ON TONAL TRANSPARENCY*

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1. Introduction

This paper focuses on some intriguing aspects of tone sandhi in the San Miguel El Grande dialect of Mixtec, an Otomanguean language spoken in the state of Oaxaca in Southern Mexico. I will refer to this dialect as SM. My data come from descriptions, dictionaries, and texts provided by Kenneth Pike, Cornelia Mak, Anne Dyk and Betty Stoudt in various publications from the 1940's through the 60's (see References). One striking feature of tone sandhi in SM is tonal transparency. My main goals here are to propose an optimality-theoretic account of this particular phenomenon and connected tonal properties, and to test the appropriateness of tonal underspecification as a mode of representation in Optimality Theory (OT).

By tonal transparency, I mean the following effect observed in SM: in docking to its host, a prefixal floating tone may skip its host's first vowel if this vowel carries a mid tone, and thus surprisingly anchor into a non-leftmost position. Only mid-tone vowels can be transparent in this way. High-tone and low-tone vowels are not. A distinction must therefore be drawn between mid tones on the one hand, and high and low tones on the other hand. One can think of three different lines of attack to capture this required dichotomy. They are listed in (1).

(1) Tonal dichotomy: High, Low vs. Mid
- a. Underspecification: Toned (High or Low) vs. Toneless (Mid) vowels
- b. Markedness: *HIGH, *LOW » *MID
- c. Tone-parsing priorities: MAX-MID » MAX-HIGH, MAX-LOW

The first approach (1a) is the traditional appeal to underspecification: mid-tone vowels are considered phonologically toneless and thus contrast with the block of phonologically toned vowels, whatever tone (high or low) these vowels carry. The other two approaches arise from OT work. One is that on a scale comparable to the one suggested for places of articulation and Coronal Unmarkedness (Prince & Smolensky 1993), mid tones can be viewed as less marked than either high or low tones (1b). The other possibility, the most direct one, is to assume a Constraint Hierarchy where the parsing of mid tones has priority over the parsing of both high and low tones (1c). My tentative conclusion at this point is that the underspecification approach is superior to the other two in providing a full explanation of the facts in SM. I will focus here on presenting an OT account which assumes underspecification (1a), leaving a detailed comparison of all three lines of attack for another occasion.

2. Background on SM

2.1. Some basic phonological characteristics

I begin by providing some relevant background on SM phonology. Lexical words in SM are bimoraic, typically of the general segmental shapes shown in (2) and (3).

* For their useful feedback on my work on Mixtec, I would like to thank Matthew Chen, Moira Yip, and Cheryl Zoll, as well as members of the audience at the Second South Western Optimality Theory Workshop.

(2) a. CVV
b. CVCV

(3) a. CV?V
b. CV?CV

Within the (2a) group, we'll see that a crucial distinction needs to be recognized between morphemes containing a long vowel and those containing two different vowels. As illustrated in (4), when relevant, I will use underlining to signal vowels with the same melody.

(4) a. CVV (V = V)
b. CVV (V ≠ V)

SM has three level tones: High (H), Mid (M), and Low (L). Each mora can bear one tone, and only one. As indicated in (5), contour tones are thus not allowed on single moras.

(5) No contour tones on single moras

The distribution of the three level tones over the two moras of a lexical word is almost free. Out of the nine logically possible tonal patterns tabulated in (6), there are only two restrictions, having to do with the italicized MH and LL patterns.

(6)

HH	*MH*	LH
HM	MM	LM
HL	ML	*LL*

One restriction is that the LL pattern does not occur at all. By contrast, the other two double patterns, HH and MM, are attested. These facts are illustrated in (7) (In all examples, an acute accent represents a high tone, a grave accent represents a low tone, and mid tones are left unmarked).

(7) a. *LL
b. HH: sáná 'turkey'
c. MM: bina 'today'

I will have nothing further to say about this LL gap, which might be accidental (the LL pattern is found in a closely related dialect, Chalcatongo Mixtec; see Macauley 1996).

The second tonal gap concerns the MH pattern and is quite important for our purposes. As I will show later, this pattern is banned in derived forms of the types listed in (8), i.e. over words with a long vowel and over words with a medial glottal stop.

(8) a. CVV *MH
b. CV?V, CV?CV *MH

The MH ban catalogued in (8) seems to hold lexically as well. At least, in the SM literature I have consulted, I have been unable to find any example combining these segmental and tonal structures. As shown in (9), the MH pattern is attested elsewhere, i.e. in CVV words with two different vowels and in CVCV words.

(9) a. CVV √MH
b. CVCV √MH

For clarity, I have regrouped in (10)-(12) the three striking contrasts regarding the distribution of the MH tonal pattern.

(10) a. $C\underline{VV}$ *MH
b. CVV √MH

(11) a. CV?V *MH
b. CVV √MH

(12) a. CV?CV *MH
b. CVCV √MH

The contrast in (10) shows the importance of the distinction drawn in (4) above among CVV words. The two contrasts in (11) and (12) flag the crucial role played by medial glottal stops in tonal matters. Altogether, these contrasts demonstrate that vowel length and medial glottal stops are independent factors in the prohibition against the MH tonal pattern.[1]

2.2. SM's floating high tones

In this section, I provide some background description on floating high tones in SM. SM has lexical floating high tones acting as prefixes on an immediately following morpheme. It is the anchoring behavior of these high tones which will be of interest to us throughout the rest of this paper.

As shown in (13), floating high tones may occur in three lexical contexts in SM (I use the notation "(H)" to represent a floating high tone): (i) at the end of words, as illustrated in (13a) with a lexical minimal pair, (ii) as part of purely consonantal morphemes, as illustrated in (13b) with the lexical representation of the causative, and (iii) as part of so-called 'zero words', as illustrated in (13c) with the lexical representation of the continuative prefix.[2]

(13) a. kee (H) 'to eat' vs. kee 'to go away'
b. s (H) [causative prefix]
c. (H) [continuative prefix]

I have defined these floating high tones as prefixal because they can be described as normally anchoring to the first vowel in their host, as exemplified in (14) with CVCV hosts containing only mid tones.

(14) a. hà (H) 'that' + z&uku 'mountain' —› hà z&úku 'that mountain'
b. s (H) 'causative' + kahi 'to eat' —› skáhi 'to feed'
c. (H) 'continuative' + kunu 'to weave' —› kúnu 'is weaving'

The placement of these three floating high tones on a host's initial vowel contrasts with the placement of another floating high tone which serves to derive modifiers. The latter tonal morpheme completely replaces the tonal pattern of its host,[3] as illustrated in (15) with several types of bases.

[1] To my knowledge, the independence of these two factors has not been previously recognized in the literature on Mixtec (see Section 4.2 below).
[2] The continuative prefix may also have diverse palatalizing influences depending on the stem to which it is associated (Pike 1944: 123; Tranel 1995a: 309, note 7).
[3] Only the lexically anchored tonal pattern is replaced. Thus, if a host contains a final floating high tone, this floating high tone remains operative and the derived modifier will create a prefixal tonal "perturbation" in the following morpheme (see Tranel 1995a: 308).

(15)		Base		Derived modifier
	a.	z&unu	'tree'	z&únú
	b.	z&u?u	'mouth'	z&ú?ú
	c.	z&uù	'stone'	z&úú
	d.	sùc&í	'child'	súc&í
	e.	tá¢?a¢	'comrade'	tá¢?á¢

This high tone morpheme thus forms a tonal template that can be defined in terms of alignment as demanding that the high tone coincide with both edges of its host,[4] whereas the prefixal high tones in (13) can be defined as demanding to be leftmost in their hosts. Another difference between the two types of floating tones is that the high tone forming modifiers takes over the lexical tonal pattern of its host regardless of the host's segmental or tonal make-up, whereas as we are about to see, the prefixal high tones are in a sense bossed around by their hosts.

2.3. The association of prefixal floating high tones

Prefixal floating high tones anchor into the next morpheme, and as we saw in the examples in (14), they may very well be found on the first vowel of their hosts, where well-behaved prefixal tones should appear. Things, however, are not that orderly, it seems, and in reality, the landing sites of these prefixal floating high tones vary depending on the host's own tonal and segmental make-up.

I will focus first on the import of the host's tonal make-up. The crucial fact here is that contrary to what one might expect, a prefixal floating high tone does not automatically dock onto its host's first vowel. Instead, it prefers to attach to the first low-tone or high-tone vowel in the host, even if this requires skipping over an intervening mid-tone vowel. In other words, mid-tone vowels are transparent. This pattern is typical for hosts of the shapes given in (16), that is, morphemes with no medial glottal stop and CVV morphemes with a sequence of two different vowels.

(16) a. CVCV (medial C ≠ ?)
b. CVV (V ≠ V)

The tonal facts just described are schematized and illustrated in (17), where X represents any tone (H, M, or L).

