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Alternations and Preservations in Tone Sandhi of Meixian Hakka*

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This paper presents an Optimality-Theoretic analysis of disyllabic tone sandhi in Meixian Hakka. In this paper, the alternations of tones are identified as being motivated by dissimilatory and assimilatory force at the tone internal structure. Since the tonal changes occur under highly marked condition, several locally conjoined constraints are posited to capture them. At the same time, a series of IDENT(F) constraints integrated with tone features are introduced into the analysis in order to explain the selection of the most optimal outputs in the di-tonal grammar. This study also discusses the existence of two phonologically distinct mid level tones in the dialect.

Key words: Meixian Hakka, Optimality Theory, disyllabic tone sandhi, assimilation, dissimilation, local conjunction

1. Introduction and framework

Cheung's (2011) phonetic work on Meixian Hakka presents disyllabic tone sandhi rule as follows:

(1) Meixian Hakka tone sandhi rules
33 → 35 / _ 11, 41, <u>41</u>
41 → 33 / _ 11, 41, <u>41</u>
51 → 55 / _ 11, 41, 51, <u>41</u>

While the set of rules (1) given in Cheung's study may provide a general view of the tonal alternations, the study itself did not address the motivations/triggers of the tone sandhi nor the theoretical mechanisms of the alternation. The study also did not explain why several tones do not undergo tone sandhi under similar condition/context.[1] The purpose of the present study is therefore to fill this gap by exploring the tone internal structure and providing a constraint-based framework/grammatical model. The model is expected to provide an insight on how a ranking hierarchy of tone

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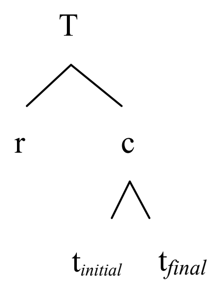
[1] As the tonal alternations are influenced by their adjacent tone, I suggest that Meixian Hakka tone sandhi belongs to contextual tone sandhi.

related constraints triggers the tonal alternations. Within the hierarchy, I will also illustrate how several tones and/or tonal features are retained in the dialect. The thorough examination of the internal structure and the proposed constraint-based model should allow us to have a more comprehensive understanding of Meixian Hakka disyllabic tone sandhi.

To investigate the internal structure of the tone, this paper adopts Bao's (1990) tonal geometry and some of the notations presented in Chen (2000:82).

(2) Tonal representation



T = tone, tone root (e.g., 55, 33, 31)
r = register (high/low register, or [+upper]/[-upper])
c = contour (level/fall/rising)
$t_{initial}$/t_{final} = terminal node with high (h) or low (l) pitch/tone melody

In this model, binary terminal nodes containing tone melody/pitch target are dominated by the contour node while both contour node and register node are dominated by the tonal node. Register value serves as a distinctive feature for tones with similar contour. For example, if a tonal system in the language has two falling tones, then the one with the higher pitch will be considered as the high-registered [+upper] variant and the lower one will be considered as the low-registered [-upper] variant.[2]

The study is couched within Optimality Theory (OT; Prince & Smolensky 1993/2004, McCarthy & Prince 1993). The IO-Identity constraint family, IDENT(F), will particularly be considered in the tone sandhi analysis. I will integrate the tonal features of the tonal geometry (2) into a set of IDENT constraints. Some of these faithfulness constraints are specified to be undominated in rank to present particular preservational effects in the di-tonal grammar.

(3) IDENT [F] (identity): Correspondent segments are identical with respect to feature F.

To capture the highly marked construction tone sandhi in Meixian Hakka, this paper applies the theory of Conjunction Constraint, which is intended to exclude the

[2] I would like to refer the reader to Chen (2000:78-101) for a discussion on the tonal representation and how such a model makes more complete typological predictions compared to alternative models.

worst of the worst candidates (Smolensky 1993, 1995, Itô & Mester 1998, Łubowicz 2002, 2005). In the theory, constraints in CON are locally conjoined into a more complex constraint in order to rule out an unwanted candidate, an effect that cannot be achieved by a single constraint. Itô & Mester (1998:10) define the local conjunction constraint as follows:

(4) Local conjunction of constraints

a. Definition

Local conjunction is an operation based on the constraint set forming composite constraints: Let C1 and C2 be members of the constraint set CON. Then their local conjunction C1 & C2 is also a member of CON.

b. Interpretation

The local conjunction C1 & C2 is violated if and only if both *C1 and *C2 are violated in some domain δ.

c. Ranking (universal)

C1 & C2 >> C1

C1 & C2 >> C2

In this paper, I adopt two approaches of local conjunction of markedness constraints: Lin's (2011) strategy that combines assimilation and dissimilation constraints with tonal markedness constraints in order to capture some tone sandhi in Dongshi Hakka, and Fukuzawa's (2001:236) double OCP approach towards stop alternation in Yucatec Maya.

