

Interlanguage Tone Sandhi: A Constraint Based Approach to tone sandhi in Mandarin-Min Code-Mixing*

Hui-shan Lin
National Tsing Hua University

A rule-based analysis is not very promising in accounting for tone sandhi in Mandarin-Min code-mixing. This paper provides a non-derivational analysis to this tone sandhi phenomenon under the Optimality Theory (Prince & Smolensky 1993). A set of constraints, which includes the EquiDom constraint, the ParseR constraint, the $*T^{\text{Min}}$ constraint, the CCP-L constraint, and the IO-Ident constraint, are proposed. With this constraints set, tone sandhi in Mandarin-Min code-mixing is accounted for naturally.

Keywords: Mandarin-Min code-mixing, tone sandhi, Optimality Theory, universal constraints

1. Introduction

This paper investigates tone sandhi in terms of code-mixing data between two Chinese languages, Mandarin and Southern Min. The issue explored here is the interaction of tone sandhi rules in these two languages. The Mandarin tone sandhi rule ($L \rightarrow LH/__L$) and the Southern Min tone sandhi rule ($T \rightarrow T'/__T$). Previous study (Hsiao and Lin 1999b) shows that in Mandarin-Southern Min code-mixing, the tone sandhi rule of Southern Min must be ordered extrinsically before the tone sandhi rule of Mandarin. The present study argues, however, that the demand for an extrinsic rule ordering between Mandarin and Southern Min tone sandhi rules is inadequate. Instead, an Optimality Theory (OT) approach is needed, where the tonal output in Mandarin-Min code-mixing can be accounted for without multi-stage derivations. Section 2 offers a brief introduction of the tonotactic systems of Mandarin and Southern Min. Section 3 reviews Hsiao and Lin's (1999a, 1999b) analyses of tone sandhi in code-mixing. Section 4 offers an OT solution of the tonal problems in questions. Section 5 concludes this paper.

2. Tonotactics of Mandarin and Southern Min

2.1 Tonotactics of Mandarin

Mandarin has four tones: high level (H), rising (LH), low (L)¹ and falling (HL). In Mandarin, adjacent low tones are prohibited to occur in an adjacent string. When there are, the first low tone changes to a LH tone. The rule that captures this phenomenon is known as below:

(1) Mandarin Tone Sandhi Rule:

$$L \rightarrow LH/_L$$

Example (2) illustrates how this rule accounts for tone sandhi in Mandarin.

(2) ‘umbrella’

	yu	san
	rain	umbrella
base tone	L	L
Mandarin tone sandhi rule	LH	
sandhi tone	LH	L

In (2), there are two adjacent low tones, the low tone of *yu* and the low tone of *san*; therefore, the Mandarin tone sandhi rule applies and changes the first low tone to a sandhi tone

2.2 Tonotactics of Southern Min

There are seven base tones in Southern Min, five smooth tones (e.g. HH, HL, LL, LM and MM) and two checked tones (e.g. M and H).² Each has a corresponding

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** Code-mixing here refers to intra-sentential code-mixing.

¹ This paper follows the notation used in Shih (1986) and Hsiao (1991) to represent the Mandarin third tone as a low (L) tone since the phonological function of Mandarin third tone is a low.

² Generally, this paper follows Hsiao's (1991, 1995) notations to represent the Southern Min tones according to their beginning and end points (e.g. HH represents a high level tone) and these notations are irrelevant to the Obligatory Contour Principle, which prohibit two adjacent identical elements (Leben 1973; Goldsmith 1976). The base tone of Ying Qu and the sandhi tone of Yang Qu can be represented

sandhi tone in the non-final position (of a domain), as illustrated in (3). For example, the base tone of *tang* (3a) is HH, but when it occurs in non-final position, it surfaces with a MM.

(3)	Tone Category	Base Tone	Sandhi Tone
a.	Ying Pin	<i>tang</i> ‘East’ HH	<i>tang po</i> ‘Eastern’ MM
b.	Yin Shang	<i>tong</i> ‘party’ HL	<i>tong po</i> ‘party organization’ HH
c.	Yin Qu	<i>tong</i> ‘ridgepole’ LL	<i>tong niu</i> ‘pillar’ HL
d.	Yin Ru	<i>tok</i> ‘supervise’ M	<i>tok hak</i> ‘educational inspector’ H
e.	Yang Ping	<i>tong</i> ‘same’ LM	<i>tong hak</i> ‘schoolmate’ MM
f.	Yang Qu	<i>sia</i> ‘thank’ MM	<i>sia le</i> ‘thanking gift’ LL
g.	Yang Ru	<i>tok</i> ‘poison’ H	<i>tok ioh</i> ‘toxicant’ M

In other words, in Southern Min, base tones are prohibited to occur in an adjacent string. A general rule that accounts for these tone sandhi phenomena is known as below:

(4) Southern Min Tone Sandhi Rule:

$$T \rightarrow T' / _ T \quad (T = \text{base tone}, T' = \text{sandhi tone})$$

Example (5) illustrates how this rule accounts for tone sandhi in Southern Min.

(5) ‘thanking gift’

	<i>sia</i>	<i>le</i>
	thank	gift
base tone	MM	HL
Southern Min tone sandhi rule	LL	
sandhi tone	LL	HL

In (5), there are two base tones in an adjacent string, the base tone of *sia* and the base tone of *le*; therefore, the Southern Min tone sandhi rule applies and changes the base

as ML or LL. For ease of discussion, they are represented as LL in this paper.

tone of *sia* to a sandhi tone.

2. Derivational approach to tone sandhi in Mandarin-Southern Min code-mixing

In their observations of tone sandhi in Mandarin-Southern Min code-mixing, Hsiao and Lin (1999a, 1999b) present three very interesting findings. First, they show that in the event of code-mixing, a Mandarin base tone can cause its preceding Southern Min tone to undergo Southern Min tone sandhi and a Southern Min low tone can cause its preceding Mandarin tone to undergo Mandarin tone sandhi. Second, in code-mixing, the Mandarin utterances are still subject to the Mandarin tone sandhi domain³ and Southern Min utterances are still subject to the Southern Min tone sandhi domain.⁴ Third, they show that in code-mixing, the two tone sandhi rules involved apply following an extrinsic order,⁵ where the Southern Min tone sandhi rule must apply before the Mandarin tone sandhi rule to derive the correct output. Their observations can be illustrated by the following example.⁶ (In the following examples, the Southern Min parts are boldfaced, and the Mandarin parts are not).