(17) Pattern with words containing a low tone or a high tone

a. (H) + LX and (H) + HX —› HX

e.g. (H) + kìku —› kíku 'to sew'
(H) + sùc&í —› súc&í 'child'
(H) + káni —› káni 'long'
(H) + lúlí —› lúlí 'small'

b. (H) + ML and (H) + MH —› MH [TRANSPARENCY OF MID-TONE VOWELS]

e.g. (H) + z&ukù —› z&ukú 'branch'
(H) + z&aù —› z&aú 'cave'
(H) + kuc&í —› kuc&í 'pig'

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[4] Another example of a tonal template in SM is the pattern HL, which is used to mark direct address (Pike 1948: 87). It too entirely replaces the lexical tonal pattern of its host (e.g. *tiú* 'uncle' —› *tíù*).

(17a) shows that a floating high tone replaces an initial low or high tone. Actually, when a floating high tone lands on an already high-tone vowel, one could assume that the two high tones coalesce. For the sake of symmetry with what obviously happens to low tones (they are lost), I will however assume here that replacement rather than coalescence occurs.[5] The pattern in (17a) actually holds true of all hosts, regardless of their segmental make-up: thus, in all cases, if the first mora carries a low tone or a high tone, it will always attract the floating high tone.

(17b) shows the transparency effect: if the first vowel of the host morpheme is mid toned, then the floating high tone ignores this vowel and hops over to the second vowel, where it replaces a low tone or a high tone, yielding a MH pattern. As already mentioned, this transparency pattern is only true for hosts of the shapes given in (16) above.

What happens if the host has only mid-tone vowels? As already illustrated in (14), and as diagrammed in (18), in this case, a floating high tone invariably anchors to that host's first vowel.

(18) Pattern with MM words
(H) + MM —› HM   e.g. (H) + z&uku—› z&úku 'mountain'

This pattern is true for all hosts, regardless of their segmental make-up. However, as shown in (19), an interesting additional fact here is that words with a long vowel have the option of spreading the high tone over the whole vowel.

(19) Pattern with CMM words
(H) + MM —› HM ~ HH   e.g. (H) + kee —› kée ~ kéé 'to go away'

It is worth noting that this option is exclusively attested on hosts with long mid-tone vowels.[6] So, for instance, as shown in (20), given a host with a long vowel and a LM tonal pattern, the anchoring of a floating high tone yields only one possibility, the HM pattern; HH is not attested in such a case.

(20) (H) + LM —› HM, *HH   e.g. (H) + c&ìi —› c&íi, *c&íí
'beneath'

Under certain conditions, the tonal transparency of mid-tone vowels shown in (17b) can be thwarted. Anti-transparency, as I will call this phenomenon, brings us to the import of a host's segmental make-up. Transparency is blocked in two specific cases, which are listed in Column (A) of the table in (21). First, transparency is blocked when a medial glottal stop occurs in the host, and secondly, transparency is blocked in CVV hosts with a long vowel. In these two cases, a floating high tone replaces the mid tone on the first mora, regardless of the tone carried by the second mora. A low tone or a high tone on the second mora is thus powerless here to attract a floating high tone. Illustrations are provided in the table in (21) with hosts exhibiting a lexical ML tonal pattern. In Column (B) of the table are the anti-transparency cases, and they are contrasted in Column (C) with already familiar transparency cases taken from (17b).

[5] The impact of this choice on the analysis revolves around the nature of the constraint forcing the parsing of a floating high tone. If this constraint turns out to be that high tones get priority in parsing, then coalescence must be assumed rather than replacement (see Tranel 1995b,c, where such a view is adopted).

[6] This option also seems possible with CV?V hosts when the two vowels are the same (Pike 1948: 79-80). I found one example interpretable in this way, which I list in (i) (Mak 1958: 64).

(i) z&´k´ (H) 'bone' + z&u?u 'mouth' —› z&´k´ z&ú?ú 'jaw bone'

However, the high tones on the word for 'mouth' in the output could be due instead to the floating high tone morpheme that serves to form modifiers (see (15b) above).

(21) Anti-transparency vs transparency

(A)	(B) Anti-transparency	(C) Transparency [from (17b)]
Case I: Medial ?	(H) + CM?L —› CH?L, *CM?H (H) + ta?ù —› tá?ù, *ta?ú 'to beat'	(H) + CMCL —› CMCH, *CHCL (H) + z&ukù —› z&ukú, *z&úkù 'branch'
Case II: Long V	(H) + CML —› CHL, *CMH (H) + koò —› kóò, *koó 'snake'	(H) + CML —› CMH, *CHL (H) + z&aù —› z&aú, *z&áù 'cave'

Case I shows that a medial glottal stop prevents a floating high tone from skipping a mid-tone vowel in order to replace a subsequent low tone. In other words, a medial glottal stop constitutes a barrier for a floating high tone, counteracting the otherwise observed transparency of mid-tone vowels. Case II shows the other instance where the transparency of mid-tone vowels is likewise overridden, namely when a long vowel is involved. As mentioned earlier, although these anti-transparency cases both involve an offending MH tonal pattern, it does not appear that a single causal agent can be held responsible, given the three-way contrast repeated in (22a-c).

(22)	a.	(H) + koò	—›	kóò	*koó	'snake'
	b.	(H) + z&aù	—›	z&aú	*z&áù	'cave'
	c.	(H) + ta?ù	—›	tá?ù	*ta?ú	'to beat'

(22a) vs. (22b) shows that a contrast exists between CVV morphemes with a long vowel and CVV morphemes with two different vowels. And (22b) vs. (22c) shows that a contrast exists between the absence vs. presence of a medial glottal stop.

The basic task in the remainder of this paper, then, is to explain on the one hand the transparency of mid-tone vowels to the anchoring of prefixal floating high tones, and on the other hand the anti-transparency effects conditioned by medial glottal stops and long vowels. I will also account for the special spreading of floating high tones which is optionally allowed by hosts containing long mid-tone vowels. As already mentioned, the following analysis is couched within OT and assumes an underspecification approach to tonal contrasts in SM.[7]

3. Theoretical preliminaries

Before presenting my analysis (Section 4), I lay out in this section a set of working hypotheses. For the most part, they concern unviolated undominated constraints in SM. For convenience, these constraints are listed together in (23), with brief informal definitions.

(23) Set of unviolated undominated constraints assumed for SM

a. PARSE (T): Floating tones must be parsed
b. DEP-TONE: Don't insert tones
c. T/A CORR: If parsed, lexical tones must stay home
d. NO CONT: No contour tones on single moras

[7] I have sought elsewhere (Tranel 1995a,b,c) to show the superiority of an OT account over a rule-based derivational treatment. The OT analysis presented here is based on these earlier papers, but with significant modifications, in particular with respect to the treatment of medial glottal stops and the restricted optional spreading of floating high tones.

e. UNIFORMITY: No coalescence
f. TONAL OCP: No identical adjacent anchored tones within morphemes

First, I assume that the floating high tones under investigation must be parsed, leaving aside any discussion of the exact nature of the high-ranking constraint enforcing their parsing onto a following morpheme (see note 5 above). For concreteness, PARSE (T) in (23a) is used as the enforcer here. There is only one circumstance where a floating high tone is not parsed, that's when it belongs to a lexical word that occurs before a pause. This indicates that the parsing of floating high tones may actually be violated, but I will not be concerned with such cases in this paper (see Tranel 1995b,c for an account). Instead, I will assume throughout that a following host is available and that the floating high tone must be integrated into it. I will therefore usually consider as relevant only those candidates with the floating high tone parsed.

Secondly, I extend the notion of Correspondence (McCarthy & Prince 1995) to tones and tonal associations (see also McCarthy 1996). In this respect, I assume two types of faithfulness constraints: (i) tone-specific MAX and DEP constraints, called MAX-TONE and DEP-TONE, and (ii) a TONE/ANCHOR CORRESPONDENCE constraint labelled T/A CORR. I discuss briefly here how these three constraints operate in SM.

MAX-TONE, given in (24), bans the deletion of tones.

(24) MAX-TONE: Every input tone has an identical output correspondent

In SM, when a floating high tone replaces a lexically anchored tone, MAX-TONE is violated. For example, in (25), the low tone fails to be parsed, and a MAX-TONE violation is incurred.

(25) (H) + CLCH —› CHCH

MAX-TONE must thus be a violable, dominated constraint in SM.

By contrast, DEP-TONE, which is given in (26), and which bans the insertion of tones, is unviolated in SM. The tones found in optimal candidates must all have a source in their respective inputs.

(26) DEP-TONE: Every output tone has an identical input correspondent

I will therefore assume that DEP-TONE is undominated in SM. This constraint applies in the phonology, and does not affect phonetic implementation, where phonologically toneless vowels must be supplied with a default mid tone.

