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Revisiting non-idempotency in Tibetan vowel harmony

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1. Introduction

Magri (2017) discusses a central property, idempotency, within classical Optimality Theory, where phonological grammar always faithfully outputs phonotactically legit forms. Magri's analyses explore several options to achieve non-idempotency in grammars to display a chain-shift, or counterfeeding interaction in a rule-based framework. Besides chain-shift, counterfeeding ordering is seen in various phonological phenomena including derived environment effects. The current paper thus shows a case of vowel harmony in Lhasa Tibetan where the harmony is blocked in certain derived environments, using the options to non-idempotency.

Vowel harmony in Lhasa Tibetan exhibits an interesting pattern that nonhigh vowels raise to assimilate the height of high vowels in disyllabic words bidirectionally (Ultan, 1973; Chang & Shefts, 1964; Dawson, 1983). Two exceptions occur: in progressive harmony, a geminate low vowel [a:] in the second syllable blocks height assimilation; in regressive harmony, a schwa derived from an unstressed /a/ word-finally does not trigger assimilation. These two blocking environments both speak to the need of failing idempotency in Optimality Theory (Magri, 2017) by treating the [a:] and the derived schwa differently from the rest of the input/output inventory for vowel harmony.

The paper is structured as follows. Section 2 gives an overview of the vowel inventory in Tibetan with a focus on crucial vowel and consonant processes. Section 3 and 4 discuss the general pattern of Tibetan vowel harmony and some options to account for exceptions to the general pattern by tackling idempotency using Agreement-by-Correspondence constraints (Bennett & DelBusso, 2018) and local conjunction of markedness and faithfulness constraints (Lubowicz, 2002). Section 5 proposes a viable alternative to Tibetan vowel harmony using Stem-Affix asymmetry identity constraints (Baković, 2000). Section 6 summarizes the different families of constraints and concludes with implications. It will be shown that with various solutions proposed, different configurations of the OT constraints converge on the same problem as to resolving the non-idempotency of vowel harmony in derived environments.

2. Relevant processes regarding Tibetan vowel harmony

2.1. Vowels

Lhasa Tibetan has eight vowel phonemes: /i, y, e, ø, ɛ, a, u, o/ (Hari, 1977; DeLancey, 2003). Vowel length is contrastive and long vowels only appear in certain vowels /i:, e:, u:, o:, a:/ and open syllables (Hari, 1977; DeLancey, 2003). Nasalization on vowels are also contrastive (DeLancey, 2003). Four more vowel allophones appear: [ɪ, ʊ, ɔ, ə] when local vowel processes trigger raising and centralization (see Chang (1968) and Dawson (1983) for detailed analyses).

Below is a chart of all the surface vowels in Lhasa Tibetan adapted from Dawson (1983).

Table 1. Vowels in Lhasa Tibetan

		-back		+back	
		-round	+round	-round	+round
+high	-constricted	i	y		u

	+constricted	ɪ		ə	ʊ
-high	-constricted	e	ø		o
	+constricted	ɛ		a	ɔ

2.2. Vowel harmony and centralization

The phenomenon of vowel height approximation, or vowel harmony, is documented in Dawson (1983), Chang (1968), Hari (1977), Miller (1966) and Sprigg (1961). The general process is to assimilate the height of any nonhigh vowels to a high vowel in disyllabic words bidirectionally. Specifically, high vowels [i, ɪ, y, u, ʊ, ə] triggers height approximation in nonhigh vowels [a, e, ø, ɛ, o, ɔ] to become their high counterparts [ə, i, y, ɪ, u, ʊ]. For example, the first vowel /o/ in /q^h**o/** 'hear' regressively raises to [u] in [q^h**u-**qi] with suffixation (*-qi* is the future tense marker). This vowel harmony is dominant in suffixed verbs and adjectives, and compounds. As for the exceptions to the general rule, a detailed analysis is given in Section 3.

Two other processes, Centralization (called Laxing in Dawson (1983)) and Pre-labial Centralization are crucial to the vowel height assimilation. Centralization refers to the process of changing an unstressed /a/ into a schwa word-finally, which mostly happens in suffixes, such as past tense verbal suffix [-p**ə**] < /-p**a**/, etc. Similarly, Pre-labial Centralization (called Pre-labial Laxing in Dawson (1983)) changes an /a/, followed by a tautosyllabic *p*, into the schwa, for example, [l**ə**p] < /l**a**p/ 'teach'. The schwa derived from the Pre-labial Centralization process in the stem triggers the vowel harmony in suffixation or compounding whereas the schwa derived from Centralization does not.