(6) ‘The dog bites President Li.’

gou	ka	li	zong	tong		
dog	bite	Li	president			
	#			#	Southern Min tone sandhi domain	
()	()	Mandarin tone sandhi domain
L	MM	L	L	L	Base Tone	

³ Hsiao and Lin (1999b) follow Shih’s (1986) Foot Formation Rule and define the Mandarin tone sandhi domain as a prosodic foot.

Foot Formation Rule (FFR) (Shih’s 1986: 110)

Foot (f) Construction

- a. IC: Link immediate constituents into disyllabic feet.
- b. DM: Scanning from left to right, string together unpaired syllables into binary feet, unless they branch to the opposite direction.

Super-foot (f’) Construction

Join any leftover monosyllable to a neighboring binary foot according to the direction of syntactic branching.

⁴ Hsiao and Lin (1999b) follow Hsiao’s (1995) Phonological Phrase (ϕ) Parameter and define the Southern Min tone sandhi domain as a phonological phrase.

ϕ Parameter (Hsiao’s 1995: 83)

$\phi = \langle]\#, XP^{-a\wedge-c} \rangle$ where $-a$ = non-adjunct, $-c$ = non-clitic,
 $] =$ right edge, $\wedge =$ and

⁵ Rules are said to be extrinsically ordered if their interaction is governed by tailor-made ordering statements designed for that specific set of rules in a particular language (Katamba 1989: 128).

⁶ Some of the code-mixed examples cited in this paper are either inspired by or taken directly from the corpus in Shih (1994).

LH LL L LH L Output

In (6), two interesting tonal changes are observed: first, the Mandarin *gou* followed by the Southern Min *ka* (whose *sandhi* tone is a low) changes to a sandhi tone; second, the Southern Min *ka* followed by the Mandarin *li* (which is a base tone) changes to a sandhi tone. The first tonal change shows that (i) **a Southern Min low tone can trigger Mandarin tone sandhi**, that (ii) the **Mandarin *gou***, which is followed by a Southern Min domain boundary, **is sensitive to the Mandarin tone sandhi boundary** rather than the Southern Min tone sandhi domain boundary, otherwise, it should have kept its base tone and that (iii) **the Southern Min tone sandhi rule applies before the Mandarin tone sandhi rule**, otherwise, the Mandarin *gou* followed by the *base* tone of the Southern Min *kaMM* should not have underwent tone sandhi. The second tonal change shows that (i) **a Mandarin base tone can trigger Taiwanese tone sandhi** and that (ii) the **Southern Min *ka***, which is followed by a Mandarin domain boundary, **is sensitive to the Southern Min tone sandhi domain boundary** rather than the Mandarin tone sandhi domain boundary, otherwise, it should have kept its base tone.

However, the extrinsic rule ordering demanded in Hsiao and Lin's analysis is actually not very promising. That is because extrinsic rule ordering is recently realized to be too powerful and too abstract to reveal the human mental process⁷ and "is something of a last resort in any account (Cheng 1996: 154)". Therefore, the following section examines if OT, a theory that avoids serial derivation⁸ and rule ordering, can account for tone sandhi in Mandarin-Southern Min code-mixing.

4. An OT approach to tone sandhi in Mandarin-Southern Min code-mixing

4.1 Optimality theory

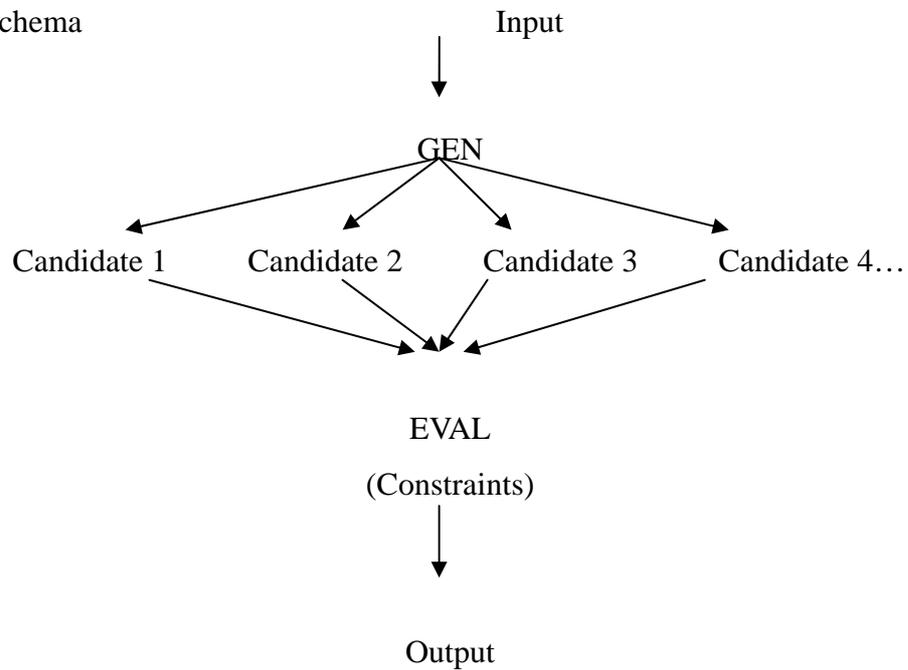
The Optimality Theory (OT) is introduced by Prince and Smolensky (1993).

⁷ Due to the limit of time and space, I will not elaborate the problems of rule ordering here. For those who are interested in the problems of rule ordering, please refer to Koutsoudas et al (1974), Ringen (1972), and Hooper (1976), etc.

⁸ One of the fundamental principle of the OT is Parallelism which stipulates that "Best-satisfaction of the constraint hierarchy is computed over the whole hierarchy and the whole candidate set. There is no serial derivation". (McCarthy and Prince 1993:2).

Unlike traditional transformations, OT disallows serial derivations. The input–output relation in OT can be shown in the schema here below.

(7) OT Schema



In OT, the input, which must be linguistically well-formed, is assigned to an indefinite set of candidates by GEN(erator), a mechanism that is capable of adding, deleting and rearranging things with almost no limitations. The candidate set is then evaluated *parallelly* by the mechanism of EVAL(uator) based on a set of universal constraints that are ranked on a language-specific ground. In OT, constraints are violable; however, the violations should be minimal, that is, the optimal candidate is the one that violates the lower ranked and the least constraints.

The operation of OT can be demonstrated in the following tableau, where common OT analysis is done. In an OT tableau, the input is placed at the top left cell. The candidates generated from the input by GEN appear in the leftmost column. The constraints of interest are at the top of the tableau. The leftmost constraint is the highest ranked and the rightmost constraint is the lowest ranked. Violations of the constraints are indicated by the symbol *, and the fatal violation is marked by the symbol !. Shaded areas in the tableau indicate that the constraints in the shaded areas

should no longer be considered since a higher ranked constraint has already been violated. A pointing hand \curvearrowright within the tableau marks the candidate that is predicted by EVAL as optimal and a pointing hand \curvearrowright outside the tableau, if any, marks the candidate that is the correct output in reality but not selected by EVAL.