T/A CORR, which is informally given in (27), is a faithfulness constraint on tonal association which is also unviolated and undominated in SM.

(27) T/A CORR: If a lexically anchored tone T is parsed, its lexical association to any Tone Bearing Unit (TBU) must be strictly maintained

What I intend to capture with this constraint and its high ranking in SM is the following. If a lexically anchored tone is parsed, it absolutely cannot be associated with any vowel other than its lexical anchor. In particular, when a floating high tone replaces, say, a low tone, that low tone cannot be parsed on another vowel (even a toneless vowel) in order to avoid a MAX-TONE violation. The parsing of a floating high tone in SM thus does not create a domino effect whereby delinked tones are displaced down the string of TBU's. Some languages, e.g. Kikuyu, allow such chain reaction effects (Clements & Ford 1979), and in their Constraint Hierarchies, T/A CORR would presumably be ranked low. But SM strictly prohibits this phenomenon, and undominated T/A CORR achieves this result, at the expense of tone-parsing violations. This effect corresponds to what McCarthy 1996 has recently dubbed NO FLOP, which basically declares that no feature can be displaced from its lexical anchor to another anchor.

Another effect of T/A CORR is that a lexically anchored tone cannot spread (this effect corresponds to McCarthy's 1996 NO SPREAD). By T/A CORR, the reason such a tone cannot spread is that it would then be associated to a vowel to which it is not lexically associated. I will use T/A CORR as a cover term for both NO FLOP and NO SPREAD, as SM does not appear to distinguish between the two related effects.

It is important to emphasize that T/A CORR does not necessarily ban a single tone linked to two vowels, even in SM, where T/A CORR is undominated. A doubly-linked tonal configuration is not in violation of T/A CORR under two types of circumstances. (i) If the double link exists as part of an input, then T/A CORR is actively satisfied through complete faithfulness. (ii) If the doubly-linked tone comes from a lexical floating high tone, then T/A CORR is satisfied vacuously. The reason is that floating tones are by definition not lexically anchored; whatever anchoring they have in a candidate will therefore not violate their anchoring in the input, since they have none.

Note also that T/A CORR does not adjudicate deletion cases. Thus, a candidate where a lexically anchored tone has been deleted will not for this reason incur a violation of T/A CORR, although of course it will incur a violation of MAX-TONE.

To sum up, then, all T/A CORR does in SM is prevent a lexically anchored tone from being anchored to a different vowel in any viable candidate.

Thirdly, floating high tones in SM could conceivably anchor to an already toned vowel without displacing its lexical tone, thereby giving rise to a contour tone and avoiding potential MAX-TONE or T/A CORR violations. This sort of phenomenon is attested in many languages, but does not occur in SM. I enforce this SM pattern by means of another undominated constraint, NO CONTOUR (NO CONT). As indicated in (28), NO CONT basically bars a TBU from branching into two tones. This constraint reflects one half of the well-known generalization that everything else being equal there will be at most a one-to-one association between TBU's and tones. Toneless vowels vacuously satisfy NO CONT.

(28) NO CONT: A TBU cannot branch into more than one tone

In SM, when a floating high tone is anchored into a lexically toned vowel, NO CONT, then, will basically force the removal of that lexical tone.

A possible effect of NO CONT on a floating high tone anchoring into an already high-tone vowel could be coalescence, but coalescence could also be the result of an active tonal OCP constraint. As already mentioned, for the sake of symmetry with what happens to low tones, I will assume that replacement rather than coalescence occurs in such cases. To ensure this result, I will assume that both UNIFORMITY (23e) and the tonal OCP (23f) are undominated in SM (UNIFORMITY is the constraint proposed by McCarthy & Prince 1995 against coalescence).

The example in (29), repeated from (25) in expanded form, can usefully serve to illustrate how these various assumptions function in SM.

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(29)             CV1CV2
              +   |   |     —›  CHCH
        (HØ)      L1  H2
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We start here with an input composed of a floating high tone and a CVCV morpheme with a LH tonal pattern. The desired output has high tones throughout. Five interesting candidates are listed in (30) (the indices here serve to keep track of which high tone is which: thus, HØ represents the floating high tone in the input and H2 represents the high tone anchored to V2 in the input). Excluded from consideration for now are (ungrammatical) candidates where the floating high tone would skip the first (low-tone) vowel of the host. The grammatical output actually has three conceivable phonetically identical representations, which are given in (30c-e).

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(30)    a. C  V1  C   V2          b. C  V1  C   V2
              |       |                 / \      |
              L1      H2             HØ  L1     H2

        c. C  V1  C   V2          d. C  V1  C  V2          e. C  V1  C  V2
              |       |                   \     /                 \     /
              HØ      H2                  HØ, 2                     HØ
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Tableau (31) shows how, given my set of working hypotheses, (30e) emerges as the optimal candidate.[8]

Tableau (31)

(H) + CLCH	Status	PARSE (T)	DEP-TONE	T/A CORR	NO CONT	UNIFORM	OCP	MAX-TONE
(30a)	†	*!	√	√	√	√	√	* [HØ]
(30b)	†	√	√	√	*!	√	√	√
(30c)	†	√	√	√	√	√	*!	* [L1]
(30d)	†	√	√	*!	√	*!	√	* [L1]
(30e)		√	√	√	√	√	√	** [L1,H2]

Candidate (30e) violates lower-ranked MAX-TONE twice (since it fails to parse both lexically anchored tones L1 and H2), but it satisfies all the undominated constraints. By contrast, the other candidates all violate at least one of the undominated constraints. Thus, candidate (30a) fails to parse the floating high tone and fatally violates PARSE (T). Candidate (30b) is the most tonally faithful candidate, but at the expense of a contour tone, banned by undominated NO CONT. Candidates (30c) and (30d) violate MAX-TONE just once (since they only fail to parse L1), but (30c) fatally violates the OCP (since it contains two adjacent high tones), and (30d) fatally violates both T/A CORR and UNIFORMITY (it violates T/A CORR because the high tone lexically linked to V2 is now also linked to V1, which wasn't the case in the input, and it violates UNIFORMITY because a single high tone corresponds to two separate high tones in the input).

4. Underspecification Analysis

With these preliminaries behind us, I now move on to an analysis of the data, assuming an underspecification approach. I will first consider transparency (Section 4.1), then the two cases of anti-transparency (Sections 4.2 and 4.3), and finally the highly restricted case where the floating high tone may spread over the two moras of a long mid-tone vowel (Section 4.4).

4.1. Transparency

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[8] (30c) might reasonably be regarded as a more legitimate output than homophonous (30e). Should this view be indeed preferable, then the tonal OCP, assumed here to be unviolated and undominated, would need to be demoted to below MAX-TONE in the Constraint Hierarchy, thereby allowing (30c) to be picked over (30e) (see Tableau (31)). This change would not affect the rest of the analysis (see also notes 12, 25 and 26 below).

I begin with the straightforward cases where a floating high tone expectedly docks onto the first vowel of its host. These cases are presented again in (32), in compact fashion, with hosts of the type CVCV. T represents a high-tone or low-tone vowel and X represents any vowel.

(32) a. (H) + CMCM —› CHCM
b. (H) + CTCX —› CHCX

We can see that a floating high tone anchors to the first vowel of its host under two conditions: either the host has a MM tonal pattern, as in (32a), or else its first vowel carries a low tone or a high tone, as in (32b).

I take such data to indicate that the floating high tones under consideration function as prefixes and thus want to be associated to the leftmost vowel in their hosts. This preference can be captured by the alignment constraint in (33), ANCHOR-LEFT, which states that our floating high tones must be leftmost-anchored (equivalently, left-aligned) in their hosts.

(33) ANCHOR-LEFT: (H) must be leftmost-anchored

However, as we have seen already (see (16) and (17b) above) and as diagrammed once more in (34), this preference is overridden in CVCV and CVV hosts with a mid-tone first vowel and a low or high tone on the second vowel. In such cases, the floating high tone ignores the mid-tone first vowel and docks instead to the second vowel, yielding the transparency effect.