2. Tone inventory and tone sandhi patterns

This study is constructed on the phonetic work of Cheung (2011), which focuses on the spoken variety in Meijiang District of Meixian County, China. In Table 1, the tone inventory and alternations reported in Cheung (2011) are presented and articulated in a way consistent with Bao's tonal geometry (2).

Table 1. Meixian Hakka tone inventory

Underlying/base tones			Sandhi/derived tones		
tone 1	=	33 (Hr,ll)	Derived tone 1	=	35 (Hr,lh)
tone 2	=	11 (Lr, ll)	n.a.		
tone 3	=	41 (Lr, hl)	Derived tone 3	=	33 (Lr,hh)
tone 4	=	51 (Hr,hl)	Derived tone 4	=	55 (Hr, hh)
tone 5	=	55 (Hr,hh)	n.a.		
tone 6	=	41 (Lr, hl)	n.a.		

In Table 1, two mid level tones[3] that are represented with different register values can be recognized, underlying tone 1 and derived tone 3. Their different register feature is argued to be related to the undominated ranking of IDENT-r, a faithfulness constraint that restricts a different input-output mapping in register (to be elaborated in Section 3.3). The undominated status of IDENT-r implies that the register feature between the underlying tone and its derived tone must be correspondingly identical. Thus, underlying mid level tone 1 must have a similar high register feature in order to correspond to its derived tone which has a high register feature; mid level derived tone 3 must have low register feature in order to correspond to its underlying tone.

Moreover, in Table 2, I present a 6x6 di-tonal combinations in Meixian Hakka with their internal register and pitch values. The structural information provided in the table provides more details about the alternations and preservations of di-tonal combinations, which allow one to identify what kinds of features change, and what triggers the change.

[3] The existence of two mid level tones within Chinese dialects is observable; Cantonese, for example, has two underlying mid level tones (Chan 1987 as cited in Yip 2001:312).

Table 2. Di-tonal combinations

S2 / S1	tone 1 33 Hr, ll	tone 2 11 Lr, ll	tone 3 41 Lr, hl	tone 4 51 Hr, hl	tone 5 55 Hr, hh	tone 6 41 Lr, hl
tone 1 33 Hr, ll	33-33 Hr-Hr ll-ll	**35**-11 Hr-Lr lh-ll	**35**-41 Hr-Lr lh-hl	33-51 Hr-Hr ll-hl	33-55 Hr-Hr ll-hh	**35**-41 Hr-Lr lh-hl
tone 2 11 Lr, ll	11-33 Lr-Hr ll-ll	11-11 Lr-Lr ll-ll	11-41 Lr-Lr ll-hl	11-51 Lr-Hr ll-hl	11-55 Lr-Hr ll-hh	11-41 Lr-Lr ll-hl
tone 3 41 Lr, hl	41-33 Lr-Hr hl-ll	**33**-11 Lr-Lr hh-ll	**33**-41 Lr-Lr hh-hl	41-51 Lr-Hr hl-hl	41-55 Lr-Hr hl-hh	**33**-41 Lr-Lr hh-hl
tone 4 51 Hr, hl	51-33 Hr-Hr hl-ll	**55**-11 Hr-Lr hh-ll	**55**-41 Hr-Lr hh-hl	**55**-51 Hr-Hr hh-hl	51-55 Hr-Hr hl-hh	**55**-41 Hr-Lr hh-hl
tone 5 55 Hr, hh	55-33 Hr-Hr hh-ll	55-11 Hr-Lr hh-ll	55-41 Hr-Lr hh-hl	55-51 Hr-Hr hh-hl	55-55 Hr-Hr hh-hh	55-41 Hr-Lr hh-hl
tone 6 41 Lr, hl	41-33 Lr-Hr hl-ll	41-11 Lr-Lr hl-ll	41-41 Lr-Lr hl-hl	41-51 Lr-Hr hl-hl	41-55 Lr-H hl-hh	41-41 Lr-Lr hl-hl

From Table 2, I make several generalizations regarding the tone sandhi in Meixian Hakka, as given in the following:

1) The different input-output tone mapping is only found in the left syllable.
2) The alternation can be divided into two types: dissimilation and assimilation. The dissimilation type is divided into two kinds:
   i. Intersyllabic dissimilation of a low pitch when the right syllable tone is a low register tone, e.g., 33(Hr,l**l**)-(**l**l,**Lr**)11 → 35 (Hr,l**h**)-(**l**l,**Lr**)11; 33(Hr,l**l**)-(**l**l,**Hr**)33 → *35 (Hr,l**h**)-(**l**l,**Hr**)33
   ii. Intersyllabic dissimilation of a falling contour when both syllables are high register tones, e.g., 51(**Hr, fall**)-(**fall**,**Hr**)51 → 55 (**Hr, level**)-(**fall**,**Hr**)51; 41(**Lr, fall**)-(**fall**,**Hr**)51 → *33 (**Lr, level**)-(**fall**,**Hr**)51