Input	Constraint A	Constraint B	Constraint C	Constraint D	Constraint E
candidate 1	*!				
candidate 2		*!			
candidate 3			*		*!*
\curvearrowright candidate 4			*	*	

In the tableau, candidate 1 and candidate 2 are rejected because they violate the higher ranked constraints. In OT, the higher ranked constraints have total dominance over the lower constraints (referred to as the Strict Dominance Hypothesis). Candidate 3 and candidate 4 both violate Constraint C once, and they are tied in Constraint C. In this case, ties are resolved by the evaluation of the rest of the constraints. In this tableau, Constraint D and Constraint E are at the same rank, as they are separated by dashed lines. Candidate 3, which incurs two violations in Constraint E, is rejected. Candidate 4 is thus selected as the optimal candidate.

4.2 Tonal constraints for tone sandhi in Mandarin-Southern Min code-mixing

This section will first propose constraints to account for Mandarin tone sandhi and Southern Min tone sandhi respectively. Later it will show how tone sandhi in code-mixing is accounted for by OT.

4.2.1 Constraints for Mandarin tone sandhi

As is shown in section 2.1, in Mandarin, adjacent low tones are prohibited. This tone sandhi phenomenon can be accounted for by the following constraint.

(8) OCP-L: Adjacent low tones are prohibited.

The OCP-L constraint demands that no adjacent low tones are allowed. It is motivated by the universal constraint of Obligatory Contour Principle that disallows adjacent identical elements (Leben 1973; Goldsmith 1976). In addition to OCP-L, another constraint, IO-Ident, is needed.

(9) IO-Ident: The output tones must be identical to the input tones.

IO-Ident belongs to one of the faithfulness constraint family in OT that requires that the output must be identical with the input. It is a very common constraint in OT. Without it, the optimal candidate of any input would very possibly be pronounced as [ba], which is the phonologically most unmarked form.⁹ The ranking proposed between these two constraints is:

(10) OCP-L >> IO-Ident

Tableau (11) shows how these two constraints account for Mandarin tone sandhi.

(11) ‘buy rice’

mai mi buy rice L L	OCP-L	IO-Ident
☞ a. LH L		*
b. L L	*!	

In (11), candidate (b) violates OCP-L because it has two adjacent low tones. Candidate (a) violates the IO-Ident constraint because one of its output tones is not identical with that in the input. Since OCP-L is higher ranked than IO-Ident, (a) which violates the lower ranked constraint, is selected as the optimal output. However, tableau (12) shows that these two constraints are not enough to account for Mandarin tone sandhi.

(12) ‘buy rice’

mai mi buy rice L L	OCP-L	IO-Ident
☞ a. LH L		*
☞ b. L LH		*

⁹ C.f. Chomsky 1994

In (12), EVAL would wrongly select both candidate (a) LH L and candidate (b) L LH as the optimal candidates since both violate once in the IO-Ident constraint and neither violates the OCP-L constraint. Therefore, another constraint, ParseR, is needed to rule out candidate (b).

(13) ParseR: Parse the rightmost tone within a domain.¹⁰

This constraint is based on the claim that Mandarin, like Min and some Southern Wu dialects, belongs to a right-prominent system.¹¹ That is because these dialects tend to maintain the identity of the rightmost tone (of words or even prosodic domains), while allowing tones to change on the non-final tones in sandhi contexts (Chen 1996: 271).

¹⁰ The domain here will be defined by the prosodic constraints proposed in Lin (2000). Lin (2000) proposes a set of prosodic constraints to account for Mandarin tone sandhi domain. Some of the constraints that are relative to this study are listed below:

FtBin: Foot must be binary under syllabic analysis.

*Mono: Avoid monosyllabic feet.

ParseSyll : Parse syllables into foot.

Align(IC, Ft)L: Align the left edge of the immediate constituents (IC) to the left edge of the foot (Ft).

Align(IC, Ft)R: Align the right edge of the immediate constituents (IC) to the right edge of the foot (Ft).

The ranking for the constraints is: ParseSyll, *Mono >> FtBin, Align(IC, Ft)L, Align(IC, Ft)R. The following tableau exemplifies how these constraints correctly predict the Mandarin tone sandhi domain. (in the tableau, constituents that are embraced by '[...]' are prosodic words, constituents that are embraced by '{...}' are immediate constituents and constituents that are embraced by '(...)' are feet.)

'small umbrella'

[xiao [yu san]] {σ {σ σ } ₁ } ₂	Parse Syll	*Mono	FtBin	A(IC, Ft)L	A(IC, Ft)R
a. ((σ σ) ₁ σ) ₂			*	*!	
b. (σ (σ σ) ₁) ₂			*		
c. (σ) ₁ (σ σ) ₂		*!	*		
d. σ (σ σ) ₁	*!			*	
e. (σ σ σ) ₁			*	*!	

In the tableau, candidate (d) violates the undominated ParseSyll constraint because the first syllable in (d) is left unparsed. (d) is thus rejected. Candidate (c) also violates one of the undominated constraints, the *Mono constraint, because foot1 in (c) is a monosyllabic foot. Candidate (c) is rejected, too. Candidate (a), (b) and (e) all violates the FtBin constraint once because foot2 in (a), foot2 in (b) and foot1 in (e) all have three syllables. However, since the second syllables in both (a) and (e) are not left aligned with the left edge of the immediate constituent1, (a) and (e) also incur violations in the Align(IC, Ft)L constraint. Consequently, (b) is selected as the optimal output.

For more prosodic constraints, please refer to Lin (2000).

¹¹ C.f. also Hashimoto 1986, Duanmu 1993, 1994.

(14) ‘buy rice’

mai mi buy rice (L L) ¹²	ParseR	OCP-L	IO-Ident
☞ a. LH L			*
b. L LH	*!		*
c. L L		*!	*

In (14), candidate (b) is ruled out because *mi*, which is the rightmost tone within the Mandarin tone sandhi domain, is changed to a sandhi tone. That incurs a violation in the dominant constraint, ParseR. Candidate (c) is also rejected because it has two adjacent low tones in the output which result in a violation of the OCP-L constraint.

In sum, the final ranking for Mandarin tone sandhi is ParseR >> OCP-L >> IO-Ident.¹³

4.2.2 Southern Min tone sandhi

¹² The tone sandhi domain for *mai mi* ‘buy rice’ is derived by the following tableau.

