*Rules vs. Constraints: A Case Study**

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1 Introduction

In this paper, I sketch a cross-theoretical comparison of the treatment of floating high tones in Mixteco (a language of Southern Mexico studied by Kenneth Pike in the 1930's and 40's).[1] My goal is to make a case for a theory of phonology based on violable universal constraints (specifically, Optimality Theory),[2] as opposed to the more traditional derivational framework relying on language-specific rules and unviolable constraints (which gradually became standard in generative phonology practice, beginning with Kisseberth 1970a,b). Because of space limitations, I will not present in detail the two analyses within their respective framework or offer a comprehensive comparative assessment (see Appendix I for a summary of both approaches).[3] Rather, my intent here is to give a general sense of why I think OT can provide an overall account that is preferable on both descriptive and explanatory grounds. For this purpose, I will focus on two salient properties of Mixteco's floating high tones and outline how each theory fares in handling them.

The two properties in question revolve around Mixteco's mid-tone vowels. In general - and this is the first property to be considered - these vowels are transparent to the association of floating high tones. Thus, contrary to what might be expected in such tone sandhi configurations, a prefixal floating high tone does not automatically dock onto the first tone-bearing element of its host. Instead, it prefers to attach to the first low-tone or high-tone vowel of its host morpheme, even if it requires skipping an intervening mid-tone vowel. The flip side - and this is the second property of interest here - is anti-transparency effects, that is, cases where the transparency of mid-tone vowels is thwarted. For example, a medial glottal stop prevents a floating high tone from ignoring an initial mid-tone vowel in favor of a subsequent low-tone or high-tone vowel.

The essence of my argument will be (i) that these intriguing facts can be very naturally explained if we assume that they result from universal constraints making conflicting demands on linguistic substance and prioritized in a Mixteco-specific way (through constraint ranking), and (ii) that by contrast, a theory including unviolable universal constraints is inherently unable to account for the same facts.

2 Background on Mixteco

2.1 Some basic characteristics

Lexical words in Mixteco are bimoraic, typically of the general shapes shown in (1).

(1) CVV, CVCV

For our purposes, it will be useful, as indicated in (2) and (3), to distinguish two phonological classes of words within each of the two categories in (1).

(2) *Words with contiguous vowels*
- a. Words with a long vowel (V = V): C<u>VV</u>
- b. Words with vowels in hiatus (V ≠ V): CVV

(3) *Words with medial consonants*
- a. Words with a medial glottal stop: CV?V
- b. Words with no medial glottal stop (medial C ≠ ?): CVCV

The distinction in (2) among words with contiguous vowels is between on the one hand vocalically monomelodic words, i.e. words with a single long-vowelled syllable, represented in (2a) with the underlining, and on the other hand vocalically bimelodic words, i.e. words with two syllables in hiatus, represented in (2b). The distinction made in (3) separates words containing a medial glottal stop, as in (3a), from words with a medial consonant that is not a glottal stop, as in (3b).

Each mora can bear one, and only one, of three level tones: High (H), Mid (M), or Low (L).[4] Thus, as diagrammed in (4), contour tones do not occur.

(4) *No contour tones:*

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* μ
  / \
 T T
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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 (5), there are only two restrictions, having to do with the italicized MH and LL patterns.

(5)

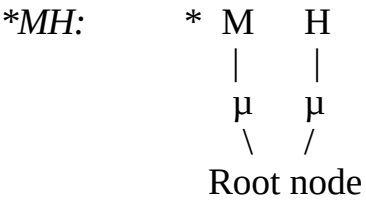
HH	*MH*	LH
HM	MM	LM
HL	ML	*LL*

One restriction, diagrammed in (6), is that the LL pattern does not occur at all (by contrast, the other two double patterns, HH and MM, are attested, as in sáná 'turkey' and bina 'today').