   The assimilation type tone sandhi only targets the terminal node when the right syllable is a low register tone, e.g., 33(Hr, l**l**)-(**h**l,**Lr**)41 → 35(Hr,l**h**)- (**h**l,**Lr**)41; 33(Hr, l**l**)-(**h**l,**Hr**)51 → *35(Hr,l**h**)-(**h**l,**Hr**)51

3) When two forces targeting the sequence at a terminal node level (intersyllabic assimilation and dissimilation) are existent in the grammar, dissimilation is preferred in the grammar. Such a condition is captured by ranking the dissimilatory constraint higher in the constraint hierarchy than assimilatory constraints (to be discussed in Section 3.3).
4) These alternations, however, do not affect the value of their register tier, initial terminal node, and tonal duration.
5) There are 3 tones, 11, <u>41</u>, and <u>55</u>, that do not undergo any tonal change despite being found in the same environment.

3. OT analysis

The analysis of Meixian Hakka's tone sandhi is based on the generalization made from the previous section. The dissimilatory and assimilatory types of tone sandhi will be presented in this section along with certain preservations of structural values for the input tones, and a table showing how the unattested outputs of the di-tonal sequence that undergo sandhi are ruled out. I would like to remark on three elements that never change their forms before proceeding to the analysis of the alternations. First, Meixian Hakka's disyllabic tone sandhi always targets the first tone. Therefore, this paper assumes that the second syllable is the head, which is protected by the undominated IDENT-HD (adopted also by Lin 2011:323). Second, short/*ru* tones in Meixian Hakka remain identical and therefore are protected from changes by IDENT-ST. Third, tonal duration in Meixian Hakka keeps the same value. For example, if a long/*shu* tone is given as an input then it will surface as a long tone/*shu*.

(5) IDENT-T-HD: Assign one violation mark for every output tone in the head position that differs from its input correspondent.
(6) IDENT-ST: Assign one violation mark for every output short tone that differs from its input correspondent.
(7) IDENT-TD[4]: Assign one violation mark for every output tone that differs from its input correspondent in the tone duration feature.

[4] This constraint is motivated by alternation of 51 (Hr,hl) to 55 (Hr,hh). This constraint will rule out *<u>55</u>(Hr,<u>hh</u>).

3.1 Dissimilatory and assimilatory tone sandhi

The first type of tonal alternations that I analyze is the dissimilatory tone sandhi, which can be captured by OCP constraints (Obligatory Contour Principle; Leben 1973, Goldsmith 1976, McCarthy 1986). As I have identified in the previous section, there are two kinds of tonal dissimilation: dissimilation of a low level pitch at the terminal node and dissimilation of a falling contour.

The first kind of dissimilation is triggered by the existence of a low register tone on the right/head syllable. I capture this type of tone sandhi by adapting Lin's (2011) approach that conjoins OCP constraint(s) with tonal markedness constraints (de Lacy 2002) at the head position.

(8) OCP-t(l): Assign one violation mark for every pair of tones that have a sequence of intersyllabic low pitch values at the terminal node.[5]

(9) *HD/Lr: Assign one violation mark for a tone in the head position that has a low register feature.

(10) [OCP-t(l)&*HD/Lr]$_{\text{Dis}}$: Assign one violation mark for every tonal pair that violates both OCP-t(l) and *HD/Lr. Local domain: disyllabic tonal pair.[6]

(11) IDENT-T: Assign one violation mark for every output tone that differs from its input correspondent.

Overall, tableaux (12) and (13) illustrate how the alternation of the tones with a low-registered head tone is captured by [OCP-t(l)&*HD/Lr]$_{\text{Dis}}$.

(12) *tsu*33-*p^hi*11 → *tsu*35- *p^hi*11 'pork skin'

33-11 Hr-Lr ll-ll	[OCP-t(l) &*HD/Lr]$_{\text{Dis}}$	IDENT-T	OCP-t(l)	*HD/Lr
☺ a. 35-11 Hr-Lr l[h-l]l		*		*
b. 33-11 Hr-Lr l[l-l]l	*!W	L	*	*

[5] To avoid the OCP effect taking place within a syllable, (Hr,[ll]) → (Hr,[hl]), it is necessary to define the domain of violation of the OCP as only occurring at the intersyllabic adjacent terminal node.

[6] One reviewer points out the potential for an over-generation effect of the local conjunction constraints proposed/adapted in this paper. Nevertheless, the phenomena identified in this study are observable in other Chinese dialects (Chen 2000:107-109, Lin 2011). Thus, generation of patterns unattested in different dialects by the conjoined constraints is minimal.