[mai mi] {σ σ}	ParseSyll	*Mono	FtBin	A(IC, Ft)L	A(IC, Ft)R
a. (σ (σ))		*!	*		
☞ b. (σ σ)					
c. σ (σ)	*!	*	*	*	
d. σ σ	*!*			*	*

¹³ In (14), the ranking between ParseR and OCP-L does not seem to be crucial because neither constraints is violated by the optimal candidate. However, in the adagio reading in Mandarin tone sandhi, adjacent L tones do exist, as shown in the following example, the ParseR constraint must dominate the OCP-L constraint to predict the correct output.

‘He bought pears’

ta mai shuei li he buy water pear (H L)(L LH)	ParseR	OCP-L	IO-Ident
☞ a. H LL LH		*	
b. H LHL LH	*!		*

As is shown in section 2.1, in Southern Min, base tones are prohibited to occur in an adjacent string. This tone sandhi phenomenon can be accounted for by the following constraint.

(15) OCP-T: Avoid adjacent base tones.

The OCP-T constraint demands that adjacent base tones are not allowed. This constraint is also motivated by the universal constraint of Obligatory Contour Principle.

The OCP-T constraint is in conflict with the IO-Ident constraint listed below. That is because to satisfy the OCP-T constraint, if two base tones are adjacent (i.e. T T), at least one tone must be changed to a sandhi tone; however, to satisfy the IO-Ident constraint, base tones in the input should not undergo any change, even if they are in an adjacent string.

(16) IO-Ident: The output tones must be identical to the input tones.

In addition, the ParseR constraint is needed to account for Southern Min tone sandhi; otherwise, both (a) and (b) in (17) would be selected as optimal.

(17) 'raining'

	loo hoo fall rain MM MM	OCP-T	IO-Ident
☞	a. LL MM		*
	b. MM LL		*
	c. LL LL		**!
	d. MM MM	*!	

In (17), neither (a) (with the pattern T' T) nor (b) (with the pattern T T') violates the OCP-T constraint because neither candidates has adjacent base tones. Since they violate fewer constraints than (c) and (d) and are tied in the IO-Ident constraint, both of them are selected as the optimal outputs.

(18) ParseR: Parse the rightmost tone within a domain.¹⁴

¹⁴ The domain here will be defined by the prosodic constraints proposed in Lin and Hsiao (1999). Lin

By the ranking the constraint, ParseR, higher than OCP-T and IO-Ident, (17b) can successfully be ruled out, as illustrated in (19).

(19) ‘raining’

	loo hoo fall rain MM MM) _p ¹⁵	ParseR	OCP-T	IO-Ident
☞ a.	LL MM			*
b.	MM LL	*!		*
c.	LL LL	*!		**
d.	MM MM		*!	

Note; however, that the present ranked constraints, ParseR >> OCP-T >> IO-Ident,

and Hsiao (1999) propose the following prosodic constraints to account for Southern Min tone sandhi domain.

AlignXP-R: Align the right edge of an independent XP with the right edge of a phonological phrase.
(independent = non-lexically governed).

AlignLex-R: Align the right edge of a prosodic word with the right edge of a lexical word.

AlignP-R: Align the right of a p-phrase with the right of a prosodic word.

AlignF-R: Align the right edge of a focused constituent with the right edge of a p-phrase.

The constraint ranking is: AlignF-R >> AlignLex-R, AlignP-R >> AlignXP-R. The following tableau exemplifies how these constraints correctly predict the Southern Min tone sandhi domain, where constituents that are embraced by ‘[...]’ are syntactic constituents, ‘)w’ marks the right edge of a prosodic word, and ‘)p’ marks the right edge of a phonological phrase.

‘I (not you) love dancing.’ (the ProN is focused)

I love dancing <i>gua ai thiau-bu</i> [[[δ] _D] _{DP} [[δ] _{V1} [δ δ] _V] _{VP}] _{IP}	ALIGNF-R	ALIGNLEX-R	ALIGNP-R	ALIGNXP-R
☞ a.) _{p1}) _w) _w) _p			*	
b.) _{p1}) _w) _p) _w) _p			*	*!(V1)
c.) _w) _w) _p	*!(DP)			* (DP)

In the tableau, (c) violates that AlignF-R constraint because the right edge of the focused pronoun, *gua*, is not aligned with the corresponding edge of a phonological phrase. It violates the AlignXP-R constraint because the right edge of the DP in (c), which is an independent XP, is not aligned with the right edge of a phonological phrase. (c) is rejected. (a) and (b) both violate the AlignP-R constraint because p1 in both candidates are not right aligned with the right edge of a prosodic word. However, (b) also violates the AlignXP-R constraint because the V1 in (b), which is not an XP, is right aligned with a phonological phrase. (b) is thus rejected. (a) is selected as the optimal domain output.

¹⁵ The tone sandhi domain for *loo hoo* ‘raining’ is derived by the following tableau.

loo hoo fall rain [δ δ] _{VP}	AlignF-R	AlignLex-R	AlignP-R	AlignXP-R
☞ a.) _w) _p				
b.				*!(VP)

though capable of accounting for Southern Min with disyllabic tone groups here above quite well, it fails to pick out the correct outputs for tone groups that are composed of more than two syllables. That is because OCP-T is not capable of ruling out incorrect outputs for quadrasyllabic tone groups like (20b) whose tone pattern is T' T T' T.

(20) ‘want to marry a beautiful wife’

	beh chua sui bo want marry beautiful wife M MM HL HL) _p ¹⁶	ParseR	OCP-T	IO-Ident
☞	a. H LL HH HL			***!
☞	b. H MM HH HL			**

In (20), candidate (a) incurs more violations in the IO-Ident constraint than candidate (b). Since neither (a) (with the pattern T' T' T' T) nor (b) (with the pattern T' T T' T) have adjacent base tones, neither violates the OCP-T constraint. Consequently, candidate (a) is wrongly selected as the optimal output.

To get rid of this problem, the OCP-T constraint needs to be modified a little bit. In the derivational approach, the Southern Min tone sandhi rule, when applies within disyllabic tone groups, changes the first tone (= all but the final tone) to a sandhi tone, and when it applies within tone groups that are more than disyllabic, the rule, which is simultaneously applied to the input, always changes all but the final tones of the tone groups to sandhi tones. In fact, Southern Min tones, unless being spoken in isolation, always surface as sandhi tones in the output, *with the exception of the domain final tone*. Therefore, the *T constraint listed below is proposed to substitute the OCP-T constraint.