(34) Transparency effect

(H) + CMCT	—›	CMCH,	*CHCT	(medial C ≠ ?)
(H) + CMT	—›	CMH,	*CHT	(V ≠ V)

The descriptive generalization emerging from (32) and (34) is that when there is a choice, a floating high tone is attracted to a high-tone or low-tone vowel rather than to a mid-tone vowel. High tones and low tones thus function together, and differently than mid tones. The underspecification approach to this dichotomy is to consider that mid-tone vowels are distinguished from high-tone and low-tone vowels by being phonologically toneless, their surface tone resulting from a default mid tone being assigned at the level of phonetic implementation. The claim, then, is that tone languages may phonologically contrast toneless vowels with toned vowels, and that the existence of a surface tone on phonologically toneless vowels is merely a byproduct of our vocal apparatus. It is a physiological necessity for a voiced vowel to be realized with a tone (i.e. the vocal cords must vibrate at a certain rate phonetically interpretable as a tone in a tone language).[9]

It must be said that phonetic implementation has both a language-specific component and a universal component. Thus, languages may differ as to which tone they will use as a default tone: SM uses a mid tone, but other languages are known to use a low tone (e.g. Margi; see Pulleyblank 1986, Tranel 1992-94). The universal component, at least to my knowledge, is that a high tone is never used as a default tone. If this observation is correct, then an explanation along traditional markedness lines must be invoked to account for why when it comes to default values cross-linguistically, the dichotomy among tones is high on the one hand (not a possible default tone) vs. low and mid on the other hand (possible default tones), with the choice between low and mid being language-particular.

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[9] In a Sapirian experiment, it might be surmised that in transcribing their language, native speakers of SM would mark high tones and low tones, but leave mid tones unmarked, in a way reminiscent also of native speakers of Chinese insisting that there is no tone on morphemes with the so-called neutral tone.

The central constraint that I propose to capture transparency under this approach is TPFAITH (Tonal Prominence Profile Faithfulness). As shown in (35), TPFAITH seeks to enforce tonal prominence profile correspondence between input and output.

(35) TPFAITH: Preserve tonal prominence profile

Given tonal underspecification, vowels in SM are phonologically either toned or toneless. Toned vowels are tonally prominent whereas toneless vowels are tonally non-prominent. The general idea behind TPFAITH is that candidates will be faithful with respect to tonal prominence profiles if and only if they parallel their inputs in terms of the distribution of toned vs. toneless vowels. TPFAITH thus abstracts away from the distinction between low and high tones; it is only concerned with the distinction between toned and toneless vowels. Basically, then, TPFAITH states that a tonally prominent vowel must remain so (i.e. a toned vowel must remain toned) and a tonally non-prominent vowel must remain so (i.e. a toneless vowel must remain toneless).

There are altogether four possible tonal prominence profiles on SM lexical words, and they are listed in (36). That there are just four is due to the fact that there are only two tonal slots per lexical word (see Section 2.1 above regarding bimoraicity and the absence of contour tones). Note that there can therefore maximally be just one TPFAITH violation for a given candidate, that is a change from one of the tonal prominence profiles to another.[10]

(36)	Tones	Tonal Prominence Profiles		
	a. MM	Ø	none	(MM [toneless] morphemes)
	b. TT	—	even profile	(HH, HL and LH morphemes)
	c. MT	**d**	ascending profile	(MH and ML morphemes)
	d. TM	**f**	descending profile	(HM and LM morphemes)

The anchoring of a floating high tone to a host, then, is taken to create a TPFAITH violation when it results in a change between input and candidate from one tonal prominence profile to another. Importantly, when a floating high tone replaces a low tone or a high tone, TPFAITH is not violated. But TPFAITH is violated when a floating high tone lands on a toneless vowel. As an enforcer of the preservation of tonal prominence profiles, TPFAITH will thus guarantee that everything else permitting, toneless vowels will be ignored in favor of already toned vowels as anchors for floating high tones.[11]

The two tableaux in (37) illustrate the role of TPFAITH in SM. In these and subsequent tableaux, the apple designates the optimal candidate or "good guy", the dagger points to the "bad guy". As usual, asterisks indicate contraint violations and exclamation marks indicate fatal violations. Additionally, I use check marks to specify constraint satisfaction. Another important notational point to keep in mind here is that M now represents a toneless vowel.

Tableau (37a): Role of TPFAITH

Input: (H) + CMCL	Status	TPFAITH
a. CMCH	🍎	√
b. CHCL	†	*

[10] By contrast, in a language allowing three or more tonal slots per morpheme, TPFAITH could be violated more than once in a given candidate. For example, with an input such as MTM (**d f**), a candidate of the form TTM (— **f**) would incur one TPFAITH violation, but a candidate of the form TTT (— —) would incur two violations.

[11] TPFAITH is not without parallel to FOOT-FORM. For a group of two syllables to respect FT-FORM-IAMBIC or FT-FORM-TROCHAIC is to abide by a certain prominence profile - a stress profile - over a given domain. This is exactly the type of thing TPFAITH seeks to enforce, but at the tonal level.

Tableau (37b): Role of TPFAITH

Input: (H) + CLCM	Status	TPFAITH
a. CHCM		√
b. CLCH	†	*

The inputs in the two tableaux in (37) both contain a floating high tone followed by a CVCV morpheme. The difference is that in Tableau (37a), the CVCV morpheme has a toneless first vowel and a low-tone second vowel, whereas in Tableau (37b), it has a low-tone first vowel and a toneless second vowel. In both tableaux, the floating high tone is parsed on the lexically toned vowel in candidate (a) and on the toneless vowel in candidate (b). We can see that TPFAITH can make the correct distinction in both cases, since it favors the grammatical candidates in (a) over the ungrammatical candidates in (b).

Notice that in both tableaux in (37), the winning candidates fail to parse the low tone of the input, whereas the losing candidates do parse it. As illustrated in the two tableaux in (38), this shows that TPFAITH must dominate MAX-TONE.

Tableau (38a): TPFAITH » MAX-TONE

Input: (H) + CMCL	Status	TPFAITH	MAX-T
a. CMCH		√	*
b. CHCL	†	*!	√

Tableau (38b): TPFAITH » MAX-TONE

Input: (H) + CLCM	Status	TPFAITH	MAX-T
a. CHCM		√	*
b. CLCH	†	*!	√

Consider next the effect obtained by anchoring floating high tones onto hosts with two toneless vowels. The association of the floating high tone in such cases will necessarily result in a violation of TPFAITH, as it will change one of the toneless vowels into a toned one. As shown by Tableau (39), TPFAITH is powerless to make a decision in such cases.

Tableau (39): TPFAITH powerless

Input: (H) + CMCM	Status	TPFAITH
a. CHCM		*
b. CMCH	†	*

The input in this tableau is a CVCV morpheme with toneless vowels and a preceding floating high tone. We can see that TPFAITH is equally violated by the two candidates.

The Constraint Hierarchy must pick as optimal the candidate where the floating high tone is anchored to the first rather than the second toneless vowel. As shown in Tableau (40), this decision can be entrusted to ANCHOR-LEFT, which was introduced in (33) above.

Tableau (40): Role of ANCHOR-LEFT

Input: (H) + CMCM	Status	TPFAITH	ANCHOR-LEFT
a. CHCM		*	√
b. CMCH	†	*	*!

In Tableau (40), the two candidates tie on TPFAITH, which they both violate, but candidate (a) wins because it satisfies ANCHOR-LEFT, whereas candidate (b) violates it.

As shown by Tableau (41), the relative ranking of TPFAITH and ANCHOR-LEFT can be established by considering CVCV hosts containing a toneless first vowel and a toned second vowel.

Tableau (41): TPFAITH » ANCHOR-LEFT

Input: (H) + CMCL	Status	TPFAITH	ANCHOR-LEFT
a. CMCH		√	*
b. CHCL	†	*!	√

The fact that candidate (a) must be the winner demonstrates that TPFAITH dominates ANCHOR-LEFT.

TPFAITH thus dominates both MAX-TONE and ANCHOR-LEFT. This dominance derives the transparency effect. The relative ranking of the latter two constraints can be determined by considering CVCV hosts with a low-tone first vowel and a high-tone second vowel (see (29) above). Tableau (42) shows that ANCHOR-LEFT must dominate MAX-TONE.

Tableau (42): ANCHOR-LEFT » MAX-TONE

Input: (HØ) + CL1CH2	Status	TPFAITH	ANCHOR-LEFT	MAX-T
a. CHØCHØ		√	√	** [L1, H2]
b. CL1CHØ	†	√	*!	* [H2]

For this type of input, Tableau (31) above evaluated the five candidates in (30) and ruled in favor of (30e). (30e) appears as (42a) in Tableau (42), where it faces the challenge of (42b), a candidate not previously considered. Like (42a), (42b) satisfies TPFAITH, as well as all the undominated constraints listed in Tableau (31). (42a) and (42b) differ only in relation to ANCHOR-LEFT and MAX-TONE. (42a) satisfies ANCHOR-LEFT and (42b) violates it, whereas (42b) does better than (42a) with respect to MAX-TONE (since it violates this constraint once instead of twice). The dominance of ANCHOR-LEFT over MAX-TONE ensures the emergence of the grammatical output CHCH found in (42a), rather than the ungrammatical output CLCH in (42b).[12]

The crucial constraint rankings discussed in this section are recapitulated in (43).