(13) *pu*41-*t^h^eu* 11/ → *pu*33-*t^h^eu* 11 'axe'

41-11 Lr-Lr hl-ll	[OCP-t(l) &*HD/Lr]Dis	IDENT-T	OCP-t(l)	*HD/Lr
☺ a. 33-11 Lr-Lr h[h-l]l		*		*
b. 33-11 Hr-Lr l[l-l]l	*!W	L	*	*

(14) *tsa*51-*t^h^eu*11/→*tsa*55- *t^h^eu*11 'sugarcane'

51-11 Hr-Lr hl-ll	[OCP-t(l) &*HD/Lr]Dis	IDENT-T	OCP-t(l)	*HD/Lr
☺ a. 55-11 Hr-Lr h[h-l]l		*		*
b. 51-11 Hr-Lr H[l-l]l	*!W	L	*	*

(15) *si*33-*kua*33 → *si*33-*kua*33 'watermelon'

33-33 Hr-Hr ll-ll	[OCP-t(l) &*HD/Lr]Dis	IDENT-T	OCP-t(l)	*HD/Lr
☺ a. 33-33 Hr-Hr l[l-l]l			*	
b.35-33 Hr-Hr l[h-l]l		*!W		

Tableaux (12), (13), and (14) present the tonal alternations that forbid the sequence of an intersyllabic low pitch when the head is a low register tone. Ranking [OCP-t(l)&*HD/Lr]Dis above IDENT-T triggers this tone sandhi. In tableau (15), the faithful candidate (a), 33-33, surfaces as the optimal candidate due to the local conjoined constraint, [OCP-t(l)&*HD/Lr]$_{Dis}$, not targeting this pair as the head tone belongs to the high register. The markedness constraints, OCP-t(l) and *HD/Lr, have no effect on the di-tonal grammar and are ranked below IDENT-T.

The second kind of dissimilation pair that can be captured by OCP-based constraint is the input pair 51(Hr,hl)-(hl,Hr)51 that changes to 55(Hr,hh)-(hl,Hr)51. The left syllable high falling tone alternates into a high level tone. After examining the structure of the tonal combinations, I suggest that another OCP-based constraint conjunction is needed in order to prevent a sequence of falling tones when the register values of both tones are high. Thus, I posit a conjoined constraint consisting of two OCP constraints that target a sequence of high register tones with falling contour. This constraint should rank higher than faithfulness IDENT-T.

(16) OCP-c(fall): Assign one violation mark for every pair of tones that has an intersyllabic falling contour.

(17) OCP-r(H): Assign one violation mark for every pair of tones that has an intersyllabic high register value.

(18) [OCP-c(fall)&OCP-r(H)]$_{Dis}$: Assign one violation mark for every tonal pair that violates both OCP-c(fall) and OCP-r(H). Local domain: Disyllabic tonal pair.

(19) *fu*51-*kui*51 → *fu*55-*kui*51 'wealth'

51-51 [Hr-Hr] [fall-fall] hl-hl	[OCP-c(fall) &OCP-r(H)]$_{Dis}$	IDENT-T	OCP c(fall)	OCP-r(H)
☺ a. 55-51 [Hr-Hr] [level-fall] hh-hl		*		*
b.51-51 [Hr-Hr] [fall-fall] hl-hl	*!W	L	*	*

Tableau (19) illustrates the tonal alternations that are captured by [OCP-c(fall)&OCP-r(H)]$_{Dis}$, which forbids the sequence of high-registered falling tones. The other two single OCP constraints are outranked by IDENT-T and therefore inactive in the disyllabic tonal grammar of Meixian Hakka.

The second type of alternation is intersyllabic tonal melody assimilation when the right syllable is a low register tone. I adopt Lin's (2011) strategy in conjoining the NOJUMP constraint (Hyman & VanBik 2004) with the tonal markedness constraint *HD/Lr.

(20) NOJUMP-t: Assign one violation mark for every pair of tones that has a different intersyllabic pitch value.

(21) [NOJUMP-t&*HD/Lr]$_{Dis}$ (Lin 2011): Assign one violation mark for every tonal pair that violates both NOJUMP-t and *HD/Lr. Local domain: disyllabic tonal pair.

(22) *tsu*33-*tu*41 → *tsu*35-*tu*41 'pork bowel'
*su*33-*tsok*41 → *su*35-*tsok* 41/41 'desk'

33-41/41 Hr-Lr ll-hl	[NOJUMP-t &*HD/Lr]$_{Dis}$	IDENT-T	NOJUMP-t	*HD/Lr
☺ a. 35-41/41 Hr-Lr l[h-h]l/hl		*		*
b. 33-41/41 Hr-Lr l[l-h]l/hl	*!W	L	*	*

(23) *pu*41-k^h*au*41 → *pu*33-k^h*au*41 'make-up examination'
*tu*41-*pok*41 → *tu*41-*pok*41 'gambling'

41-41/41 Lr-Lr ll-hl	[NOJUMP-t &*HD/Lr]$_{Dis}$	IDENT-T	NOJUMP-t
☺ a. 33-41/41 Lr-Lr l[h-h]l/hl		*	
b. 33-41/41 Hr-Lr l[l-h]l/hl	*!W	L	*

(24) *ki*51-*tsa*41 → *ki*55-*tsa*41 'reporter'
*fu*51-*tsuk*<u>41</u> → *fu*55-*tsuk*<u>41</u> 'tofu skin'