(6) **LL:*

The second tonal gap concerns the MH pattern. As diagrammed in (7), this pattern is not found over words with a long vowel, i.e. C<u>VV</u> words (by contrast, the MH pattern is attested in other CVV words; see (14) below).

(7) **MH:*



2.2 Mixteco's floating high tones

2.2.1 The lexical source of floating high tones

As shown in (8), final floating high tones may occur in three lexical contexts in Mixteco: (i) at the end of words, (ii) as part of purely consonantal morphemes, and (iii) as part of 'zero words'.[5] (8a) illustrates a lexical minimal pair, (8b) shows the lexical representation of the causative prefix, and (8c) the lexical representation of the continuative prefix.

(8) a. kee (H) 'to eat' vs. kee 'to go away'
b. s (H) 'causative'
c. (H) 'continuative'

2.2.2 The association of floating high tones

A final floating high tone anchors into the next morpheme, provided no pause intervenes. Data are provided in tabulated form in (9), illustrating the canonical patterns in (10)-(14). The blank cells in (9) represent impossible patterns. I have not included any lexical tonal pattern with an initial H in this table, as inputs of the type (H) + HX (where X is any tone) always surface as HX, with no detectable phonetic change. Also, there is no LL column, since LL is not a possible tonal pattern lexically (see Constraint (6) above).[6]

(9) *Tabulated data on (H)-association*

Inputs: (H) +	A (10a) LM -› HM	B (10a) LH -› HH	C (11) MM -› HM
CVCV (3b)	kìku -› kíku 'to sew'	sùc&í -› súc&í 'child'	z&uku -› z&úku 'mountain'
CV?V (3a)	hà?a -› há?a 'to give'	ɽdè?é -› ɽdé? é 'to look at'	be?e -› bé?e 'house'
CVV (2b)	CLM -› CHM	CLH -› CHH	CMM -› CHM
C<u>VV</u> (2a)	c&ìi -› c&íi 'beneath'	kWàán -› kWáán 'yellow'	kee -› kée~kéé 'to go away'

Inputs: (H) +	D (10b, 14) ML -› MH	E (12, 13) ML -› HL	F (10b) MH -› MH	G (12) MH -› HH
CVCV (3b)	z&ukù -› z&ukú 'branch'		kuc&í -› kuc&í 'pig'	
CV?V (3a)		ta?ù -› tá?ù 'to beat'		CM?H -› CH?H
CVV (2b)	z&aù -› z&aú 'cave'		CMH -› CMH	
C<u>VV</u> (2a)		koò -› kóò 'snake'		no lexical MH

In general, as shown in columns A, B, D, and F of the table in (9), the floating high tone replaces the first low or high tone, skipping an initial mid-tone vowel if need be. This situation is schematized in (10), where X represents any tone (H, M, or L).

(10) *General pattern with words containing a low or high tone*

a. (H) + LX and (H) + HX —› HX

b. (H) + ML and (H) + MH —› MH

(10a) shows that a floating high tone replaces an initial low or high tone. (10b) shows that a floating high tone replaces a low or high tone on the second vowel if the first vowel is mid toned. In other words, mid-tone vowels are transparent. All word types (see (2) and (3) above) exhibit the pattern in (10a). The pattern in (10b) is restricted to the word types in (2b) (CVV words) and (3b) (CVCV words) (excluded are the word types in (2a), i.e. C<u>VV</u> words, and (3a), i.e. CV?V words).

As diagrammed in (11), and as illustrated in column C of the table in (9) above, if the following morpheme has only mid tones, a floating high tone always anchors to its first vowel, although in words with a long vowel (C<u>VV</u> words), the floating high tone may optionally link to the second half of the long vowel as well.[7]

(11) *MM words*

(H) + MM —› HM (optionally HH in C<u>VV</u> words)

I now turn to the special cases involving words with a medial glottal stop (CV?V words (3a)) and words with a long vowel (C<u>VV</u> words (2a)). Relevant examples are located in columns E and G of the table in (9) above. As shown in (12), with CV?V words, a preceding floating high tone always replaces the tone on the first vowel, even if this tone is mid and the second vowel is low toned or high toned.