(43) TPFAITH » ANCHOR-LEFT » MAX-TONE

To summarize, TPFAITH is the pivotal constraint accounting for transparency effects, but its very existence depends on the recognition of a possible phonological contrast between toned and toneless vowels in tone languages. TPFAITH works to preserve the tonal prominence profile of morphemes. In SM, it is satisfied at the expense of failing to anchor prefixal floating high tones onto the leftmost vowel of hosts (violations of ANCHOR-TONE) and at the expense of failing to parse lexically anchored tones (violations of MAX-TONE). Languages where a prefixal floating tone systematically anchors onto the first vowel of its hosts would differ from SM in having ANCHOR-LEFT dominate TPFAITH.

4.2. Medial glottal stops

[12] If (30c) were to be the optimal candidate rather than (30e) [= (42a)] (see note 8 above), the ranking of ANCHOR-TONE and MAX-TONE could be left undetermined, since (30c) and (42b) tie on MAX-TONE with one violation each.

I now address the first anti-transparency case, the one involving medial glottal stops. As noted earlier (see (21B, Case I) above) and as diagrammed again in (44), with hosts containing a medial glottal stop, a preceding floating high tone is strictly limited to docking onto its host's first vowel, even in cases where one would otherwise expect an initial toneless vowel to be skipped in favor of a subsequent toned vowel. In other words, medial glottal stops block transparency.

(44) Anti-transparency effect (Case I)

(H) + CM?L —› CH?L, *CM?H
(H) + CM?CL —› CH?CL, *CM?CH

TPFAITH thus seems to be consistently violated in words with medial glottal stops. This anti-transparency phenomenon clearly indicates that medial glottal stops and tones interact in SM and must share common ground.

In recent years, several researchers working on Mixtec (see Macauley & Salmons 1995; Macauley 1996: Chapter 2) have proposed to view medial glottal stops in these languages as a phonological laryngeal feature - [constricted glottis] - on the preceding vowel. Several arguments (distributional, phonetic, and diachronic) have been adduced in favor of this proposal, and I will adopt it here. For convenience of reference, I will however continue to use the expression "medial glottal stop", and I will also continue to symbolize this laryngeal feature on vowels with a postvocalic glottal stop.

This proposal allows the canonical segmental patterns of lexical words in SM to be reduced to the two listed in (45), by eliminating the two in (46) that otherwise need to be recognized ((45) and (46) are repeated from (2) and (3) in Section 2.1 above).

(45)	a. CVV	(46)	a. CV?V
	b. CVCV		b. CV?CV

In addition, a more general picture of syllable structure emerges for SM: SM is a language banning codas.

The counterpart of course is that [constricted glottis] must be considered as a distinctive feature on SM vowels, with the occurrence of this feature restricted in seemingly puzzling ways. First, it may only occur on the first vowel of morphemes. Secondly, it is limited to roots, as opposed to affixes or clitics (Macauley & Salmons 1995; Macauley 1996). Plausible OT-based explanations are however available for these restrictions.[13] Thus, the first restriction may fall out from the constraint LEFTMOST[LAR] proposed by MacEachern 1996 independently of the SM data:[14] "Laryngeal features (asp, glott) should be at the beginning edge of the morpheme". The second restriction seems to reflect the generalization, encodable within OT (see McCarthy & Prince 1994, 1995), that everything else being equal, affixes are less marked than roots.

Among the arguments often given in favor of reducing the four canonical patterns in (45) and (46) to the two in (45) is the putative fact that tone sandhi rules in Mixtec languages apply differently to CVV words and to CVCV words, and that CV?V words behave like CVV words rather than CVCV words. For SM, however, the contrasts in (47)-(49), repeated from (10)-(12) above, belie this broad generalization (see in particular (48)) and thus cancel the tonal argument usually adduced in favor of such a reduction.

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[13] Equivalent restrictions would also have to be explained under the view that medial glottal stops in SM are regular segments. Perhaps the most challenging issue facing this view would be why a consonant should be allowed in coda position morpheme-internally but not morpheme-finally, since languages generally seem freer in this respect word-finally than word-internally.

[14] MacEachern is actually concerned with laryngeal features on consonants (aspiration, glottalization). I am therefore suggesting here an extension of LEFTMOST[LAR]'s domain.

(47) a. C$\underline{\text{VV}}$ *MH
b. CVV √MH

(48) a. CV?V *MH
b. CVV √MH

(49) a. CV?(C)V *MH
b. CVCV √MH

The contrasts in (47)-(49) are not however incompatible with the laryngeal feature view of medial glottal stops, and in fact other tonal evidence within SM continues to stand against interpreting medial glottal stops as regular medial consonants. Thus, consider the contrast in (50).

(50) a. CV?V *MH e.g. (H) + ta?ù —› tá?ù 'inheritance' (*ta?ú)
b. CVCV √MH e.g. (H) + sutù —› sutú 'priest'(*sútù)

Given such a contrast, and assuming that medial glottal stops are regular medial consonants, one might expect morphemes containing the other laryngeal consonant /h/ in medial position to pattern with (50a) rather than (50b) (Steriade 1987). But, as diagrammed in (51), they actually pattern with (50b).

(51) CVhV √MH e.g. (H) + tuhì —› tuhí 'to scrape'

Medial /h/ thus patterns with true medial consonants rather than with its laryngeal congener /?/. This apparent behavioral divergence between /h/ and /?/ can be explaind away if so-called medial glottal stops are in fact not medial consonants in SM.

As I will now argue, the anti-transparency effect caused by medial glottal stops can also serve as evidence in favor of the proposal that a medial glottal stop in SM is phonologically a laryngeal feature on the preceding vowel. The adoption of this proposal unifies in an important way our conception of medial glottal stops, low tones, and high tones: what high tones, low tones, and [constricted glottis] have in common is that they each provide a special laryngeal specification on vowels. By contrast, mid-tone vowels, being phonologically toneless, have no such laryngeal specification.

Under this view, then, one is entitled to claim that the feature [constricted glottis] renders the carrying vowel laryngeally prominent, in the same way that a high tone or a low tone renders a carrying vowel laryngeally prominent (tonal prominence being also laryngeal prominence). In parallel to the prominence of high tones and low tones, the prominence attributable to [constricted glottis] can now be rather naturally seen as the characteristic which attracts floating high tones. This attraction is governed by the action of TPFAITH when the host's second vowel is toneless, as shown in Tableau (52), and through the action of ANCHOR-LEFT when the second vowel is toned, as shown in Tableau (53) (In these two tableaux, the boldface on input vowels indicates a laryngeally prominent vowel, i.e. a vowel carrying a high tone, a low tone, or the [constricted glottis] feature).[15]

Tableau (52)

Input: (H) + C**V**CM	Status	TPFAITH	ANCHOR-LEFT

[15] I keep the term TPFAITH (originally an abbreviation for Tonal Prominence Profile Faithfulness; see Section 4.1 above) to refer more broadly now to Laryngeal Prominence Profile Faithfulness.

a. C **V** C M | H		√	√
b. C **V** C H	†	*!	√

Tableau (53)

Input: (H) + C**V**C**V**	Status	TPFAITH	ANCHOR-LEFT
a. C **V** C **V** | H		√	√
b. C **V** C **V** | H	†	√	*!

Given the previously established ranking TPFAITH » ANCHOR-LEFT (see Tableau (41) above), Tableau (52) illustrates how TPFAITH is the decision-maker for an input with a laryngeally prominent first vowel and a toneless second vowel, and Tableau (53) illustrates how the decision is passed on to lower-ranking ANCHOR-LEFT when the input contains two tonally prominent vowels. High tones, low tones, and medial glottal stops thus function alike, *qua* laryngeal specifications on vowels, as opposed to mid tones, which are phonologically speaking absence of laryngeal specification.[16]

To summarize, the anti-transparency effect of medial glottal stops can be made to fall under the generalization that a prefixal floating high tone will be automatically attracted to the first laryngeally prominent vowel in its host. This account depends on two critical proposals. The first is that a medial glottal stop in SM is phonologically a laryngeal feature on the preceding vowel. The second critical proposal has to do with tonal underspecification: mid-tone vowels are phonologically toneless and thus have no laryngeal prominence, as opposed to any vowel carrying a high tone, a low tone, or a [constricted glottis] feature.[17]

4.3. *MH

The other case of anti-transparency occurs with hosts containing a long vowel with a lexical ML tonal pattern (see (21B, Case II) above). As diagrammed again in (54), when hosting a floating high tone, such words yield a HL tonal pattern, rather than the MH pattern expected under transparency.

(54) Anti-transparency effect (Case II)
(H) + CML —› CHL, *CMH

[16] The feature [constricted glottis] differs from high and low tones distributionally: as already mentioned, it may only occur on the first vowel of roots. There is however no apparent other restrictions; in particular, [constricted glottis] may co-occur with any tone (H, L, or M).