¹⁶ The tone sandhi domain for *beh chua sui bo* is derived by the following tableau.

beh chua sui bo want marry beautiful wife [δ δ] _v [δ δ] _{[NP]DP} VP	AlignF-R	AlignLex-R	AlignP-R	AlignXP-R
☞ a.) _w) _w _p				
b.) _w _p) _w _p				*! (V)

(21) *T: No base tones in the output.¹⁷

The hedge part in Southern Min tone sandhi (*with the exception of the domain final tone*) will always cause the correct tonal output to have a violation in the *T constraint per domain (ref. candidate (a) in (22)). However, such violation is O.K. since in OT, constraints are violable. The problematic tone pattern, T' T T' T (candidate (b) in (20)), which violates *T twice (because it has two base tones), will no longer be selected as optimal any more (ref. (22b)). Of course, there may be candidates who violate no *T at all (like candidate (c) in (22)). But they will definitely be ruled out because complete satisfaction of *T implies that all of the tones, including the domain final tone, should surface as sandhi tones, and that would surely cause violations in the undominated ParseR constraint.

(22) 'want to marry a beautiful wife'

	beh want M	chua marry MM	sui beautiful HL	bo wife HL) _p	ParseR	*T	IO-Ident
☞ a.	H	LL	HH	HL		*	***
b.	H	MM	HH	HL		**!	**
c.	H	LL	HH	HH	*!		****
d.	M	MM	HL	HL		**!***	
e.	M	LL	HL	HH	*!	**	**

In sum, the ranked constraints proposed for Southern Min tone sandhi are ParseR >> *T >> IO-Ident.

4.2.3 Tone sandhi in code-mixing

In code-mixing, where both the Mandarin tone sandhi rule and the Southern Min tone sandhi rule are playing the role, the constraints for both Mandarin tone sandhi and Southern Min tone sandhi need to be combined. These two sets of constraints are

¹⁷ The *T constraint is a kind of anti-faithfulness/anti-correspondence constraint that requires obligatory alternations between two structures. The anti-faithfulness/anti-correspondence constraint has been applied in analyzing repetition avoidance in reduplication in Yip (1996), in deriving certain patterns of quantitative enhancement in Yupik languages in Bakovic (1996), and in accounting for affix-controlled accent in Alderete (1999), etc.

repeated below.

(23) Mandarin tone sandhi: ParseR >> OCP-L >> IO-Ident

(24) Southern Min tone sandhi: ParseR >> *T >> IO-Ident

Two issues are raised when these two constraints are being combined. First, what is the ranking for these two sets of tonal constraints when they are combined? Second, what is the reference of the domain in the ParseR constraint. The ParseR constraint requires that the rightmost tone within a domain should be parsed. Which domain does the ParseR constraint refer to, the Mandarin tone sandhi domain, the Southern Min tone sandhi domain, or both? The first issue will be discussed in 4.2.3.1 and the second issue will be discussed in 4.2.3.2. For ease of discussion, the ParseR constraint, as well as the tone sandhi domain, will be omitted in the exemplified OT tableaux in section 4.2.3.1. (The examples given will be limited to within one Mandarin and Southern Min tone sandhi domain).

4.2.3.1 Rankings of Mandarin and Southern Min tone sandhi constraints

Since the ranking of the Mandarin tone sandhi constraints is ParseR >> OCP-L >> IO-Ident and the ranking of the Southern Min tone sandhi constraints is ParseR >> *T >> IO-Ident; accordingly, when the constraints of Mandarin tone sandhi and Southern Min tone sandhi are combined, the ParseR constraint should still be ranked the highest and the IO-Ident constraint should still be ranked the lowest. In other words, the only ranking that needs to be decided is the ranking between the OCP-L constraint and the *T constraint.

???

(25) ParseR >> $\left\{ \begin{array}{l} \text{OCP-L} \gg *T \\ \text{OCP-L, } *T \\ *T \gg \text{OCP-L} \end{array} \right\} \gg \text{IO-Ident}$

Before deciding the ranking between the OCP-L constraint and the *T constraint, some modification of these two constraints must be done. The definition of the

OCP-L constraint is repeated in (26) and the definition of the *T constraint is repeated in (27).

(26) OCP-L: Adjacent low tones are prohibited.

(27) *T: No base tone in the output.

We know that after the combination of these two tonal constraints, the code-mixed input will be evaluated by both the OCP-L constraint and the *T constraint. In other words, the Mandarin portion and the Southern Min portion of the input will be evaluated by both the OCP-L constraint and the *T constraint. However, it must be noted that though adjacent low tones are prohibited in Mandarin, they are not prohibited in Southern Min, as exemplified in (28) and (29) respectively.

(28) ‘fruit’	shuei	guo
	water	fruit
base tone	L	L
sandhi tone	LH	L

(29) ‘old house’	ku	chu
	old	house
base tone	MM	LL
sandhi tone	LL	LL

Similarly, though base tones are generally (with the exception of the domain final tone) prohibited in Southern Min, most Mandarin tones occur with their base tones in the output, except for the low tones followed by other low tones, as exemplified in (30) and (31) respectively.

(30) ‘want to marry a beautiful wife’	beh	chua	sui	bo
	want	marry	beautiful	wife
base tone	M	MM	HL	HL
sandhi tone	H	LL	HH	HL

(31) ‘pencil eraser’	qian bi	ca
	pencil	eraser
base tone	H	L H
sandhi tone	H	L H

Therefore, in code-mixing, the OCP-L constraint must be restricted to Mandarin tones only; otherwise, EVAL would wrongly select candidate (b) in tableau (32), rather than candidate (a), as the optimal candidate. Because if OCP-L is not restricted to Mandarin low tones, the Southern Min *kuLL chuLL* in candidate (a) will violate the dominant OCP-L constraint and eventually be ruled out.

(32) ‘want to go to the old house’

	xiang qu ku chu want to old house L HL MM LL	OCP-L	IO-Ident
☞	a. L HL LL LL	*!	*
☞	b. L HL MM LL		

Therefore, the OCP-L constraint should be modified as below:

(33) OCP-L^{Mandarin}: Adjacent Mandarin low tones are prohibited.

Likewise, in code-mixing, the *T constraint must be restricted to Southern Min tones only; otherwise, EVAL would wrongly select candidate (b) in tableau (34) as the optimal output. That is because candidate (a) contains three base tones, the Mandarin *xiang* and *qu*, and the Southern Min *chu* but candidate (b) only contains two base tones, the Mandarin *qu* and the Southern Min *chu*; therefore, candidate (b) is selected because it incurs less violations in the *T constraint.