(12) *CV? V words*

(H) + XX —› HX (even if XX = ML or MH)

A medial glottal stop thus prevents a floating high tone from skipping a mid tone to replace a subsequent low or high 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.

The behavior of a floating high tone with a following word of type (2) (C<u>VV</u> or CVV words) conforms to the patterns described in (10) and (11) above, except regarding words containing both a long vowel (C<u>VV</u> words) and the underlying tonal pattern ML. In these cases, the transparency of the mid-tone vowel is again overridden, this time by the *MH constraint given in (7) above, and as shown in (13), the tonal pattern HL surfaces instead of MH.

(13) *C<u>VV</u> words with underlying ML tonal pattern*

(H) + ML —› HL

(14) depicts the striking contrast that obtains with CVV words, which do exhibit transparency.

(14) *CVV words with underlying ML tonal pattern*

(H) + ML —› MH

Finally, Mixteco's floating high tones do not surface before a pause, i.e. they never get integrated into their own lexical morphemes, even if landing sites are available.

3 Cross-theoretical comparison

3.1 Two salient properties

As already mentioned, the two salient properties to be considered here are the general transparency of mid-tone vowels and the anti-transparency effect of medial glottal stops. The contrast is illustrated again in (15) and (16) on canonical forms with a lexical ML tonal pattern.

(15) *Transparency of mid-tone vowels*
(H) + CMCL —› CMCH (not *CHCL)

(16) *Anti-transparency effect*
(H) + CM?L —› CH?L (not *CM?H)

3.2 Transparency

In rule-based approaches, transparency effects are commonly handled through underspecification. The basic relevant concept is that a node can spread through the transparent segment to a subsequent segment without causing a line-crossing violation (Goldsmith 1976). In our tonal case, this idea translates into viewing mid-tone vowels as phonologically toneless and receiving a mid tone by default. Although I believe this view to be correct for Mixteco's mid-tone vowels, I would like to show that it creates serious difficulties in a rule-based analysis, whereas it has true explanatory value within OT.

In a rule-based analysis, the phonological tonelessness of Mixteco's mid-tone vowels allows the transparency effect to be captured by avoiding a line-crossing violation, but it does not explain the phenomenon in any way. A rule is needed specifying that the floating high tone must be linked to the first toned vowel in the next morpheme (see Part (a) of H-Association (33) in Appendix I below). This treatment begs the question of why a floating high tone would prefer to anchor to an already toned vowel, in some cases even displacing the lexical tone, when there is by all measures a more readily accessible vowel, namely one that is both closer and tonally free.[8]

Another problem has to do with the UAC, the Universal Association Convention automatically linking free tones to free tone-bearing units (TBU's) (Goldsmith 1976). Under perturbation by a preceding floating high tone, we saw earlier (see (10a) above) that words with a LM tonal pattern change to HM. This is illustrated in (17a) and (17b) with mìni, the word for 'puddle' (Pike 1948: 79). The linking of the floating high tone to the low-tone vowel by Part (a) of (H)-Association (33) causes the low tone to delink, since contour tones are banned in the language (see Appendix I below).

(17) a. [m i n i b. m i n i c. * m i n i

| —› | —› | |

(H)] L (33a) H L UAC H L

But if the second vowel in the word is lexically toneless, the UAC predicts that the delinked low tone should attach to it, incorrectly yielding the HL pattern in (17c). What is required instead is (17b), with the second vowel receiving a default mid tone.

Another problematic case arises with perturbing words whose last vowel is mid toned. Consider for instance the word for 'mountain', z&uku (H), a noun with mid tones and a final floating high tone. Its lexical representation is as in (18a).