2.3. Consonant degemination

Another relevant consonant process is Consonant Degemination (Dawson, 1983), which deletes the second consonant when two identical consonants are created adjacently through suffixation: [lə**p**ə] < /la**p-p**a/ 'he taught'.

3. Raising Harmony

The vowel harmony in Lhasa Tibetan has been analyzed in a rule-based representational framework (Chang, 1968; Dawson, 1983), and prosodic phonology (Sprigg, 1961) up to the 90s. More recently constraint-based approaches have started being applied to Tibetan vowel harmony, e.g., Archangeli (1999) uses Tibetan as an example to illustrate how the set of ALIGN constraints interact with FAITH constraints to arrive at the desired outputs. Yet there lacks a complete analysis of Tibetan vowel harmony within the OT framework, especially looking into the exceptions from a computational perspective targeting non-idempotency.

3.1. Generalizations

The general process of vowel harmony, as briefly described in Section 2.2, is that in disyllabic words nonhigh vowels are changing into their [+high] counterparts when a high vowel is in the word. The assimilation of height in nonhigh vowels is bidirectional, that is, progressive or regressive depending on the position of high vowels. Specifically, nonhigh vowels [a, e, ø, ɛ, o, ɔ] are raised to [ə, i, y, ɪ, u, ʊ] when one of the high vowels [i, ɪ, y, u, ʊ, ə] appears in a disyllabic word. The following tables 2 and 3 adapted from Dawson (1983) and Chang (1968) show some data for regressive and progressive raising harmony.

Table 2. Regressive raising in Lhasa Tibetan

stem	**negative marker *-ku***	**future tense *-qi***	**gloss**
/teː/	[tiːku]	[tiːqi]	'give'
/nɛː/	[niːku]	[nɪːqi]	'sleep'

/lɔ:/	[lʊ:ku]	[lʊ:qi]	‘read’
/lap/	[ləpku][1]	[ləpqi]	‘teach’
stem	**stem**	**compound**	**gloss**
/me/ ‘fire’	/siŋ/ ‘wood’	[misĩ:]	‘firewood’
/nɛ:/ ‘sleep’	/q^{h}u:/ ‘net’	[nɪ:qu]	‘mosquito net’
/to/ ‘stone’	/pũ:/ ‘pile’	[tupũ:]	‘pile of stones’
/lɔ:/ ‘electricity’	/rĩ:/ ‘price’	[lʊ:rĩ:]	‘price of electricity’
/p^{h}ø:/ ‘Tibet’	/lu:/ ‘sheep’	[p^{h}y:lu:]	‘Tibetan sheep’
/p^{h}ø:/ ‘Tibet’	/lap/ ‘radish’	[p^{h}y:ləp][2]	‘Tibetan radish’
/ma:/ ‘war’	/mi/ ‘person’	[mə:mi]	‘soldier’

Table 3. Progressive raising in Lhasa Tibetan

stem	**2p. past interrog.** ***- pɛ:~- pɪ:***	**stem**	**nominal/adjectival suffix *-po~-pu***
/nã:/ ‘do’	[nã:pɛ:]	/qa/ ‘happy’	[qapo]
/te:/ ‘give’	[te:pɛ:]	/se:/ ‘yellow	[se:po]
/si:/ ‘look’	[si:pɪ:]	/sĩ/ ‘tasty’	[sĩpu]
/kap/ ‘make’	[kəpɪ:][3]	/tə/ ‘thin’	[təpu]
stem	**stem**	**compound**	**gloss**
/ri/ ‘mountain’	/tse/ ‘peak’	[ritsi]	‘mountain peak’
/u/ ‘head’	/nɛ:/ ‘pillow’	[unɪ:]	‘pillow’
/mi/ ‘person’	/t^{h}o/ ‘list’	[mitu]	‘list of people’
/qu/ ‘body’	/lɔ:/ ‘lungs’	[qulʊ:]	‘lungs’
/tu/ ‘barley’	/sø̃:/ ‘seed’	[tusỹ:]	‘barley-seed’
/u/ ‘head’	/ta/ ‘hair’	[utə]	‘hair’