41-41/<u>41</u> Lr-Lr hl-hl	[NOJUMP-t &*HD/Lr]$_{Dis}$	IDENT-T	NOJUMP-t
☺ a. 33-41/<u>41</u> Lr-Lr h[h-h]l/<u>hl</u>		*	
b. 33-41/<u>41</u> Hr-Lr l[l-h]l/<u>hl</u>	*!W	L	*

The argument that [NOJUMP-t&*HD/Lr]$_{Dis}$ must rank higher than the faithfulness constraint IDENT-T is corroborated through observation of the tableaux (22), (23), and (24). All of the faithful candidates (b) in the tableaux satisfy IDENT-T but violate [NOJUMP-t&*HD/Lr]$_{Dis}$ so they are ruled out in the grammar as optimal outputs.

3.2 Preference for dissimilation over assimilation

Meixian Hakka di-tonal grammar prefers dissimilation of intersyllabic low tone melody to assimilation of intersyllabic tone melody. Within OT framework, this preference is expressed by ranking the dissimilation constraint [OCP-t(l)&*HD/Lr]$_{Dis}$ higher than the assimilation constraint [NOJUMP-t &*HD/Lr]$_{Dis}$ in the hierarchy. The output that present the argument for this ranking can be identified by a sequence of 41-11 that changes to 33-11 as shown in (25a) which satisfies a higher ranked [OCP-t(l)&*HD/Lr]$_{Dis}$ while violating [NOJUMP-t&*HD/Lr]$_{Dis.}$

(25) [OCP-t(l)&*HD/Lr]$_{Dis}$ >> [NOJUMP-t&*HD/Lr]$_{Dis}$
*pu*41-*t*^{h}*eu* 11 → *pu*33-*t*^{h}*eu* 11 'axe'

41-11 Lr-Lr hl-ll	[OCP-t(l) &*HD/Lr]$_{Dis}$	[NOJUMP-t&*HD/Lr]$_{Dis}$
☺ a. 33-11 Lr-Lr h[h-l]l		*
b. 41-11 Lr-Lr h[l-l]l	*!W	L

3.3 Preservation of structural features

In Meixian Hakka di-tonal grammar, every derived tone is identical in value to its underlying counterpart, for example, when the input tone has a high register value, the output tone must also have a high register value. Such faithful input-output mapping of the register feature explains the duality in the status of mid-level tones in this dialect, as presented in Table 1. In this constraint-based analysis, the two-register-feature stability is governed by an undominated IDENT-r constraint (26).

(26) IDENT-r: Assign one violation mark for every output tone that differs from its input correspondent in register.

(27) Preservation of high register value
*tsu*33-*p^h^i*11 → *tsu*35-*p^h^i*11 'pork skin'

33-11 Hr-Lr ll-ll	IDENT-r	[OCP-t(l) &*HD/Lr]$_{Dis}$
☺ a. 35-11 [Hr]-Lr lh-ll		
b. 33-11 [Lr]-Lr hh-ll	*!W	

(28) Preservation of low register value
*pu*41-*t^h^eu*11 → *pu*33-*t^h^eu*11 'axe'

41-11 Lr-Lr hl-l	IDENT-r	[OCP-t(l) &*HD/Lr]$_{Dis}$
☺ a. 33-11 [Lr]-Lr hh-ll		
b. 35-11 [Hr]-Lr lh-ll	*!W	

Tableaux (27) and (28) above illustrate the tonal alternations triggered by the highly ranked conjunction constraint, [OCP-t(l) &*HD/Lr]$_{Dis}$. But instead of alternating to a candidate with a different register value, as shown from the tableaux, Meixian Hakka di-tonal grammar prefers a tone with only a difference in tone melody. The high ranked IDENT-r serves as a determinant for selecting the optimal output in Meixian Hakka di-tonal grammar.

I assume that there are two terminal nodes in the tonal geometry (2). Each of them contains a pitch target (see Yip 2001 on the discussion of initial and final phonetic target of tone). This binary terminal node plays a role in our analysis since the selection of the optimal output in Meixian Hakka relies on the pitch value of the terminal node. As has been observed, structurally, the pitch value of the initial terminal node in Meixian Hakka does not change its pitch, as shown below:

1) 33 (Hr,ll) → 35 (Hr,lh), *51 (Hr,hl), *55 (Hr,hh)
2) 41 (Lr,hl) → 33 (Lr,hh), *11 (Lr, ll)
3) 51 (Hr,hl) → 55 (Hr,hh), *35 (Hr, lh)

I propose that this identical input-output tone melody feature is governed by an undominated ranking of a faithfulness constraint that integrates the initial feature of terminal nodes.

(29) IDENT-t*initial*: Assign one violation for every output tone that differs from its input correspondent in the terminal node initial feature.

