* ⇦
(P5)	(LH.(LH.L))	(**L**.L)	(LH.(**HL**.L))	* (**L.(L**.L))
(P6)	(%H.(LH.L))	(**L**.L)	(%H.(**HL**.L))	*(%H.(**L**.L))

It is argued here that the reason why tone sandhi does not apply from right to left to increase identity in (P5) and (P6) is to prevent marked forms, or tonal changes at the prominent position. For instance, in (P5), if the resultant output were derived by the right-to-left directionality, the resultant output would involve tonal change at the prominent left edge and thus violate the IDENT-IO-T-L constraint. On the other hand, in (P6), the resultant output of a right-to-left directionality would result in a tonal sequence that does not conform to the AGREE-t constraint at the left edge; such a sequence is highly marked because it violates the dominant constraint $_{U}$[AGREE-t. Thus, the left-to-right directionality in (P5) and

(P6) is readily captured by the domination of IDENT-IO-T-L and $_U$[AGREE-t over IDENT-BOT.

The domination of the IDENT-IO-T-L constraint and the $_U$[AGREE-t constraint over the IDENT-BOT constraint reflects that identity preservation is important in Hakha-Lai, unless the maximization of identity would generate forms that are highly marked (i.e. forms that contain marked form in the prominent position) or forms that involve tonal changes at the prominent edge. In brief, in Hakha-Lai, tone sandhi generally applies from right to left to preserve identity between prosodically related outputs, unless the resultant outputs would involve highly marked tonal strings or tone sandhi at the prominent edge.

The following tableaux demonstrate that the normal application patterns can be accounted for by the same set of constraints proposed for underapplication above.

(63) *ka* LH.LH.L → (LH.(**HL**.L))

Base: **L**.L (← LH.L)

(LH.(LH.L))	$_U$[AGREE-t	IDENT-IO-T-L	IDENT-BOT	AGREE-t	IDENT-IO-T	LINE
☞ a. (LH.(**HL**.L)) ⇨ (normal application)			*		*	*
b. (**L**.(**L**.L)) ⇦		*!			**	
c. (**HL**.(**L**.L))		*!			**	*
d. (LH.(LH.L))	*!		*	**		
e. (LH.(**L**.L))	*!			*	*	
f. (**HL**.(LH.L))		*!	*	*	*	*

(64) %H.LH.L → (%H.(**HL**.L))
Base: **L**.L (← LH.L)

(%H.(LH.L))	U[AGREE-t	IDENT-IO-T-L	IDENT-BOT	AGREE-t	IDENT-IO-T	LINE
☞ a. (%H**.**(**HL**.L)) ⇨ (normal application)			*		*	*
b. (%H.(**L**.L)) ⇦	*!			*	*	
c. (%H.(LH.L))	*!			**		

4.3 Further Support of Identity Preservation

Recall that preserving identity between prosodically related forms is important in Hakha-Lai. To achieve it, tone sandhi normally applies from right to left. The only reason for the directionality to change is to avoid generating outputs that involve highly marked forms or tonal changes at the prominent edge.

(65) Tone sandhi generally applies from right to left to preserve identity between prosodically related outputs, unless the resultant outputs of such directionality would involve highly marked forms or tonal change at the prominent edge.

In (P5) and (P6), we have seen that in order to prevent the unwanted forms in (65) (i.e. highly marked forms or tonal changes at the prominent edge), tone sandhi chooses to apply from left to right. Thus, it seems that tone sandhi in Hakha-Lai must operate either from right to left (default) or from left to right (to avoid unwanted forms). But in (P7) and (P8) below, the attested outputs are clearly not derived by either a right-to-left (ref. (66a), (67a)) or a left-to-right (ref. (66b), (67b)) directionality. However, would they thus constitute counter examples to the proposal of identity preservation?

(66) (P7) /*ka* LH.LH.LH.L/ → [*ka* LH.**HL**.**HL**.L]

a. ⇦	*ka LH.LH.LH.L → ka LH.LH.***L***.L → ka LH.***L***.***L***.L → *ka* ***L.L.L.L***
b. ⇨	*ka LH.LH.LH.L →ka LH.***HL***.LH.L (n/a) →ka LH.***HL***.LH.L → *ka LH.***HL***.***L***.L*

(67) (P8) /%H.LH.LH.L/ → [%H.**HL**.**HL**.L]

a. ⇦	*%H.LH.LH.L → %H.LH.***L***.L → *%H.***L***.***L***.L*
b. ⇨	*%H.LH.LH.L → %H.***HL***.LH.L (n/a) →%H.***HL***.LH.L → *%H.***HL***.***L***.***L****

In fact, they support the current proposal. By looking at (66a) and (67a), we can see that the reason tone sandhi does not follow the default right-to-left direction is due to the fact that such directionality would generate output that involves tonal change at the prominent edge in the former (ref. (66a) = (68b)) and output that contains highly marked form in the latter (ref. (67a) = (69b)). But why do they not choose a reverse left-to-right directionality like (P5) and (P6)? The reason (P7) and (P8) do not choose a left-to-right directionality as (P5) and (P6) do is because the attested outputs are more identical to their respective tonal bases than the outputs derived by a left-to-right directionality (compare candidates (a) and (c) in tableaux (68) and (69)).