Raising harmony is seen in verbal or adjectival suffixation and compounds. For example, regressive harmony is triggered by a high vowel in the suffix or the second syllable: [t**i:**qi] < /t**e:**-qi/ ‘will give’, [p^{h}**y:**lu:] < /p^{h}**ø:**+lu:/ ‘Tibetan sheep’; progressive harmony is triggered by a high vowel in the stem or the first syllable, as seen in suffix alternations and compounds: [qa-**po**] ‘happy’ ~ [s**ĩpu**] ‘tasty’, [rits**i**] < /rits**e**/ ‘mountain peak’.

However, besides the general rule, there exist some exceptions to the vowel harmony, as shown in Table 4, adapted from Dawson (1983) and Chang (1968). First, if the second vowel is a long vowel [a:] (often in suffixes, e.g., *-pa:*, *-ta:*, *-tã:*), progressive harmony fails to apply. Second, word-final schwa in suffixes (e.g., *-pə, -tsə*, etc.) does not trigger regressive harmony in stem vowels.

Additionally, in a few cases of noun compounds, lowering, instead of raising, is triggered by a nonhigh vowel to achieve vowel harmony (Chang, 1968; Dawson, 1983; Hari, 1977). But the lowering cases are an independent issue besides raising, and for the reason of second-handed information, the present study only focuses on the raising vowel harmony in Tibetan, which happens in all the verbs, adjectives, and a part of noun compounds.

[1] The schwa on the surface can also be derived from the pre-labial centralization.
[2] Pre-labial centralization in /lap/ feeds regressive vowel harmony.
[3] Pre-labial centralization in /kap/ feeds progressive vowel harmony.

Table 4. Exceptions to raising harmony in Lhasa Tibetan

stem	**comparative suffix** ***-pa:, -ra:, -ŋa:***	**stem**	**past tense** ***/-pa/ [-pə]***
/sĩ/ 'tasty'	[sĩpa:]	/te:/ 'give'	[te:pə]
/rĩ/ 'long'	[rĩŋa:]	/nɛ:/ 'sleep'	[nɛ:pə]
/t^hu:/ 'thick'	[t^hupa:]	/lɔ:/ 'read'	[lɔ:pə]
/ku/ 'make'	[kura:]	/tã:/ 'be enough'	[tã:pə]
stem	**stem**	**compound**	**gloss**
/mi/ 'person'	/qo/ 'head'	[mẽqo]/[mĩqu]	'human head'
/c^hu/ 'water'	/qo/ 'head'	[c^hõqo]/[c^hũqu]	'water source'
/ti/ 'this'	/nɛ:/ 'from'	[tenɛ:]/[tinɪ:]	'therefore'
/tỹ:/ 'front'	/so/ 'tooth'	[tø̃:so]/[tỹ:su]	'front tooth'

To illustrate an example: the long vowel /a:/ in the comparative suffix *-pa:* blocks progressive vowel harmony in [sĩp**a:**] < /sĩ-p**a:**/ 'tasty', but /a:/ in the stem undergoes changes through regressive vowel harmony, seen in [m**ə:**mi] < /m**a:**+mi/ 'soldier'. The blocking effect of the long vowel /a:/ reflects the asymmetry between progressive and regressive harmony, which is likely due to different directionality-related strengths for vowel harmony.

However, cases with the word-final schwa are more complicated. The word-final schwa in suffixes does not trigger raising harmony; for example, [t**e:**pə] < /t**e:**-pə/ 'give'. Yet other schwas which appear before a labial *p*, as in [p^hy:l**ə**p] and [k**ə**pɪ:], do trigger harmony in the other vowels. In other words, Pre-labial Centralization feeds raising harmony whereas Centralization counterfeeds the vowel harmony so that we see a positional blocking effect on the surface that the vowel in the stem doesn't change in the presence of a high vowel in the suffix (schwa).

3.2. Constraint-based analysis

The present analysis mainly uses the sets of CORR, CC-IDENT, and IO-IDENT constraints from the Agreement-by-Correspondence (ABC) family constraints in Bennett & DelBusso (2018) (cf. Hansson, 2007; 2010) to account for Tibetan vowel harmony. The correspondence constraints are further specified to ensure only vowels and vowels to be in correspondence and then be identical in height features (feature-restricted CORR, CC.ID; Bennett & DelBusso, 2018). As shown below, four crucial constraints are needed for the general vowel harmony pattern in Tibetan.