[17] The analysis proposed in this section deals with the MH ban in derived forms of the type CV?V and CV?CV. As mentioned in Section 2.1 above, the same tonal ban seems to hold lexically as well, but is not accounted for here. A more general solution capturing the influence of SM's medial glottal stops on the occurrence of high tones may therefore be required.

I attribute this phenomenon to a high-ranking constraint I call *MH, which is given in (55). *MH bluntly bans the MH tonal pattern on words with a long vowel.

(55) *MH: The tonal pattern MH is banned on CVV words

I will first show how *MH works within the set of constraints already established, and secondly, I will suggest an explanation for the existence of such a constraint, since it initially looks like a rather arbitrary constraint one would be better off without.

Tableau (56) shows that *MH must dominate TPFAITH.

Tableau (56): *MH » TPFAITH

Input: (H) + CML	Status	*MH	TPFAITH
a. CHL	☞	√	*
b. CMH	†	*!	√

In this tableau, the floating high tone is parsed on the first mora of the long vowel in candidate (a) and on the second mora in candidate (b). As we saw earlier (see Section 4.1 above), in CVCV or CVV cases with a ML tonal pattern, TPFAITH is the crucial decision-maker, yielding transparency. But we see now that in hosts with long vowels, TPFAITH must be overridden by *MH (i.e. *MH » TPFAITH).[18]

*MH is unviolated in SM and can be placed together with the other undominated constraints identified in Section 3 above, such as DEP-TONE, T/A CORR, NO CONT, OCP, and UNIFORMITY. (57) recapitulates the partial Constraint Hierarchy established so far.

(57) DEP-TONE, T/A CORR, NO CONT, OCP, UNIFORMITY, *MH
» TPFAITH » ANCHOR-LEFT » MAX-TONE

At first glance, the constraint *MH looks like an arbitrary constraint, with little claim to universal status. There is, however, a plausible explanation for why a language could have a negative constraint involving this specific tonal pattern to the exclusion of any other tonal pattern. Since mid-tone vowels are assumed to be lexically toneless, *MH actually prohibits a long vowel from being toneless on its first mora and high-toned on its second mora. From this perspective, the effect called here *MH can actually be viewed as the outcome of a harmony scale resulting from the conjunction of two phonetic scales, one concerning tonal strength and the other positional strength.[19] As I think can be readily gathered from the literature (see for example Tranel 1992-94), high tones seem to exhibit a greater general resilience than low tones cross-linguistically. It would therefore seem appropriate to think of high tones vs. low tones as strong vs. weak, with mid tones even weaker, especially when they are phonologically viewed as no tone at all. This scale of tonal strength is given in (58).

(58) Tonal strength scale
H > L > M (= Ø)

[18] Note that ANCHOR-LEFT would reach the same decision as *MH, but since we already know that ANCHOR-LEFT must be ranked lower than TPFAITH in order to account for transparency cases (see Tableau (41) above), it cannot be responsible for making the appropriate decision here.

[19] On harmony scales derived from phonetic scales and for an application of these concepts to syllable structure, see Prince & Smolensky 1993.

Regarding long vowels, it has also been suggested in the literature (see for instance McCarthy & Prince 1993) that first moras be viewed as strong positions (or heads) of the combination and second moras as weak positions (or dependents). This scale of positional strength in long vowels is given in (59).

```
(59) Positional strength in long vowels
          In long vowels  (μ1 μ2),  μ1 > μ2
                             \  /
                              V
```

Assuming that strong elements preferably seek strong positions and weak elements weak positions, the tonal pattern MH on a long vowel turns out to be the least harmonic tonal pattern possible, and it is therefore not surprising to see it banned in a given language such as SM, while other tonal patterns are allowed. The tonal pattern HM would be at the other end of the scale (the most harmonic pattern, with a strong tone in head position and no tone in dependent position), and other tonal patterns would occupy intermediate steps in-between these two extremes of highest and lowest harmony. Assuming that it is more important for a head position than a dependent position to be filled with its preferred element, I tentatively propose for long vowels the tonal harmony scale depicted in (60).

(60) Tonal harmony scale on long vowels
HM > HL > HH > LM > LL > LH > MM > ML > MH

The prediction made here is that for a given tonal pattern banned in a given language on long vowels, all less harmonic patterns should also be banned. The universal Constraint Hierarchy corresponding to the harmony scale of (60) is given in (61).

(61) *MH » *ML » *MM » *LH » *LL » *LM » *HH » *HL » *HM

In order to separate *MH from the rest of the hierarchy, as must be the case in SM, I assume that MAX-TONE intervenes in-between *MH and the rest of the hierarchy, as shown in (62).[20]

(62) *MH » MAX-T » *ML » *MM » *LH » *LL » *LM » *HH » *HL » *HM

As a consequence of this ranking, any putative lexical word with a long vowel and a MH tonal pattern will correctly never be able to emerge faithfully. The ranking of DEP-TONE, T/A CORR, and *MH above MAX-TONE entails that the optimal candidate will actually be phonologically toneless. This account thus predicts that a borrowed word of the type CMH should be nativized to CMM.

To summarize, the anti-transparency effect caused by long vowels in SM can be attributed to the conjunction of a universal Constraint Hierarchy governing the distribution of tones on long vowels (see (61) above), and the language-specific interleaving of TPFAITH and MAX-TONE within this Constraint Hierarchy, as depicted in (63) (where *XX encapsulates (61) to the exclusion of dominant *MH).

(63) *MH » TPFAITH » MAX-TONE » *XX

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[20] The Constraint Hierarchy in (61) must interact with other constraints as well, for example LGV/SMT, which favors level tones on long vowels (see Section 4.4 below). Note also that the absence of the LL pattern in SM (see Section 2.1 above) affects all morphemes, not just CVV morphemes. If not accidental, this gap therefore requires a separate explanation.

4.4. CMM

The final case to be considered here concerns the behavior of morphemes containing a long mid-tone vowel. As diagrammed again in (64), when hosting a floating high tone, these morphemes behave as expected by parsing the floating high tone on their initial mora, as in (64a), but they also have another option available, which is to have the floating high tone spread over both moras, as in (64b).

(64) (H) + CMM —› a. CHM
b. CHH

I attribute the possibility of spreading the floating high tone to both moras of the long vowel to the existence of a universal constraint (LONG VOWEL/SAME TONE, abbreviated LGV/SMT) favoring the same tone rather than a contour tone on a long vowel. This constraint is given in (65).

(65) LGV/SMT : No contour tones on long vowels

Note that toneless long vowels satisfy this constraint vacuously.

The main issue of course is how to prevent all long vowels from indiscriminately obeying this constraint. The challenge is particularly acute in SM, because the option of satisfying LGV/SMT is possible only under very restricted circumstances, namely the two cumulative conditions listed in (66).

(66) (i) The spreading tone must be a floating high tone
(ii) The host must be a morpheme with a long mid-tone (= toneless) vowel

I will argue first that the two-option pattern shown in (64) is due to the variable ranking of LGV/SMT with a conflicting constraint barring double linking. For our purposes, as indicated in (67), *DL (NO DOUBLE LINK) functions to prevent a tone from being associated to two TBU's.[21]

(67) *DL : A single tone must not link to more than one mora

Secondly, I will show that constraint ranking is able to discriminate correctly between the narrowly restricted case where long vowels admit two outputs and the cases where only one output must be allowed.

Let us begin with the data in (64). The output in (64a) satisfies *DL and violates LGV/SMT, whereas the output in (64b) violates *DL and satisfies LGV/SMT ((64b) violates *DL because the dominating tonal OCP constraint forces the representation with a doubly-linked high tone). Since both outputs are possible, I take it that *DL and LGV/SMT are variably ranked, one ranking yielding output (64a), the other ranking yielding output (64b), as shown in the two tableaux in (68).

Tableau (68a): *DL » LGV/SMT [—› (64a)]

Input: (H) + CMM	Status	*DL	LGV/SMT
a. CHM	☞	√	*
b. CHH	†	*!	√

[21] This constraint represents the second half of the well-known generalization, mentioned earlier with regard to NO CONT (28), that everything else being equal there will be at most a one-to-one association between TBU's and tones.

Tableau (68b): LGV/SMT » *DL [—› (64b)]

Input: (H) + C<u>MM</u>	Status	LGV/SMT	*DL
a. C<u>HM</u>	†	*!	√
b. C<u>HH</u>	☞	√	*

I have argued elsewhere (Tranel 1995c, 1996) that variably ranked constraints must be contiguous in the Constraint Hierarchy, that is they must share the same ranking properties with respect to the other constraints in the Constraint Hierarchy. This proposed universal principle on constraint ranking is given in (69) as the Ranking Cluster Condition (RCC).