(68) *ka* LH.LH.LH.L → (LH.(**HL.HL**.L));
Base: LH.**HL**.L (← LH.LH.L)

LH.LH.LH.L	$_U$[AGREE-t	IDENT-IO-T-L	IDENT-BOT	AGREE-t	IDENT-IO-T
☞ a. (LH.(**HL.HL**.L))			*	*	**
b. (**L**.(**L.L**.L)) ⇦		*!	**		***
c. (LH.(**HL.L**.L)) ⇨			**!		**

(69) %H.LH.LH.L → (%H.(**HL.HL**.L))

Base: LH.**HL**.L (← LH.LH.L)

%H.LH.LH.L	$_U$[AGREE-t	IDENT-IO-T-L	IDENT-BOT	AGREE-t	IDENT-IO-T
☞ a. (%H.(**HL.HL.**L))			*	*	**
b. (%H.(**L.L**.L)) ⇦	*!		**	*	**
c. (%H.(**HL.L**.L)) ⇨			**!		**

Thus, the attested outputs of (P7) and (P8) are those that maximally satisfy IDENT-BOT and at the same time minimally violate $_U$[AGREE-t and IDENT-IO-T-L. This is also what is going on in (P5) and (P6) (and also in (P1)-(P4)). In (P5) and (P6), the attested outputs derived by a left-to-right directionality are also the ones that maximally satisfy IDENT-BOT and minimally violate $_U$[AGREE-t and IDENT-IO-T-L. Thus, (P7) and (P8), which are derived by neither right-to-left nor left-to-right directionalities, not only do not constitute counter examples but rather serve to further strengthen the importance of identity preservation in Hakha-Lai tone sandhi.

5. CONCLUSION

In the preceding sections, I have presented the basic phenomena and the challenges of Hakha-Lai tone sandhi. The challenge Hakha-Lai tone sandhi has raised is that of seemingly unpredictable rule application directionalities observed in the multi-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 a correlation between the directionalities of rule application and normal vs. underapplications; a right-to-left directionality would produce underapplications while a left-to-right directionality would produce normal applications. Underapplications observed in Hakha-Lai tone sandhi have been shown 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, the need to achieve identity is the motivation lying behind the right-to-left directionality. Maximizing identity between prosodically related tonal outputs is important in Hakha-Lai tone sandhi. However, maximization of identity is not always fulfilled. When achieving identity would produce tonal outputs that are highly marked (captured by the positional markedness constraint of $_{U}$[AGREE-t), or tonal outputs that involve changes at the prominent position (captured by the positional faithfulness constraint of IDENT-IO-T-L) identity preservation would be sacrificed. And the default right-to-left directionality would not be followed. Thus, the motivating force in the change of directionality is the desire to prevent the unwanted forms from occurring. The selections between the different directionalities thus fall naturally from the interaction of the IDENT-BOT constrain, the $_{U}$[AGREE-t constraint and the IDENT-IO-T-L constraint. The domination of the latter two constraints over IDENT-BOT predicts that the IDENT-BOT constraint is satisfied unless the satisfaction of it would generate forms that involve highly marked forms or tonal changes at the prominent position.

The phenomena observed above are by no means unique to Hakha-Lai tone sandhi. The same are also reported in the tone sandhi phenomena in Beijing Mandarin and Sixian-Hakka (Lin 2005d), in Boshan (Lin 2004b), in Chengdu (Lin 2005a, b), and in Tianjin (Lin 2003, 2005c). As summarized in (70), achieving identity between prosodically related forms plays important roles in these Chinese dialects, unless marked forms would occur. In that case, the identity between prosodically related forms is sacrificed. Therefore, the phenomena observed in Hakha-Lai are universal tendencies which deserve attention.

(70)

		Norm of Direc.	*Motivation*	*Unless the resultant outputs would involve*
a. T → **T**/ __T (R-prominent)	Tianjin	⇨	preserve identity between prosodically related outputs	highly marked sequences (Lin 2003, 2005c)
	Sixian -Hakka	⇨		highly marked sequences (Lin 2005d)
	Boshan	⇨		highly marked sequences (Lin 2004b)
b. T → **T**/ T__ L-prominent)	Chengdu	⇦		highly marked sequences (Lin 2005a, b)
	Hakha-Lai	⇦		highly marked sequences / tonal changes at the prominent edge

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哈卡倈語的變調對應性

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本篇論文的主旨在於討論藏緬語中，哈卡倈語的連讀變調現象。深究的重點是哈卡倈語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，哈卡倈語的變調方向基本上是由右而左。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在顯著位置（prominent position）有聲調變化或有標形式時，連讀變調方向就會發生改變。因此，變調的方向性可以由位置信實制約（positional faithfulness constraint），位置音韻制約（positional markedness constraint）和輸出－輸出信實制約（OO-faithfulness constraint）之間的排列順序而得到預測。