CORR-V↔V

Segments X and Y specified [+syllabic, -consonantal] are correspondents of one another in an output string.

Assign one violation to each pair of X and Y which is not in correspondence.

V_LV_R-IDENT[HIGH]

Let V_L be a segment in the output and V_R be any correspondent of V_L in the output. If V_L is [+high], then V_R is [+high].

Assign one violation when V_R disagrees in height with V_L[+high].

V_RV_L-IDENT[HIGH]

Let V_R be a segment in the output and V_L be any correspondent of V_R in the output. If V_R is [+high], then V_L is [+high].

Assign one violation when V_L disagrees in height with V_R[+high].

IO-IDENT[HIGH]-V

Preserve the specified feature [high] of input [+syllabic, -consonantal] in the output.

Assign one violation when a vowel in the output disagrees in height with its input.

To make sure the bidirectional raising harmony surfaces, the input-output faithfulness constraint IO-IDENT should be lower ranked than the ABC markedness constraints CORR and VV-IDENT, as illustrated in the following tableaux (2) and (3).

(1) CORR-V↔V, V_LV_R-IDENT[HIGH], V_RV_L-IDENT[HIGH] >> IO-IDENT[HIGH]

(2) Regressive harmony

/te:-qi/	CORR-V↔V	V_RV_L-IDENT[HIGH]	IO-IDENT[HIGH]-V
a. te:$_2$qi$_1$	*! W		L
b. te:$_1$qi$_1$		*! W	L
c. ☞ ti:$_1$qi$_1$			*

(3) Progressive harmony

/ri+tse/	CORR-V↔V	V_LV_R-IDENT[HIGH]	IO-IDENT[HIGH]-V
a. ri$_1$tse$_2$	*! W		L
b. ri$_1$tse$_1$		*! W	L
c. ☞ ri$_1$tsi$_1$			*

The general bidirectional pattern of Tibetan vowel harmony is captured by the four basic constraints: all vowels must be in correspondence and assimilate to [+high] regardless of direction. Other FAITH constraints such as MAX-V, DEP-V, and IO-IDENT[F] where F refers to features other than [high], e.g., [back], [round], etc. are undominated and thus waived discussion in the current analysis since these corresponding processes are never observed in Lhasa Tibetan vowel harmony. The next section will discuss other constraints and rankings pertaining to the two exceptions.

4. Exceptions

4.1. Blocking

Recall the progressive raising is blocked in the presence of the geminate low vowel [a:]. In this case, the faithfulness of the output to the input /a:/ is more important than achieving the general vowel height harmony. Here, we see it is the failure of idempotency in such grammar to not capture blocking cases since raising would constantly apply to all inputs. One of Magri's solutions, constraint restriction, works to separate out the strings to which the constraint would apply. Thus, I propose a specific constraint IO-IDENT[HIGH]-A: by adding an input restriction onto the general constraint IO-IDENT[HIGH]. Accordingly, the general IO-IDENT[HIGH] constraint split into the specific IO-IDENT[HIGH]-A: constraint and a set of individual IO-IDENT[HIGH]-X constraints that apply to input vowels other than the geminate /a:/.

IO-IDENT[HIGH]-A:

Preserve the specified feature [high] of the underlying segment [+long, -high, +back, -round] in the output.

Assign one violation when an [a:] in the output disagrees in height with its input.

This constraint should be ranked higher than the markedness constraint for progressive harmony V_LV_R-IDENT[HIGH] to block raising and lower than that for regressive harmony V_RV_L-IDENT[HIGH] to allow raising. The following tableaux (5) and (6) illustrate the expanded ranking in (4).