(69) Ranking Cluster Condition (RCC): Two variably ranked constraints behave as a cluster in terms of constraint rankings

I will thus assume that as variably ranked constraints, *DL and LGV/SMT form a cluster with respect to ranking relations with other constraints in SM's Constraint Hierarchy.

In order for the account in the two tableaux in (68) to go through, SM's Constraint Hierarchy needs to fulfill two conditions. First, for the type of input considered in (68), where we have two output options, the two candidates must tie on all constraints ranked higher than LGV/SMT and *DL, since these two constraints must be the crucial decision-makers. Secondly, in all other cases of morphemes with long vowels, at least one constraint ranked higher than LGV/SMT and *DL must eliminate all competitors but the single candidate that must be allowed to emerge as optimal.

The twin tableaux in (70) reprise the two tableaux in (68), but show in addition relevant constraints that are ranked higher than LGV/SMT and *DL.

Tableau (70): (i) —› (64a) / (ii) —› (64b)

i. (H)+<u>MM</u>	Status	DEP-TONE	T/A CORR	OCP	TPFAITH	MAX-T	*DL	LGV/SMT
a. <u>HM</u>	☞	√	√	√	*	√	√	*
b. <u>HH</u>	†	√	√	√	*	√	*!	√
ii. (H)+<u>MM</u>	**Status**	**DEP-TONE**	**T/A CORR**	**OCP**	**TPFAITH**	**MAX-T**	**LGV/SMT**	***DL**
a. <u>HM</u>	†	√	√	√	*	√	*!	√
b. <u>HH</u>	☞	√	√	√	*	√	√	*

(70) anticipates constraint rankings to be established later, namely those given in (71).

(71) a. TPFAITH » {*DL ~ LGV/SMT}
b. MAX-TONE » {*DL ~ LGV/SMT}

The twin tableaux in (70) show that the two candidates that are possible outputs tie on all of the relevant constraints ranked higher than LGV/SMT and *DL. As a result, the variable ranking of *DL and LGV/SMT is able to yield the two attested options.

I must now demonstrate that for all other cases where a long vowel occurs, a single output is available and no other, despite the variable ranking of LGV/SMT and *DL. I will show that in each of these cases, at least one constraint ranked higher than the cluster {LGV/SMT ~ *DL} does the job and eliminates all but one candidate. Two categories of long-vowelled inputs need to be considered. They are listed in (72) and (73).

(72) a. C<u>LM</u>
b. C<u>ML</u>
c. C<u>HM</u>
d. C<u>HL</u>

(73) a. (H) + C<u>LM</u> —› C<u>HM</u>, *C<u>HH</u>
b. (H) + C<u>ML</u> —› C<u>HL</u>, *C<u>HH</u>
c. (H) + C<u>HM</u> —› C<u>HM</u>, *C<u>HH</u>
d. (H) + C<u>HL</u> —› C<u>HL</u>, *C<u>HH</u>

e. CLH e. (H) + CLH —› CHH
f. CHH f. (H) + CHH —› CHH

(72) lists long-vowelled lexical words on their own,[22] and (73) lists them when they are preceded by a floating high tone. In each case, no more than a single output is tolerated.

Let us begin with the list in (72). These input forms must also be the only possible outputs. For (72a-e), the issue to resolve is why there is no option where the forms are pronounced with a single tone over their long vowel, in satisfaction of LGV/SMT. For (72f), the question to answer is why there is no option satisfying *DL rather than LGV/SMT.

I first analyze (72f). (74) provides a list of relevant candidates with their main characteristics and Tableau (75) shows the relevant constraints and how they apply to the candidates in (74).

(74) CHH —› a. CHH (faithful doubly-linked H)
b. *CHH (lexical H + inserted H)
c. *CLH (inserted L + lexical H)
d. *CHM (lexical H + no tone)

Tableau (75)

CHH	Status	DEP-TONE	T/A CORR	OCP	TPFAITH	MAX-T	*DL	LGV/SMT
a. CHH		√	√	√	√	√	*	√
b. CHH	†	*!	√	*!	√	√	√	√
c. CLH	†	*!	√	√	√	√	√	*
d. CHM	†	√	√	√	*!	√	√	*

In this tableau, I have placed *DL above LGV/SMT in the Constraint Hierarchy, since this is the ranking that could potentially yield an output other than the desired one. Candidate (a), which emerges as the optimal candidate, is entirely faithful to its input and only violates *DL. The issue here is to make sure that there is no other possible output derivable by satisfying *DL. *DL satisfaction can be obtained in various ways (see candidates b-d), but it never yields a better candidate than candidate (a). In candidate (b), *DL satisfaction is achieved by inserting a separate high tone on one of the moras; such a candidate is ruled out by undominated DEP-TONE and OCP. In candidate (c), a low tone has been inserted on the first mora; this candidate, then, satisfies *DL and the OCP, but it still incurs a fatal violation of DEP-TONE. Finally, candidate (d) is made to satisfy *DL by rendering the second mora toneless; this candidate satisfies all the undominated constraints, but violates TPFAITH. To prevent this candidate from emerging as the optimal candidate, TPFAITH must be ranked higher than *DL.[23] Given that TPFAITH dominates *DL, and that *DL and LGV/SMT are variably ranked, the RCC in (69) predicts that TPFAITH should also dominate LGV/SMT. This prediction will be empirically confirmed shortly.

Summarizing the results of Tableau (75), we see that, as required by the data, only one output is possible, namely the candidate violating *DL. All other candidates are ruled out by constraints that are ranked higher than the cluster {*DL ~ LGV/SMT}, and the variable ranking of these two constraints can therefore have no effect on possible outputs.

The remaining five forms in (72a-e) fall together in that they all violate LGV/SMT. Therefore, what must be avoided here are outputs where LGV/SMT is satisfied, that is

[22] The forms CLL and CMH are not listed here since the LL tonal pattern is generally banned in the language (see Section 2.1 above) and the MH tonal pattern is banned on long vowels (see Section 4.3 above).

[23] This is one of the necessary rankings that was anticipated in Tableau (70) earlier (see (71a) above and note 27 below).

outputs of the types CLL, CHH, and CMM. The treatment of these forms can be illustrated by examining in some detail the representative case in (72a). For this purpose, I provide in (76) a list of the relevant candidates and in (77) a tableau with the relevant interacting constraints.

(76) CLM ⟶ a. CLM (faithful)
b. *CLL (doubly-linked L)
c. *CHH (doubly-linked inserted H)
d. *CMM (no tones)

Tableau (77)

CLM	Status	DEP-TONE	T/A CORR	OCP	TPFAITH	MAX-T	LGV/SMT	*DL
a. CLM	☞	√	√	√	√	√	*	√
b. CLL	†	√	*!	√	*	√	√	*
c. CHH	†	*!	√	√	*	*	√	√
d. CMM	†	√	√	√	*!	*	√	√

In Tableau (77), I have placed LGV/SMT above *DL in the Constraint Hierarchy, since this is the ranking that could potentially yield an output other than the desired one. Candidate (a), which must emerge as the only possible output, is completely faithful to its input, and only violates LGV/SMT. No other candidate can be made more harmonic by satisfying LGV/SMT. Candidate (b), which satisfies LGV/SMT by spreading the lexical low tone, is ruled out because it violates undominated T/A CORR. Candidate (c) also satisfies LGV/SMT, but by inserting a doubly-linked high tone; this candidate is ruled out too, because it violates undominated DEP-TONE. Finally, candidate (d) satisfies all the undominated constraints as well as LGV/SMT by failing to parse the low tone, but it violates TPFAITH;[24] to rule out this candidate, TPFAITH must dominate LGV/SMT. The empirical necessity of this ranking confirms the prediction made earlier by the RCC (see the discussion of Tableau (75) above).

The important result of Tableau (77) is that, again, LGV/SMT and *DL can play no role here in evaluating candidates. All decisions are made higher in the Constraint Hierarchy, which correctly yields a single possible output violating LGV/SMT. Similar tableaux can be constructed for the cases in (72b-e) to demonstrate that only a single output violating LGV/SMT is possible for these forms.

I now come to the items listed in (73). As was the case for (72), single outputs must be secured here. The outputs in (73a-d) satisfy *DL and violate LGV/SMT, so what must be ensured with them is that the Constraint Hierarchy does not yield any other option that would satisfy LGV/SMT rather than *DL. The situation is reversed for the outputs in (73e-f): they satisfy LGV/SMT and violate *DL, so what must be ensured with them is that the Constraint Hierarchy does not yield any other option satisfying *DL rather than LGV/SMT.

I first analyze (73f). (78) lists the relevant candidates.