(30) Preservation of the initial terminal node value

33-11 Hr-Lr ll-ll	IDENT-t*initial*	IDENT-r	[OCP-t(l) &*HD/Lr]$_{Dis}$
☺ a. 35-11 Hr-Lr [l]h-ll			
b. 55-11 Hr-Lr [h]h-ll	*!W		

Tableau (30) demonstrates two tonal pairs and neither of which violate the markedness constraint [OCP-t(l)&*HD/Lr]$_{Dis}$ or IDENT-r. Therefore, IDENT-t*initial* is needed to promote candidate (30a) to be the best candidate. Without it, both candidates could surface as optimal candidates.

3.4 *ALIEN

This study also adapts the markedness constraint *ALIEN (Krämer 2002:46), which is undominated in rank in the grammar, to rule out tones that do not exist in the inventory (underlying and derived tones) as optimal candidates. At the same time, this markedness constraint, along with faithfulness constraints IDENT-$t_{initial}$ and IDENT-r, contributes to the preservation of several di-tonal combinations (11-11, 11-41, and 11-<u>41</u>) that are subject to markedness constraints, [OCP-t(l)&*HD/Lr]$_{Dis}$ and [NOJUMP-t&*HD/Lr]$_{Dis}$.

(31) *ALIEN: Assign one violation mark for every non-inventory tone that surfaces in the output, e.g., *13

(32) *ALIEN, IDENT-$t_{initial}$, IDENT-r>> [OCP-t(l)&*HD/Lr]$_{Dis}$

p^h*i*11-*k*^{h}*iu*11 → *p*^{h}*i*11-*k*^{h}*iu*11 'ball made of leather'

11-11 Lr-Lr ll-ll	*ALIEN	IDENT-$t_{initial}$	IDENT-r	[OCP-t(l) &*HD/Lr]$_{Dis}$
☺ a. 11-11 Lr-Lr ll-ll				*
b. 13-11 Lr-Lr lh-ll	*!W			L
c. 33-11 Lr-Lr hh-ll		*!W	*!W	L
e. 55-11 Hr-Lr hh-ll		*!W	*!W	L

3.5 Meixian Hakka di-tonal hierarchy

After going through every single tone alternation and preservation of certain structural values, I summarize the rankings of the constraints into a hierarchy in (33). This ranking serves as a parameter in which every tonal pair generated by GEN will be sorted in order to have the optimal candidate surface. In Table 3, I provide a list of possible outputs of the di-tonal combinations that undergo tone sandhi as well as the crucial constraints that function to rule out the unattested outputs. The list contains candidates from the tonal inventory since non-inventory tones are ruled out by *ALIEN. In the list, I include a column with highly ranked constraints that rule out the losing candidates.

(33) Meixian Hakka di-tonal hierarchy

IDENT-T-HD, IDENT-ST, IDENT-TD, IDENT-r, IDENT-t$_{initial}$, *ALIEN
>> [OCP-t(l)&*HD/Lr]$_{Dis}$, [OCP-c(fall)&OCP-r(H)]$_{Dis}$
>> [NOJUMP-t&*HD/Lr]$_{Dis}$
>> IDENT-T
>> OCP-t(l), NOJUMP-t, OCP-c(fall), OCP-r(H), *HD/Lr

Table 3. List of optimal and non-optimal candidates of di-tonal sandhi pairs

Input Tones	Input Combinations That Alternate	Outputs	Ruled Out By
33 (Hr,ll)	33-11 [(Hr,ll)-(ll,Lr)]	35-11 [(Hr,lh)-(ll,Lr)]	Winning Candidate
		*33-11 [(Hr,l)-(l,Lr)]	[OCP-t(l)&*HD/Lr]$_{Dis}$
		*11-11 [(Lr,ll)-(ll,Lr)]	IDENT-r
		*41-11 [(Lr,hl)-(ll,Lr)]	IDENT-r
		*51-11 [(Hr,hl)-(ll,Lr)]	IDENT-t$_{initial}$
		*41-11 [(Lr,hl)-(ll,Lr)]	IDENT-r
		*55-11 [(Hr,hh)-(ll,Lr)]	IDENT-t$_{initial}$
		*33-11 [(Lr,hh)-(l,Lr)]	IDENT-r
		*55-11 [(Hr,hh)-(ll,Lr)]	IDENT-t$_{initial}$
33 (Hr,ll)	33-41 [(Hr,ll)-(hl,Lr)]	35-41 [(Hr,lh)-(hl,Lr)]	Winning Candidate
		*33-41 [(Hr,ll)-(hl,Lr)]	[NOJUMP-t&*HD/Lr]$_{Dis}$
		*11-41 [(Lr,ll)-(hl,Lr)]	IDENT-r
		*41-41 [(Lr,hl)-(hl,Lr)]	IDENT-r
		*51-41 [(Hr,hl)-(hl,Lr)]	IDENT-t$_{initial}$