(4) CORR-V↔V, V_RV_L-IDENT[HIGH]>> IO-IDENT[HIGH]-A: >> V_LV_R-IDENT[HIGH]>> IO-IDENT[HIGH]-X

(5) Regressive harmony

/ma:+mi/	V_RV_L-IDENT[HIGH]	IO-IDENT[HIGH]-A:
a. ma:$_1$mi$_1$	*! W	L
b. ☞ mə:$_1$mi$_1$		*

(6) Progressive harmony

/sĩ-pa:/	IO-IDENT[HIGH]-A:	V_LV_R-IDENT[HIGH]
a. ☞ sĩ$_1$pa:$_1$		*
b. sĩ$_1$pə:$_1$	*! W	L

4.2. Feeding and counterfeeding

Now we shall consider the interactions between vowel harmony and other relevant processes. As briefly discussed in Sections 2.2. and 3, Pre-labial Centralization process feeds while Centralization counterfeeds the vowel harmony. Specifically, the word-final schwa derived from a low vowel /a/ in the suffix does not trigger vowel harmony while a schwa in other environments, i.e., followed by a /p/ does.

First, consider three new constraints to account for Pre-labial Centralization, Consonant Degemination, and Centralization.

***AP+**

The sequence that the low vowel /a/ followed by a tautosyllabic labial plosive /p/ morpheme is marked.

Assign one violation for each [-high, +back, -round] [+labial, -continuant] +.

***A#**

The low vowel /a/ in a word-final position is marked.

Assign one violation for each [-high, +back, -round] #.

$*C_iC_i$

The sequence of two identical consonants is marked.

Assign one violation for two adjacent identical consonants.

These constraints should be undominated since no violation is observed in Tibetan data, as shown in the current ranking in (7) and tableaux in (8-10).

(7) CORR-V↔V, V_RV_L-IDENT[HIGH], *AP+, *A#, $*C_iC_i$, MAX-C_L >> IO-IDENT[HIGH]-A: >> V_LV_R-IDENT[HIGH]>> IO-IDENT[HIGH]-X

(8) Pre-labial Centralization with Degemination feeds progressive harmony

/kap-pɛː/	*AP+	*C_iC_i	MAX-C_L	V_LV_R-IDENT[HIGH]	IO-IDENT[HIGH]-X
a. ka$_1$ppɛː$_1$	* W	*! W			L
b. ka$_1$pɛː$_1$			*! W		L
c. kə$_1$ppɛː$_1$		* W		*! W	* L
d. kə$_1$pɛː$_1$				*! W	* L
e. ⍰ kə$_1$pɪː$_1$					**

Note that the MAX-C_L constraint penalizes the deletion of the consonant in the first syllable at the morpheme juncture in a sequence of two adjacent identical consonants after suffixation. The purpose is to ensure that the low vowel centralizes to schwa when it is followed by a tautosyllabic labial *p*. For example, (8b) does not exhibit centralization when the left *p* is deleted and thus yields an incorrect output. All resyllabifications are assumed done post hoc.

(9) Pre-labial Centralization feeds regressive harmony

/p^{h}ø-lap/	*AP+	V_RV_L-IDENT[HIGH]	IO-IDENT[HIGH]-X
a. p^{h}ø$_1$la$_1$p	*! W		
b. p^{h}ø$_1$lə$_1$p		*! W	* L
c. ⍰ p^{h}y$_1$lə$_1$p			**

(10) Centralization with opacity

/te:pa/	*A#	V_RV_L-IDENT[HIGH]	IO-IDENT[HIGH]-X
a. te$_1$:pa$_1$	*! W		
b. te$_1$:pə$_1$		*! W	* L
c. ⍰ ti$_1$:pə$_1$			**

However, compare (9) and (10), the current grammar fails to capture the counterfeeding interaction between Centralization and vowel harmony. The problem is obvious that within the current framework of OT constraints that all vowels should be in correspondence and achieve height harmony, if schwas in one context (pre-labially) trigger vowel harmony, schwas in other contexts (e.g., word-finally) must trigger vowel harmony as well. Even taking an opposite approach by banning schwas in all contexts from triggering vowel harmony, we still need to account for cases where pre-labial schwas trigger vowel harmony. The following subsections explore options of constraints in different configurations.

4.3. Anti-correspondence constraints

One option to treat pre-labial schwas and word-final schwas differently is to break the correspondence between the word-final schwa and the other surface vowel in regressive vowel harmony. Here, I posit an anti-correspondence constraint to directly penalize the correspondence between vowels and word-final schwas.

***CORR-V↔ə#**

Segments X specified [+syllabic, -consonantal] and Y [+syllabic, -consonantal, +high, +back, -round] in a word-final position cannot be correspondents of one another in an output string.

Assign one violation to each pair of X and Y which is in correspondence.