(18) a. z& u k u b. * z& u k u c. * z& u k u d. z& u k u

| | \ /

(H) H H M

Assuming that the UAC applies whenever it can, one would expect such words not to exist in the language, for if they did, they would be immediately restructured by the automatic linking of the floating tone to one of the two free vowels, as in (18b) or (18c).[9] Alternatively, one could assume on a principled basis, as has been proposed for other cases in the literature, that the UAC can be preempted by more specific language-particular rules such as (H)-Association (33).[10] This approach would correctly allow the floating high tone to anchor to the following morpheme rather than to its own lexical morpheme. The problem would however remain when our example in (18a) is used before a pause. Again, the UAC predicts that the floating high tone should link to one of the two free vowels. But it does not: M-Default applies instead, yielding the phonetic representation in (18d).

In both (17) and (18), then, M-Default must preempt the UAC; but there is no rational basis for such precedence relation, since default rules are by definition principles of last resort. One alternative of course would be to assume that a language-specific rule deletes floating tones in Mixteco just in case other language-specific rules fail to assign them to a mora. However, since the lack of phonetic realization of such floating tones can be more generally attributed to their unanchored status (that is, lack of prosodic licensing), their language-specific deletion looks like a devious way to bar the application of the UAC. Overall, the upshot is that the purported universal convention automatically associating a floating tone to a free TBU must not apply in Mixteco, despite excellent opportunities.[11]

The OT approach to transparency which I propose is also based on the phonological tonelessness of Mixteco's mid-tone vowels, but used in a directly explanatory fashion and without corresponding drawbacks. The relevant universal constraint I suggest here is TPFAITH, which stands for Tonal Prominence Profile FAITHfulness. TPFAITH formalizes the idea that the distinction between toneless and toned vowels can be an active factor in

preserving correspondences between inputs and outputs. Basically, an output should remain faithful to its input's tonal prominence profile, a toneless vowel remaining toneless, and a toned vowel remaining toned. The crucial locus of evaluation for TPFAITH is thus the abstract tonal tier, i.e. whether a vowel is toned or not, with the finer distinction H vs. L ignored.

The relative ranking of TPFAITH in a language's Constraint Hierarchy, in particular in relation to the other faithfulness constraints PARSE H and PARSE L, determines how weakly or strongly toneless vowels will attract floating tones. Thus, a relatively low ranking of TPFAITH will result in a strong attraction by favoring the parsing of free tones at the expense of preserving lexical tonal prominence profiles, and conversely a relatively high ranking of TPFAITH will weaken this attraction by favoring the preservation of lexical tonal prominence profiles at the expense of the parsing of free tones.

A relatively low ranking of TPFAITH, which is probably common across languages, essentially yields the effect of the UAC, the so-called Universal Association Convention automatically associating a floating tone to a free TBU. As we have seen already, however, Mixteco clearly shows that the UAC may in fact be violated.

The tableau in (19) illustrates how TPFAITH interacts with PARSE H and PARSE L in accounting for Mixteco's transparency phenomenon (In this and subsequent tableaux, an apple in the status column signals an optimal candidate, a dagger a non-optimal candidate. A check mark indicates constraint satisfaction, an asterisk a constraint violation. An asterisk followed by an exclamation mark indicates a fatal violation. 'M' stands for toneless vowels, 'H' for high-tone vowels, and 'L' for low-tone vowels).

(19) *PARSE H, TPFAITH » PARSE L*

Input: (H) + CMCL	Status	PARSE H	TPFAITH	PARSE L
a. CMCH		√	√	*
b. CHCL	†	√	*!	√
c. CMCL	†	*!	√	√

(19) shows that both PARSE H and TPFAITH must dominate PARSE L. Comparing candidates (a) and (b), we see that the ranking TPFAITH » PARSE L prevents the floating high tone from docking to the toneless first vowel: such a landing saves the low tone of the second vowel, but at the fatal expense of TPFAITH. Candidate (c), which satisfies both TPFAITH and PARSE L, but at the expense of PARSE H, is eliminated from contention by the ranking PARSE H » PARSE L. So, TPFAITH and various constraint interactions involving PARSE H and PARSE L explain the transparency phenomenon.