Input Tones	Input Combinations That Alternate	Outputs	Ruled Out By
		*41-41 [(Lr,hl)-(hl,Lr)]	IDENT-r
		*55-41 [(Hr,hh)-(hl,Lr)]	IDENT-$t_{initial}$
		*33-41 [(Lr,ll)-(hl,Lr)]	IDENT-r
		*55-41 [(Hr,hh-hl,Lr)]	IDENT-$t_{initial}$
33 (Hr,ll)	33-41 [(Hr,ll)-(hl,Lr)]	35-41 [(Hr,lh)-(hl,Lr)]	Winning Candidate
		*33-41 [(Hr,ll)-(hl,Lr)]	[NOJUMP-t&*HD/Lr]$_{Dis}$
		*11-41 [(Lr,ll)-(hl,Lr)]	IDENT-r
		*41-41 [(Lr,hl)-(hl,Lr)]	IDENT-r
		*51-41 [(Hr,hl)-(hl,Lr)]	IDENT-$t_{initial}$
		*41-41 [(Lr,hl)-(hl,Lr)]	IDENT-r
		*55-41 [(Hr,hh)-(hl,Lr)]	IDENT-$t_{initial}$
		*33-41 [(Lr,ll)-(hl,Lr)]	IDENT-r
		*55-41 [(Hr,hh)-(hl,Lr)]	IDENT-$t_{initial}$
41 (Lr,hl)	41-11 [(Lr,hl)-(ll,Lr)]	33-11 [(Lr,hh)-(ll,Lr)]	Winning Candidate
		*41-11 [(Lr,hl)-(ll,Lr)]	[OCP-t(l)&*HD/Lr]$_{Dis}$
		*33-11 [(Hr,hh)-(ll,Lr)]	IDENT-r
		*11-11 [(Lr,ll)-(ll,Lr)]	IDENT-$t_{initial}$

Input Tones	Input Combinations That Alternate	Outputs	Ruled Out By
		*51-11 [(Hr,hl)-(ll,Lr)]	IDENT-r
		*41-11 [(Lr,hl)-(ll,Lr)]	IDENT-TD
		*55-11 [(Hr,hh)(ll,Lr)]	IDENT-r
		*35-11 [(Hr,lh)(ll,Lr)]	IDENT-r
		*55-11 [(Hr,hh)-(ll,Lr)]	IDENT-r
41 (Lr,hl)	41-41 [(Lr,hl)-(hl,Lr)]	33-41 [(Lr,hh)-(hl,Lr)]	Winning Candidate
		*41-41 [(Lr,hl)-(hl,Lr)]	IDENT-t$_{initial}$
		*33-41 [(Hr,ll)-(hl,Lr)	IDENT-r
		*11-41 [(Lr,ll)-(hl,Hr)]	IDENT-t$_{initial}$
		*51-41 [(Hr,hl)-(hl-Lr)]	IDENT-r
		*41-41 [(Lr,hl)-(hl,Lr)]	IDENT-TD
		*55-41 [(Hr,hh)-(hl,Lr)]	IDENT-r
		*35-41 [(Hr,lh)-(hl,Lr)]	IDENT-r
		*55-41 [(Hr,hh)-(hl,Lr)]	IDENT-r
41 (Lr,hl)	41-41 [(Lr,hl)-(hl,Lr)]	33-41 [(Lr,hh)-(hl,Lr)]	Winning Candidate
		*41-41 [(Lr,hl)-(hl,Lr)]	[NOJUMP-t&*HD/Lr]$_{Dis}$
		*33-41 [(Hr,ll)-(hl,Lr)	IDENT-r

Input Tones	Input Combinations That Alternate	Outputs	Ruled Out By
		*11-41 [(Lr,ll)-(hl,Hr)]	IDENT-t$_{initial}$
		*51-41 [(Hr,hl)-(hl-Lr)]	IDENT-r
		*41-41 [(Lr,hl)-(hl,Lr)]	IDENT-TD
		*55-41 [(Hr,hh)-(hl,Lr)]	IDENT-r
		*35-41 [(Hr,lh)-(hl,Lr)]	IDENT-r
		*55-41 [(Hr,hh)-(hl,Lr)]	IDENT-r
51 (Hr,hl)	51-11 [(Hr,hl)-(ll,Lr)]	55-11 [(Hr,hh)-(ll,Lr)]	Winning Candidate
		*51-11 [(Hr,hl)-(ll,Lr)]	[OCP-t(l)&*HD/Lr]$_{Dis}$
		*33-11 [(Hr,ll)-(ll,Lr)]	IDENT-t$_{initial}$
		*11-11 [(Lr,ll)-(ll,Lr)]	IDENT-r
		*41-11 [(Lr,hl)-(ll,Lr)]	IDENT-r
		*41-11 [(Lr,hl)-(ll,Lr)]	IDENT-r
		*55-11 [(Hr,hh)-(ll,Lr)]	IDENT-TD
		*33-11 [(Lr,hh)-(ll,Lr)]	IDENT-r
		*35-11 [(Hr,lh)-(ll,Lr)]	IDENT-t$_{initial}$
51 (Hr,hl)	51-41 [(Hr,hl)-(hl,Lr)]	55-41 [(Hr,hh)-(hl,Lr)]	Winning Candidate
		*51-41 [(Hr,hl)-(hl,Lr)]	[NOJUMP-t&*HD/Lr]$_{Dis}$