Note that this anti-correspondence constraint is directly at odds with CORR-V↔V[4] when the right vowel is a word-final schwa, so it must be ranked higher than the CORR constraint to preclude height assimilation in vowels triggered by word-final schwas.

With this markedness constraint, let us revisit the cumulative ranking in (11) and tableaux (12-13) for feeding and counterfeeding.

(11) *CORR-V↔ə# >> CORR-V↔V, V_RV_L-IDENT[HIGH], *AP+, *A#, *C_iC_i, MAX-C_L >> IO-IDENT[HIGH]-A: >> V_LV_R-IDENT[HIGH]>> IO-IDENT[HIGH]-X

(12) Pre-labial Centralization feeds regressive harmony

/p^{h}ø-lap/	*CORR-V↔ə#	CORR-V↔V	V_RV_L-IDENT[HIGH]	IO-IDENT[HIGH]-X
a. p^{h}ø$_2$lə$_1$p		*! W		* L
b. p^{h}ø$_1$lə$_1$p			*! W	* L
c. ☞ p^{h}y$_1$lə$_1$p				**

(13) Centralization counterfeeds regressive harmony

/te:pa/	*CORR-V↔ə#	CORR-V↔V	V_RV_L-IDENT[HIGH]	IO-IDENT[HIGH]-X
a. ☞ te$_2$:pə$_1$		*		*
b. te$_1$:pə$_1$	*! W	L	* W	*
c. ti$_1$:pə$_1$	*! W	L		** W

We see that the anti-correspondence constraint captures the counterfeeding relation in (13) by disallowing the correspondence between the left vowel and the word-final schwa. The winning candidate (13a) contains two non-corresponding vowels and violates the lower-ranked CORR-V↔V constraint. In the other case of (12) with Pre-labial Centralization, vowels must be in correspondence since the anti-correspondence constraint does not apply there.

The following Hasse diagram (14) summarizes the constraints ranking discussed so far.

(14) *CORR-V↔ə#

CORR-V↔V V_RV_L-IDENT[HIGH] (*AP+, *A#, *C_iC_i, MAX-C_L)

IO-IDENT[HIGH]-A:

V_LV_R-IDENT[HIGH]

IO-IDENT[HIGH]-X

[4] One might propose a more restricted CORR constraint by positing stressed vowels must be correspondents. In this case, the CORR-[+stress] constraint replaces the previous constraint CORR-V↔V, which should now be lower-ranked. However, the CORR-V↔V still does not help because it does not differentiate between the different contexts of schwas in the application of regressive harmony.

4.4. Local conjunction

Besides inventing a new type of anti-correspondence constraints based on the ABC family, a plausible alternative is to propose local conjunction of markedness and faithfulness constraints (Lubowicz, 2002; Magri, 2017). Lubowicz's solution was to solve saltation, or counterbleeding, in derived environments while Magri's was to display chain-shift by building up blocks of faithfulness constraints. For the current study, the blocking effect brought about by the derived word-final schwa can also be captured by local conjunction of markedness and faithfulness constraints. By violating the input-output faithfulness in the left vowel, a lower-ranked markedness constraint is activated to disfavor the word-final schwa.

First, we split the IO-IDENT(HIGH) into two constraints, IO-IDENT(HIGH)-V_L and IO-IDENT(HIGH)-V_R, to penalize the unfaithful mappings for the left and right vowels, respectively. Since the derived environment effect of word-final schwa is seen on regressive harmony, we conjoin the IO-IDENT(HIGH)-V_L constraint with the low-ranked markedness constraint which prohibits the undesirable word-final schwa. The faithfulness for the left vowel is crucial to activate the phonotactics of the word-final schwa to not trigger regressive harmony. This conjunction constraint thus remains undominated.

IO-IDENT[HIGH]-V_L

Preserve the specified feature [high] of the left input [+syllabic, -consonantal] in the output.

Assign one violation when the left vowel in the output string disagrees in height with its input.

IO-IDENT[HIGH]-V_R

Preserve the specified feature [high] of the right input [+syllabic, -consonantal] in the output.

Assign one violation when the right vowel in the output string disagrees in height with its input.

***ə#**

Segment X specified [+high, +back, -round] at the word-final position is marked.

Assign one violation for each word-final schwa.