Let us come back briefly to examples such as (17) above, which are of the canonical form given in (20).

(20) (H) + CLCM —› CHCM (not *CHCL)

Put in metaphorical derivational terms, we can now explain why a low tone set afloat by (H)-Association through automatic delinking does not anchor to a subsequent toneless vowel. If it did, TPFAITH would be violated, and as illustrated again with the tableau in (21), it is better in Mixteco to violate PARSE L than TPFAITH (TPFAITH » PARSE L).

(21)

Input: (H) + CLCM	Status	PARSE H	TPFAITH	PARSE L
a. CHCM	☛	√	√	*
b. CHCL	†	√	*!	√

What about examples such as (18) above, which are of the canonical form given in (22), and which showed that floating high tones must be prevented from anchoring into the toneless vowels of their own morphemes, contra the UAC?

(22) CMCM (H) —› CMCM (not *CHCM or *CMCH)

As illustrated with the tableau in (23), the lack of such prosodic licensing is explained in the proposed OT analysis by the undominated constraint AFFIX.

(23) *AFFIX » PARSE H*

Input: CMCM(H)	Status	AFFIX	PARSE H
a. CMCM	☛	√	*
b. CHCM	†	*!	√
c. CMCH	†	*!	√

AFFIX basically defines affixation by demanding a morphologically alien host for an affix. Here, in order to satisfy higher-ranked AFFIX, the final floating high tone must not be parsed into its own lexical morpheme, leading to a tolerable PARSE H violation. AFFIX can thus be seen as another constraint (together with TPFAITH) tempering the tonal attraction exerted by toneless vowels. Whereas TPFAITH provides a phonological rationale based on faithfulness, AFFIX works from a morphological perspective in restricting the association of free tones to free TBU's.

To summarize, I think that the transparency of mid-tone vowels in Mixteco is intimately connected to their phonological tonelessness. However, although underspecification has been a traditional tool of rule-based analyses to handle transparency (because it formally allows getting around the line-crossing constraint), it actually provides no explanation for the phenomenon. In fact, as we have just seen with Mixteco, underspecification is incompatible with the UAC viewed as an unviolable universal demand on phonological representations. The key to resolving the paradox is the realization, implemented within the proposed OT analysis, that the effect of the UAC, which is to parse free tones without disturbing anchored tones, may conflict with other universal demands, such as AFFIX and TPFAITH, and lose out to

them, as with the Mixteco's constraint rankings AFFIX » PARSE H and TPFAITH » PARSE L.

The phonological tonelessness of mid-tone vowels receives additional motivation within the OT approach by contributing to the explanation of other phenomena, in particular the anti-transparency effect of medial glottal stops, to which we now turn.

3.3 Anti-transparency

What is interesting about Mixteco's words with a medial glottal stop is that a preceding floating high tone always links to the first vowel, even if it is toneless and the next vowel is toned. Thus, as illustrated again in (24), medial glottal stops thwart transparency by forming a barrier to the association of floating high tones.

(24) (H) + ta?ù 'to beat' —› tá?ù (not *ta?ú)

Assuming that glottal stops and high tones share a feature-geometric tonal tier allows both theoretical approaches under consideration to handle this anti-transparency effect, but as we will see later, the behavior of initial glottal stops distinguishes sharply between the two analyses.

In the rule-based analysis, linking the prefixal floating high tone to the second vowel in (24) would create a line-crossing violation with the medial glottal stop. The floating high tone therefore links to the toneless first vowel instead, by Part (b) of (H)-Association (33) (see Appendix I below).