(34) ‘want to go to the old house’

	xiang qu ku chu want to old house L HL MM LL	*T	IO-Ident
☞	a. L HL LL LL	***!	*
☞	b. LH HL LL LL	**	**

The *T constraint should be modified as below:

(35) *T^{Min}: No Southern Min base tones in the output.

Now, consider the ranking between the $OCP-L^{Mandarin}$ constraint and the $*T^{Min}$ constraint. In OT, a ranking exists only when two constraints conflict (McCarthy and Prince 1993: 7). In other words, a ranking is necessary between two constraints only if one constraint is violated (at least some of the times) to avoid the violation of the other constraint. If two constraints never conflict, no ranking is needed between them. This is what happens to $OCP-L^{Mandarin}$ and $*T^{Min}$. In Mandarin-Southern Min code-mixing, $OCP-L^{Mandarin}$ is never violated to satisfy $*T^{Min}$ or the reverse. Consider the following examples where (36a) is formed by Mandarin utterance followed by Southern Min utterance and (36b) is constructed by Southern Min utterance followed by Mandarin utterance.

(36)

(a) Mandarin + Southern Min input output	xiang chua sui bo want marry beautiful wife L MM HL HL LH L HH HL	violates $*T^{Min}$ once does not violate $OCP-L^{Mandarin}$
(b) Southern Min + Mandarin input output	beh be shuei guo want buy fruit M HL L L H HH LH L	does not violate either $OCP-L^{Mandarin}$ or $*T^{Min}$

In (36a), though the $*T^{Min}$ constraint is violated once, it is not violated to satisfy the $OCP-L^{Mandarin}$ constraint. In (36b), the output satisfies both $OCP-L^{Mandarin}$ and $*T^{Min}$; therefore, neither constraints is violated to obey the other constraint. Obviously, $OCP-L^{Mandarin}$ and $*T^{Min}$ do not conflict. Accordingly, these two constraints should be placed at the same rank in the constraint hierarchy, as illustrated in (37).

(37) ‘want to buy fruit’

beh be shuei guo want buy fruit M HL L L	$OCP-L^{Mandarin}$	$*T^{Min}$
a. H HH LH L		
b. H HL LH L		*!
c. H HH L L	*!	

In sum, the present ranking for the constraints for tone sandhi in code-mixing should be:

(38) ParseR >> OCP-L^{Mandarin}, *T^{Min} >> IO-Ident

4.3.2.2 Tone sandhi domain in code mixing

Now, we should turn to the issue regarding the reference of domain in ParseR in code-mixing. The derivational approach (Hsiao and Lin 1999b) shows that in code-mixing, the Mandarin utterances are still subject to the Mandarin tone sandhi domain and that the Southern Min utterances are still subject to the Southern Min tone sandhi domain. This study also proposes that for the Mandarin part in code-mixing, the reference domain of the ParseR constraint should be the Mandarin tone sandhi domain while for the Southern Min part, the reference domain should be the Southern Min tone sandhi domain.

Consider first what would happen if the reference domain in the ParseR constraint refers to only the Mandarin tone sandhi domain. Take (39) for illustration, where the reference domain is restricted to the Mandarin tone sandhi domain.

(39) ‘want to eat fruit’

	beh cia shuei guo want eat fruit M H L L () () ¹⁸	ParseR	OCP-L ^{Mandari} _n	*T ^{Min}	IO-Ident
☞ a.	H H LH L			*	**
☞ b.	H M LH L	*!			***
c.	M H L L		*	**!	

In (39), the correct output, (b) is rejected by mistake because the Southern Min *cia*,

¹⁸ The Mandarin tone sandhi domain for the string *beh cia shuei guo* is derived by the following tableau.

[beh] [cia] [shuei guo] want eat fruit {σ {σ {σ σ}}}	ParseSyll	*Mono	FtBin	A(IC, Ft)L	A(IC, Ft)R
a. (σ (σ (σ σ)))			**!		
☞ b. (σ σ) (σ σ)				*	
c. (σ (σ σ) σ)			**!		
d. (σ σ σ σ)			**!	**	

which is located at the rightmost position of the Mandarin tone sandhi domain does not parse its tone.

Consider next what would happen if the reference of the domain in the ParseR constraint refers to only the Southern Min tone sandhi domain. Take (40) for illustration where the reference domain is restricted to the Southern Min tone sandhi domain.

(40) ‘The dog wants to drink wine.’

	gou	xiang	lim	jiu	ParseR	OCP-L ^{Mandarin}	*T ^{Min}	IO-Ident
	dog	want	drink	wine				
	L	L	HH	HL				
	$\sigma)_p$	σ	σ	$\sigma)_p$ ¹⁹				
☞ a.	L	L	MM	HL		*	*	**
☞ b.	LH	L	MM	HL	*!		*	**

In (40), the correct output, (b) is rejected by mistake because the Mandarin *gou*, which is located at the rightmost position of the Southern Min tone sandhi domain, does not parse its tone.

The two tableaux above show that in code-mixing, the reference domain of the ParseR constraint should not be restricted to either the Mandarin tone sandhi domain or the Southern Min tone sandhi domain. Actually, the reference domain in the ParseR constraint should refer to both the Mandarin tone sandhi domain and the Southern Min tone sandhi domain. It refers to the Mandarin tone sandhi domain in the Mandarin part of the code-mixed string and it refers to the Southern Min tone sandhi domain in the Southern Min part of the code-mixed string. The problem is how the shift of the domain references is constrained. Without restriction, the dual referent-ship of the ParseR constraint would still cause EVAL to select the wrong candidate as optimal. That is because without any restriction on the references of the domain, Mandarin tones in code-mixing can be sensitive to either the Mandarin tone sandhi domain, the Southern Min tone sandhi domain or both; likewise, Mandarin tones in code-mixing can be sensitive to the Southern Min tone sandhi domain, the Mandarin tone sandhi domain or both. Take (41) for example.

¹⁹ The Southern Min tone sandhi domain for the string *gou xiang lim jiu* is derived by the following tableau.

	gou	xiang	lim	jiu	AlignF-R	AlignLex-R	AlignP-R	AlignXP-R
	dog	want	drink	wine				
	[[δ] _{NP1}] _{DP}	[[δ] _v	[[δ] _v					
	[[[δ] _{NP2}] _{DP}] _{VP}] _{VP}							
☞ a.	)_w) _p	)_w) _p	)_w) _p	)_w) _p				
b.	)_w	)_w) _p	)_w) _p	)_w) _p				*! (NP1)

(41) ‘want to eat fruit’

<p>beh cia shuei guo want eat fruit M H L L () ())_p²⁰</p>	ParseR	OCP-L ^{Mandarin}	*T ^{Min}	IO-Ident
☞ a. (H H) (LH L)				**
☞ b. (H M) (LH L)	*!			**

In (41), if the Southern Min *cia* is sensitive to the Mandarin tone sandhi domain then (a), rather than (b), will be selected as the optimal output. That is because the Southern Min *cia*, which is followed by a Mandarin tone sandhi domain boundary, parses its tone in (a), but not in (b).