The alternative full ranking (15) is illustrated by tableaux (16-17) with existing ABC constraints in Section 4.2.

(15) IO-ID(H)-V_L&*ə# >> CORR-V↔V, V_RV_L-IDENT[HIGH], *AP+, *A#, *C_iC_i, MAX-C_L >> IO-IDENT[HIGH]-A: >> V_LV_R-IDENT[HIGH]>> IO-IDENT[HIGH]-V_R, IO-IDENT[HIGH]-V_L, *ə#

(16) Feeding

/ p^hø-lap/	IO-IDENT[HIGH]-V_L&*ə#	V_RV_L-IDENT[HIGH]	IO-IDENT[HIGH]-V_R	IO-IDENT[HIGH]-V_L	*ə#
a. p^hø$_1$lə$_1$p		*! W	*	L	
b. ☞ p^hy$_1$lə$_1$p			*	*	

(17) Counterfeeding

/te:pa/	IO-IDENT[HIGH]-V_L&*ə#	V_RV_L-IDENT[HIGH]	IO-IDENT[HIGH]-V_R	IO-IDENT[HIGH]-V_L	*ə#
a. ☞ te_1:$pə_1$		*	*		*
b. ti_1:$pə_1$	*! W	L	*	* W	*

As opposed to the anti-correspondence constraint which breaks the vowel-vowel correspondence to preclude agreement on height between correspondents, the conjoined constraint maintains the correspondence relation between surface vowels and decouples the input-output faithfulness from a surface markedness pattern in a complex derived context effect. With the presence of a marked word-final schwa, it is fatal to also violate the faithfulness of height in the left input vowel.

The following Hasse diagram (18) summarizes the constraints ranking discussed so far.

(18) IO-IDENT[HIGH]-V_L&*ə#

CORR-V↔V V_RV_L-IDENT[HIGH]   (*AP+, *A#, *C_iC_i, MAX-C_L)

IO-IDENT[HIGH]-A:

V_LV_R-IDENT[HIGH]

IO-IDENT[HIGH]-V_R IO-IDENT[HIGH]-V_L *ə#

5. An alternative: Stem-affix asymmetry

Besides ABC constraints, another family of constraints capturing the asymmetry between stem and affix is implemented within the Transderivational Correspondence Theory (stem-controlled vowel harmony; Baković, 2000). Baković's idea was to preserve the harmonic feature value of the stem in affixation. For the current study, we see bidirectional vowel height assimilation, which means the harmonic feature value [+high] is preserved in both stem and affix. Therefore, I propose the following SA/AS-IDENT constraints to account for the two directions, as opposed to the CORR and VV-IDENT family of constraints.

SA-IDENT[HIGH]

A segment Y specified [+syllabic, -consonantal] in the affix of an affixed form [stem+affix] must have the same specified feature [high] as its correspondent X specified [+high, +syllabic, -consonantal] in the stem.

Assign one violation to each pair of X and Y which disagree on [high].

AS-IDENT[HIGH]

A segment X specified [+syllabic, -consonantal] in the stem of an affixed form [stem+affix] must have the same specified feature [high] as its correspondent Y specified [+high, +syllabic, -consonantal] in the affix.

Assign one violation to each pair of X and Y which disagree on [high].

The following tableaux (20-22) illustrate the ranking with SA/AS-IDENT and IO-IDENT constraints in (19) (compare (4)).

(19) AS-IDENT[HIGH] >> IO-IDENT[HIGH]-A: >> SA-IDENT[HIGH] >> IO-IDENT[HIGH]-X

(20) Regressive harmony

/ma:+mi/	AS-IDENT[HIGH]	IO-IDENT[HIGH]-A:
a. ma:mi	*! W	L
b. ☞ mə:mi		*

(21) Geminate /a:/ blocking in progressive harmony

/sĩ-pa:/	IO-IDENT[HIGH]-A:	SA-IDENT[HIGH]
a. ☞ sĩpa:		* L
b. sĩpə	*! W	

(22) Progressive harmony

/ri+tse/	SA-IDENT[HIGH]	IO-IDENT[HIGH]-X
a. ritse	*! W	L
b. ☞ ritsi		*

Again, to account for the counterfeeding interaction brought about by the derived word-final schwa which only appears in suffixes, we need to split the set of inputs in AS-IDENT(HIGH) constraint into AS-IDENT[HIGH]-ə and AS-IDENT[HIGH]-X so that the word-final schwa is excluded from the input inventory for regressive harmony.