Input Tones	Input Combinations That Alternate	Outputs	Ruled Out By
		*33-41 [(Hr,ll)-(hl,Lr)]	IDENT-t$_{initial}$
		*11-41 [(Lr,ll)-(hl,Lr)]	IDENT-t$_{initial}$
		*41-41 [(Lr,hl)-(hl,Lr)]	IDENT-t$_{initial}$
		*41-41 [(Lr,hl)-(hl,Lr)]	IDENT-TD
		*55-41 [(Hr,hh)-(hl,Lr)]	IDENT-TD
		*33-41 [(Lr,hh)-(hl,Lr)]	IDENT-t$_{initial}$
		*35-41 [(Hr,lh)-(hl,Lr)	IDENT-t$_{initial}$
51 (Hr,hl)	51-51 [(Hr,hl)-(hl,Lr)]	55-51 [(Hr,hh)-(hl,Hr)]	Winning Candidate
		*51-51 [(Hr,hl)-(hl,Hr)]	[OCP-c(fall)& OCP-r(H)]$_{Dis}$
		*33-51 [(Hr,ll)-(hl,Hr)]	IDENT-t$_{initial}$
		*11-51 [(Lr,ll)-(hl,Hr)]	IDENT-r
		*41-51 [(Lr,hl)-(hl,Hr)]	IDENT-r
		*41-51 [(Lr,hl)-(hl,Hr)]	IDENT-r
		*55-51 [(Hr,hh)-(hl,Hr)]	IDENT-TD
		*33-51 [(Lr,hh)-(hl,Hr)]	IDENT-r
		*35-51 [(Hr,lh)-(hl,Hr)]	IDENT-t$_{initial}$
51 (Hr,hl)	51-41 [(Hr,hl)-(hl,Hr)]	55-41 [(Hr,hh)-(hl,Lr)]	Winning Candidate

Input Tones	Input Combinations That Alternate	Outputs	Ruled Out By
		*51-41 [(Hr,hl)-(hl,Lr)]	[NOJUMP-t&*HD/Lr]$_{Dis}$
		*33-41 [(Hr,ll)-(hl,Lr)]	IDENT-t$_{initial}$
		*11-41 [(Lr,ll)-(hl,Lr)]	IDENT-r
		*41-41 [(Lr,hl)-(hl,Lr)]	IDENT-r
		*41-41 [(Lr,hl)-(hl,Lr)]	IDENT-r
		*55-41 [(Hr,hh)-(hl,Lr)	IDENT-TD
		*33-41 [(Lr,hh)-(hl,Lr)]	IDENT-r
		*35-41 [(Hr,lh)-(hl,Lr)	IDENT-t$_{initial}$

4. Conclusion

This paper analysed thoroughly the phonology of Meixian Hakka disyllabic tone sandhi which had been stated only in a set of rules in Cheung's (2011) study. The present study aimed to provide a deeper understanding of the disyllabic grammar: (a) identifying the motivation of the disyllabic tone alternation in Meixian Hakka through the exploration of the internal structure of the tones; and (b) proposing a constraint-based grammar for the tonal alternations. After carefully observing each di-tonal combination, I suggested that Meixian Hakka tone sandhi belonged to dissimilation and assimilation types of alternations that take place under specific environments. To capture the tone sandhi, this paper utilized the concept of local conjunction, which combines two single constraints to capture the tonal alternations. In particular, I adapted two types of constraint conjunctions to account for the tone sandhi: Lin's (2011) strategy combining either OCP or NOJUMP constraints with head-sensitive tonal markedness constraints and Fukuzawa's (2001) double OCP approach. Nonetheless, I found that the selection of the optimal output cannot be solely determined by the ranking of the markedness constraints. It also relied on the satisfaction of a series of undominated IDENT(F) constraints, integrated with tonal features. In this paper, I also recognized the existence of two mid-level tones based on the fact that Meixian Hakka does not allow the register feature to alter. Their faithfulness to their register features is governed by IDENT-r which holds an undominated ranking in the di-tonal grammar.

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梅縣客語雙音節變調之轉換與保留

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本研究以優選理論（Optimality theory, OT）分析梅縣客語的雙音節變調。梅縣客語的雙音節變調，是由聲調內部的兩股力量所驅動－異化（dissimilation）和同化（assimilation）。本研究提出與變調有關的聯合制約（conjoined constraints），以解釋其聲調發生改變的特殊情況；同時，為了在雙音節的文法中選出最佳的輸出值（outputs），一系列與聲調特徵相關的信實制約（IDENT(F) constraints）也被納入分析之中。最後，本研究也討論了梅縣客語中兩個不同的中平調（mid level tones）。

關鍵詞：梅縣客語、優選理論、雙音節變調、同化、異化、聯合制約