Similarly, in (42) if the Mandarin *gou* is sensitive to the Southern Min tone sandhi domain then (a), rather than (b), will be selected as the optimal output. That is because the Mandarin *gou*, which is followed by a Southern Min tone sandhi domain boundary, parses its tone in (a), but not in (b).

²⁰ The Southern Min tone sandhi domain for the string *beh cia shuei guo* is derived by the following tableau.

<p>beh cia shuei guo want eat fruit [[δ δ]_v [δ δ]_{[NP]DP}]_{VP}</p>	AlignF-R	AlignLex-R	AlignP-R	AlignXP-R
☞ a.) _w) _w _p				
b.) _w _p) _w _p				*! (V)

(42) ‘The dog wants to drink wine.’

	gou dog L ()) _p	xiang want L ()) _p	lim drink HH () ²¹) _p	jiu wine HL () ²¹) _p	ParseR	OCP-L ^{Mandarin}	*T ^{Min}	IO-Ident
☞ a.	L) _p	L	MM	HL) _p		*	*	*
☞ b.	LH) _p	L	MM	HL) _p	*!		*	**

To get rid of this problem, another constraint is needed to ensure that in code-mixing, Mandarin utterances are sensitive to all and only the Mandarin tone sandhi domain and that Southern Min utterances are sensitive to all and only the Southern Min tone sandhi domain. Here, a constraint called EquiDom, which is a modification of Bhatt’s (1997) Equi constraint is proposed. Bhatt (1997), in accounting for the syntactic behavior on the switched items in code-mixing, uses Equi (Equivalence) to constrain that switched items in code-mixing should follow the grammatical properties of the language to which they belong.

(43) Equi (Equivalence): Switched items follow the grammatical properties of the language to which they belong. (Bhatt (1997)).

Just as the switched items follow the syntactic properties of the language to which they belong, the switched items also follow the tone sandhi domains of their languages/ dialects. Therefore, it is proposed that they should be constrained by the EquiDom constraint listed below.

(44) EquiDom (Equivalence Domain): In code-mixing, switched items are paying respect to the tone sandhi domains of the languages/ dialects to which they

²¹ The Mandarin tone sandhi domain for the string *gou xiang lim jiu* is derived below:

[gou] [xiang] [lim] [jiu] dog want drink wine {σ {σ {σ σ}}}	ParseSyll	*Mono	FtBin	A(IC, Ft)L	A(IC, Ft)R
a. (σ (σ (σ σ)))			**!		
☞ b. (σ σ) (σ σ)				*	
c. (σ (σ σ) σ)			**!		
d. (σ σ σ σ)			**!	**	

belong.

EquiDom is a non-dominated constraint. It can rule out tones that are sensitive to the wrong domain. The proposed constraint ranking is:

(45) EquiDom >> ParseR >> OCP-L^{Mandarin}, *T^{Min} >> IO-Ident

Consider (46).

(46) ‘The dog wants to drink wine.’

	gou	xiang	lim	jiu	EquiDom	ParseR	OCP-L ^{Mandarin}	*T ^{Min}	IO-Ident
	dog	want	drink	wine					
	L	L	HH	HL					
	(	)	(	)²²					
	)_p	)_p	)_p	)_p					
a.	L	)_p L	MM	HL) _p	*!		*	*	*
b.	LH	L)	MM	HL) _p				*	**
c.	L	L)	MM	HL) _p			*	*!	*

According to this ranked constraints, EVAL can correctly select candidate (b) in (46) as the optimal candidate. The tone pattern *L L MM HL* (= (42a) here above) will not be selected as the output for *gou xiang lim jiu* because it would either violate EquiDom, if the Mandarin *gou* is paying respect to the wrong domain (i.e. the Southern Min tone sandhi domain) (ref. candidate (46a)) or being rejected by the OCP-L^{Mandarin} constraint if the Mandarin *gou* is paying respect to the correct domain (i.e. Mandarin tone sandhi domain) (ref. candidate (46c)).

4.2.3.3 Tone sandhi at mixed juncture

²² The Mandarin tone sandhi domain for the string *gou xiang lim jiu* is derived by the following tableau.

[gou]	[xiang]	[lim]	[jiu]	ParseSyll	*Mono	FtBin	A(IC, Ft)L	A(IC, Ft)R
dog	want	drink	wine					
{σ	{σ	{σ	σ}}					
a.	(σ	(σ	(σ σ)))			**!		
b.	(σ	σ)	(σ σ)				*	
c.	(σ	(σ	σ) σ)			**!		
d.	(σ	σ	σ σ)			**!	**	

Now consider another interesting phenomena in code-mixed tone sandhi found in Hsiao and Lin (1999a) that a Southern Min low tone can trigger Mandarin tone sandhi and that a Mandarin base tone can trigger Southern Min tone sandhi. *Southern Min tone sandhi* triggered by *Mandarin* base tones can be naturally accounted for by $*T^{Min}$. Consider (47). Candidate (b), with the Southern Min *cia*, surfaces with its sandhi tone before another Mandarin tone, is the optimal candidate while candidate (a), with *cia* obtains its base tone, is not. Clearly enough, the constraint that determines that candidate (b) is optimal and candidate (a) is not is the constraint, $*T^{Min}$.

(47) ‘want to eat fruit’

beh cia shuei guo want eat fruit M H L L () ()) _p	ParseR	OCP-L ^{Mandarin}	$*T^{Min}$	IO-Ident
a. H H LH L			*!	**
☞ b. H M LH L				***

While Southern Min tone sandhi triggered by Mandarin base tone can be naturally accounted for by $*T^{Min}$, *Mandarin tone sandhi* triggered by *Southern Min* low tones cannot be accounted for by resorting to OCP-L^{Mandarin}. Consider (48).

(48) ‘want to marry a beautiful wife’

xiang chua sui bo want marry beautiful wife L MM HL HL () () ²³) _p ²⁴	OCP-L ^{Mandarin}	*T ^{Min}	IO-Ident
☞ a. L LL HH HL		*	**
b. LH LL HH HL		*	***!