AS-IDENT(HIGH)-ə

A segment X specified [+syllabic, -consonantal] in the stem of an affixed form [stem+affix] must have the same specified feature [high] as its correspondent Y specified [+high, +back, -round] in the affix.

Assign one violation to each pair of X and [ə] which disagree on [high].

The specification of the schwa in the suffix is equivalent to the schwa at a word-final position. The discussion of other harmony-triggering schwas is waived in the current section since they comply with the general vowel harmony pattern with the same set of constraints for Pre-labial Centralization and Consonant Degemination, as detailed in Section 4.2.

Doubtlessly, this constraint is lowest-ranked since vowel harmony is never triggered by the [ə] in the suffix. The updated partial ranking in (23) is illustrated in the tableau (24).

(23) AS-IDENT[HIGH]-X >> IO-IDENT[HIGH]-A: >> SA-IDENT[HIGH] >> IO-IDENT[HIGH]-X >> AS-IDENT(HIGH)-ə

(24) Counterfeeding

/te:pa/	IO-IDENT[HIGH]-X	AS-IDENT[HIGH]-ə
b. ☞ te:pə	*	*
c. ti:pə	**! W	L

Thus, the input-restricted AS-IDENT constraint must be ranked relatively lower than other constraints so that they can be violated at a tiny cost, with little to zero chance to play a role in vowel harmony.

The summarized Hasse diagram is in (25).

(25) AS-IDENT[HIGH]-X

IO-IDENT[HIGH]-A:

SA-IDENT[HIGH]

IO-IDENT[HIGH]-X

AS-IDENT(HIGH)-ə

6. Discussion and conclusion

The exceptions to the general raising harmony in Lhasa Tibetan are rich for investigation of the idempotency in OT grammars. In particular, the interaction between raising harmony and centralization exhibits an intriguing counterfeeding ordering paradox. Though classic OT fails at the counterfeeding problem, three families of constraints work as reasonable solutions.

The common complication for each of the proposed constraints is the need to encode a highly-specific environment where the derived schwa appears. Using the anti-correspondence constraint, word-final schwa is prohibited to be in correspondence with other vowels so that the correct output always contains two non-corresponding segments. Alternatively, with local conjunction, IO-IDENT is split into two sub-constraints to penalize changes in vowels in either left or right position and one of the sub-constraints is conjoined with a lower-ranked markedness constraint. The way it works is to penalize the transparent incorrect output which conforms to vowel harmony through double violations of IO-IDENT.

There are pros and cons for each type of constraints, though. Anti-correspondence is the opposite form of correspondence. It preserves the agreement of height between correspondents and disallows the phonotactically licit word-final schwa to be in correspondence with other vowels. But it is possible that to solve problems like counterfeeding of vowel harmony in derived contexts, anti-correspondence can get too specific and dominant with an abstraction of stipulating which kind of segments cannot be in correspondence with other segments. The typological implications brought by this type of constraints need to be explored in the future.

As for local conjunction, the correspondence relation between vowels is maintained. It works to first separate the violations of input-output faithfulness as a holistic quantitative measure into two sets of violations on individual IO constraints each penalizing a single unfaithful mapping. Then, by conjoining the IO constraint with the markedness constraint which dislikes word-final schwas, the markedness constraint is only activated when the faithfulness in the left vowel is violated. The cost is that the number of constraints needed in the framework increases, and the logic implies that a word should not contain both marked and unfaithful mappings.

Finally, SA/AS-IDENT and VV-IDENT constraints are similar in their definitions. Crucially, the viable mechanism of stem-affix constraints hinges on the overlapping contexts that the word-final schwa only appears in suffixes. Therefore, without further specification, the lowest-ranked constraint AS-IDENT(HIGH)-ə with a restricted input is sufficient to account for the derived environment effects brought about by the word-final schwa.

In conclusion, I have shown ways to tackle non-idempotency arise from exceptions in Tibetan vowel harmony from the perspective of constraint restrictions and local conjunction, using adapted correspondence-based agreement constraints and stem-affix asymmetry constraints. The different types of constraints, however, speaks to the fact that phonotactically legit vowel harmony do not always output in derived environments.

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