(78) (H) + CHH ⟶ a. CHH (doubly-linked HØ)
b. *CHH (coalesced H's)
c. *CHH (two singly-linked H's)
d. *CHL (HØ + inserted L)
e. *CHM (HØ + no tone)

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24 MAX-TONE is also violated by this candidate, but irrelevantly in the comparison with candidate (a), since TPFAITH dominates MAX-TONE, as shown earlier in the tableaux in (38).

Tableau (79) presents the relevant interacting constraints. In this tableau, *DL is ranked above LGV/SMT, because this is the ranking that could potentially yield an output other than the desired one.

Tableau (79)

(H)+CHH	Status	DEP-TONE	T/A CORR	OCP	UNIFORM	TPFAITH	MAX-T	*DL	LGV/SMT
a. CHH	☞	√	√	√	√	√	*	*	√
b. CHH	†	√	√	√	*!	√	√	*	√
c. CHH	†	√	√	*!	√	√	√	√	√
d. CHL	†	*!	√	√	√	√	*	√	*
e. CHM	†	√	√	√	√	*!	*	√	*

In the optimal candidate, on line (a), the floating high tone replaces the doubly-linked high tone of the input. All relevant constraints are satisfied, except MAX-TONE and *DL. No improvement can be made by trying to get rid of either of these violations. Candidate (b) satisfies MAX-TONE, but at the expense of violating the undominated constraint banning coalescence (UNIFORMITY). Candidate (c) satisfies both MAX-TONE and *DL, but at the expense of the undominated OCP.[25] Candidate (d) inserts a low tone on the second mora to satisfy *DL, but thereby violates undominated DEP-TONE. Finally, candidate (e) makes the second mora toneless, thus satisfying *DL, but violating higher-ranked TPFAITH. Once more, all decisions here are made higher in the Constraint Hierarchy than where the cluster {*DL ~ LGV/SMT} stands, and a single output correctly results which violates *DL.

Let us now examine (73e). I provide in (80) the relevant candidates, and in (81) a tableau with the relevant constraints.

(80) (H) + CLH —› a. CHH (doubly-linked HØ)
b. *CHH (coalesced H's)
c. *CHH (two singly-linked H's)
d. *CHL (HØ + inserted L)
e. *CHM (HØ + no tone)

Tableau (81)

(H)+CLH	Status	DEP-TONE	T/A CORR	OCP	UNIFORM	TPFAITH	MAX-T	*DL	LGV/SMT
a. CHH	☞	√	√	√	√	√	**	*	√
b. CHH	†	√	√	√	*!	√	*	*	√
c. CHH	†	√	√	*!	√	√	*	√	√
d. CHL	†	√	*!	√	√	√	*	√	*
e. CHM	†	√	√	√	√	*!	**	√	*

The results in Tableau (81) are similar to those in Tableau (79). One small difference is that because the input in Tableau (81) has two anchored tones instead one just one, more violations of MAX-TONE may occur. The other small difference concerns the candidates on line (d); there is a violation of T/A CORR in Tableau (81) compared to a violation of DEP-TONE in Tableau (79); this is because in (81d) the low tone has been displaced from the first to the second mora, whereas in (79d) the low tone has been inserted. But the general outcome is the same in both tableaux: all decisions are made by constraints ranked

[25] Candidate (c) in (79), which is homophonous with candidate (a), might be viewed as a more legitimate optimal candidate, with the floating high tone substituting for the lexical high tone only on the first vowel rather than on both vowels. This result can be straightforwardly achieved by ranking the tonal OCP below MAX-TONE in SM's Constraint Hierarchy (see notes 8 and 12 above and note 26 below).

higher than the cluster {*DL ~ LGV/SMT}, and a single output is appropriately generated which violates *DL.[26]

Let us finally consider the remaining four cases in (73a-d). Here, we must prevent the floating high tone from spreading to the second mora in an attempt to satisfy LGV/SMT. The four tableaux in (82) provide the crucial information: they show that again neither LGV/SMT nor *DL can have a say about the competing candidates. As desired, the critical decision is always made higher in the Constraint Hierarchy, and always against the candidates satisfying LGV/SMT (the (b) candidates) (LGV/SMT has been ranked above *DL in (82) because this is the ranking with the potential to yield the ungrammatical outputs. All HH candidates are assumed to have a doubly-linked tone originating with the floating high tone. In the MAX-TONE column, a high-tone parsing violation is due to the lack of realization of the input's lexically anchored high tone).

(82) Tableaux (i-iv)

i. (H)+LM	Status	DEP-TONE	T/A CORR	OCP	TPFAITH	MAX-T	LGV/SMT	*DL
a. HM	☞	√	√	√	√	* [L]	*	√
b. HH	†	√	√	√	*!	* [L]	√	*
ii. (H)+ML	Status	DEP-TONE	T/A CORR	OCP	TPFAITH	MAX-T	LGV/SMT	*DL
a. HL	☞	√	√	√	*	√	*	√
b. HH	†	√	√	√	*	*! [L]	√	*
iii. (H)+HM	Status	DEP-TONE	T/A CORR	OCP	TPFAITH	MAX-T	LGV/SMT	*DL
a. HM	☞	√	√	√	√	* [H]	*	√
b. HH	†	√	√	√	*!	* [H]	√	*
iv. (H)+HL	Status	DEP-TONE	T/A CORR	OCP	TPFAITH	MAX-T	LGV/SMT	*DL
a. HL	☞	√	√	√	√	* [H]	*	√
b. HH	†	√	√	√	√	**! [H,L]	√	*

As can be seen by examining Tableaux (i) and (iii) in (82), the spreading of the floating high tone over the two moras of the long vowels (in an effort to satisfy LGV/SMT) creates a fatal violation of higher-ranked TPFAITH. Tableaux (ii) and (iv) in (82) show that the fatal violations in these cases have to be inflicted by MAX-TONE, which must therefore be ranked above LGV/SMT, and given the RCC in (69), above the cluster of variably ranked constraints {*DL ~ LGV/SMT}.[27]

To sum up, the four tableaux in (82) show that LGV/SMT can have no effect in these cases and is thus unable to enforce its preference: the floating high tone cannot spread over the two moras of the long vowels. These outcomes, where only one candidate (the one that violates LGV/SMT) may emerge as grammatical, stand in sharp contrast with the outcomes in the two tableaux in (70) above, where two candidates rather than just one may emerge as grammatical. To reiterate, the two options shown to be available in (70) are due to the following combination of factors: (i) the variable ranking assigned to *DL and LGV/SMT and (ii) the fact that the two candidates there tie on all higher-ranked constraints, thereby leaving the decision to *DL and LGV/SMT, whose variable ranking yields the two possible outputs. By contrast, in the tableaux in (82), *DL and LGV/SMT never get to make a decision, as the higher-ranked constraints TPFAITH and MAX-TONE systematically stand in the way of the candidates exhibiting spreading of the floating high tone.

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[26] As was the case in (79), candidate (c) in (81) might be considered to be a more legitimate optimal output than the homophonous candidate (a). As already noted (see notes 8, 12, and 25 above), an appropriate demotion of the tonal OCP would yield this result with no impact on the analysis.

[27] This is the other necessary ranking that was anticipated in Tableau (70) earlier (see (71b) and note 23 above).

The upshot of this section is that, in combination with tonal underspecification, constraint ranking is able to make the fine-grained distinctions required to account for the selective appearance of the same tone over the two moras of a long vowel. These welcome results depend on viewing mid-tone vowels as phonologically toneless, because it is this tonelessness that allows the two candidates in (70) to tie on TPFAITH (which they both violate) and on MAX-TONE (which they both satisfy), thereby letting the variable ranking between the members of the lower-ranked pair {*DL ~ LGV/SMT} deliver the two attested options. *DL and LGV/SMT must be ranked lower than TPFAITH and MAX-TONE, because as illustrated in (82), TPFAITH and MAX-TONE take over as decision-makers when candidates don't tie on them.

5. Conclusion

In this paper, I hope to have shown that mid-tone underspecification helps provide an inviting account, within OT, of four tone sandhi phenomena in SM: (i) the transparency of mid-tone vowels, (ii) the anti-transparency effect of medial glottal stops, (iii) the anti-transparency effect of long vowels, and (iv) the exclusive property of long mid-tone vowels to optionally allow prefixal floating high tones to spread to both of their moras. These results of course constitute only one half of the task at hand. What remains to be demonstrated in full in order to validate the appropriateness of underspecification is that other approaches based for example on tonal markedness or tone-parsing priorities are unable to do as well. Nevertheless, tonal underspecification appears to constitute a promising line of attack to improve our understanding of many facets of tone sandhi in SM. So, although the current dominant winds in OT may be blowing against underspecification, I think that we should not throw out the baby with the bath water. At least in the case of tones, this mode of representation may lead to insights not otherwise available.

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