In (48), candidate (a) rather than candidate (b) is selected as optimal. That is because though candidate (a) has two adjacent low tones in the output, the two adjacent low tones do not both belong to Mandarin; therefore, it does not violate OCP-L^{Mandarin} that avoids only adjacent Mandarin low tones. Consequently, candidate (b) that violates more times in IO-Ident is wrongly rejected. The OCP-L constraint listed below is needed to rule candidate (a) out.

(49) OCP-L : Avoid adjacent low tones.

The OCP-L constraint is a more general constraint than the OCP-L^{Mandarin}

²³ The Mandarin tone sandhi domain for the string *xiang chua sui bo* is derived by the following tableau.

[xiang] [chua] [sui bo] want marry beautiful wife {σ {σ {σ σ}}	ParseSyll	*Mono	FtBin	A(IC, Ft)L	A(IC, Ft)R
a. (σ (σ (σ σ)))			**!		
☞ b. (σ σ) (σ σ)				*	
c. (σ (σ σ) σ)			**!		
d. (σ σ σ σ)			**!	**	

²⁴ The Southern Min tone sandhi domain for the string *xiang qu ku chu* is derived by the following tableau.

[xiang] [chua] [sui bo] want marry beautiful wife [[δ] _v [[δ] _{v1} [[δ δ] _{NP}] _{DP}] _{VP}] _{VP}	AlignF-R	AlignLex-R	AlignP-R	AlignXP-R
☞ a.) _w) _w) _p				
b.) _w) _p) _w) _p				*! (V1)

constraint. Since it is not restricted to either Mandarin tones or Southern Min tones, it must not outrank the $*T^{\text{Min}}$ constraint; otherwise, wrong output would be selected as the optimal candidate, as shown in (50).

(50) ‘want to go to the old house’

	xiang qu ku chu want to old house L HL MM LL () () ²⁵) _p ²⁶	OCP=L	$*T^{\text{Min}}$
☞	a. L HL LL LL	*!	*
☞	b. L HL MM LL		**

In (50) candidate (a), which is the optimal tonal output in reality, is ruled out because it contains adjacent Southern Min low tones which are disallowed by OCP=L.

OCP=L should instead be outranked by $*T^{\text{Min}}$, as shown in (51). Accordingly, candidate (a) can be correctly selected as optimal.

(51) ‘want to go to the old house’

xiang qu ku chu want to old house L HL MM LL () ()	OCP=L ^{Mandarin}	$*T^{\text{Min}}$	OCP=L
--	---------------------------	-------------------	-------

²⁵ The Mandarin tone sandhi domain for the string *xiang qu ku chu* is derived by the following tableau.

[xiang] [qu] [ku chu] want to old house {σ {σ {σ σ}}}	Parse Syll	$*\text{Mono}$	FtBin	A(IC, Ft)L	A(IC, Ft)R
a. (σ (σ(σ σ)))			**!		
☞ b. (σ σ)(σ σ)				*	
c. (σ (σ σ) σ)			**!		
d. (σ σ σ σ)			**!	**	

²⁶ The Southern Min tone sandhi domain for the string *xiang qu ku chu* is derived by the following tableau.

xiang qu ku chu want to old house [[δ] _v [[δ] _{v1} [[δ δ] _{NP}] _{DP}] _{VP}] _{VP}	AlignF-R	AlignLex-R	AlignP-R	AlignXP-R
☞ a.) _w) _w _p				
b.) _w _p) _w _p				*! (V1)

)p			
☞ a. L HL LL LL		*	*
b. L HL MM LL		**!	

The constraint hierarchy for tone sandhi in code-mixing is:

$$(52) \text{EquiDom} \gg \text{ParseR} \gg \text{OCP-L}^{\text{Mandarin}}, *T^{\text{Min}} \gg \text{OCP=L} \gg \text{IO-Ident}$$

Before concluding (52) as the final constraint hierarchy for Mandarin-Min code-mixed tone sandhi, one should note that having both $\text{OCP-L}^{\text{Mandarin}}$ and OCP=L in the constraint hierarchy may be redundant.²⁷ Actually, the more specific constraint $\text{OCP-L}^{\text{Mandarin}}$ can be omitted to avoid such redundancy and yet retain the correct output prediction.

(53) ‘old house’

ku chu old house MM LL ())p	EquiDom	ParseR	*T ^{Min}	OCP=L	IO-Ident
a. MM LL			**!		
☞ b. LL LL			*	*	*
c. LL HL		*!			**

In (51), thought (a) does not violate the OCP=L constraint, it violates the $*T^{\text{Min}}$ twice. Though (b) violates the OCP=L constraint, it violates the $*T^{\text{Min}}$ constraint one time less than (a). Though (c) violates neither $*T^{\text{Min}}$ or OCP=L , it violates the ParseR constraint. Since ParseR outranks $*T^{\text{Min}}$, and $*T^{\text{Min}}$ outranks OCP=L , (b) can still be correctly predicted as the optimal candidate. $\text{OCP-L}^{\text{Mandarin}}$ can be omitted without influence the prediction of the attested output. In sum, the final constraint hierarchy for tone sandhi in Mandarin-Min code-mixing is:

²⁷ This is pointed out by one of the anonymous reviewers. I would like to express my gratitude to

(54) EquiDom >> ParseR >> *T^{Min} >> OCP-L >> IO-Ident

The fact that in Mandarin-Min code-mixing, *T^{Min} must be constrained to Southern Min base tones while OCP-L can account for both Mandarin adjacent L tones or adjacent L tones of different languages/ dialects also implies that OCP-L is a more widespread and general constraint than the anti-faithful *T^{Min} constraint universally.

5. Conclusion

Briefly speaking, this study has reanalyzed the tone sandhi phenomenon in code mixing based on the framework of OT. A set of tonal constraints, which includes the EquiDom constraint, the ParseR constraint, the *T^{Min} constraint, the OCP-L constraint, and the IO-Ident constraint, has been proposed to account for the tonal output in Mandarin-Southern Min code-mixing. This study successfully shows that, with this constraints set, tone sandhi in Mandarin-Southern Min code-mixing can be accounted for naturally. Moreover, the undesired extrinsic rule ordering in the derivational approach (Hsiao and Lin 1999b) can be abandoned successfully.

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About the Author: Hui-shan Lin is a doctoral student in Linguistics at National Tsing Hwa University. Specialized in Chinese Phonology, she has published several papers on the tone sandhi phenomena of Mandarin, and Southern Min at international conferences. She is also the co-author of the article "Kuo-tai-yu Jia-tza-shi de San-sen-bian-diao (Third Tone Sandhi in Mandarin-Min Code-mixing)." *Sheng Yun Lun Cong* 9. Hui-shan Lin holds an MA in Linguistics from National Chengchi University. [E-mai: hslin@mail.net.tw]

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