In OT terms, the grammatical output in (24) violates TPFAITH, while the ungrammatical output satisfies it. There must therefore be a higher constraint satisfied by the grammatical candidate and violated by the ungrammatical candidate. This constraint, I argue, is TONE-LEFT. TONE-LEFT is an alignment constraint defining floating high tones as prefixes by demanding that they be on the left edge of their host's tonal tier. As illustrated with the tableau in (25), given the assumption that glottal stops exist in some fashion on the tonal tier, the ranking TONE-LEFT » TPFAITH explains the anti-transparency effect of medial glottal stops (I provide in Appendix II a sketch of the relevance of TONE-LEFT beyond the behavior of medial glottal stops).

(25) *TONE-LEFT » TPFAITH*

Input: (H) + CM?L	Status	TONE-LEFT	TPFAITH
a. CH?L	☙	√	*
b. CM?H	†	*!	√

(25) shows that it is better in Mixteco to satisfy TONE-LEFT than TPFAITH, thus that TONE-LEFT must dominate TPFAITH. Note that in the tableau in (19) given above to illustrate the role of TPFAITH in explaining transparency, TONE-LEFT is neutralized as a deciding constraint, because the candidates there all satisfy TONE-LEFT. In particular, in the grammatical output on line

(a) of (19), where the floating high tone is parsed on the second vowel, TONE-LEFT is satisfied because the first vowel is toneless. Candidate (b) also satisfies TONE-LEFT, because the floating high tone is anchored to the first vowel. TPFAITH can thus be the decision-maker in (19), but not in (25), where it is preempted by a differentiating TONE-LEFT.[12]

So far, the two approaches are both descriptively adequate in accounting for anti-transparency. An important difference emerges, however, when words with initial glottal stops are taken into account. As shown in (26), initial glottal stops are not barriers to the association of floating high tones.

(26) (H) + ʔisò 'rabbit' —› ʔisó (not *ʔisò)

This example constitutes a serious problem of descriptive adequacy for the rule-based analysis. Its reliance on an unviolable universal constraint (the line-crossing constraint), in order to explain the anti-transparency effect of medial glottal stops, wrongly predicts that initial glottal stops should also be barriers to (H)-Association.

In a sense, what Mixteco shows here is that the line-crossing constraint is too powerful, since it can actually be violated in some cases. Precisely by insisting that universal constraints are violable, OT is able to explain the finely-tuned distinction operated by initial and medial glottal stops in Mixteco. Within OT, forms with so-called line crossings are simply candidates that exhibit some sort of metathesis with respect to a given input, and they must be evaluated like any other candidate. Line-crossing violations thus do not in and of themselves constitute grounds for the outright elimination of candidates. As we saw in (25) above, in the case of medial glottal stops, a violation of TONE-LEFT could be avoided if the floating high tone was parsed on the toneless first vowel instead of the toned second vowel. This result had the effect of an observance of the line-crossing constraint. But in the case of an initial glottal stop, the only way a preceding floating high tone can avoid violating TONE-LEFT is by not being parsed at all. What the data show is that Mixteco will parse this high tone anyway, therefore that PARSE H dominates TONE-LEFT. As illustrated with the tableau in (27), this ranking forces the parsing of the floating high tone. Candidate (c) is thus eliminated outright, leaving candidates (a) and (b) in contention. These two candidates are tied on both PARSE H and TONE-LEFT, and lower-ranking TPFAITH thus re-emerges as the deciding constraint.

(27) *PARSE H » TONE-LEFT*

Input: (H) + ʔMCL	Status	PARSE H	TONE-LEFT	TPFAITH
a. ʔMCH	☛	√	*	√
b. ʔHCL	†	√	*	*!
c. ʔMCL	†	*!	√	√

The important point here is that the demand that PARSE H be satisfied, even if it leads to a violation of TONE-LEFT, in effect creates a line-crossing violation (that is, in comparison with the input, the optimal candidate exhibits a

metathesis between the floating high tone and the initial glottal stop). But this violation is tolerated, because of the way in which Mixteco resolves the conflict between PARSE H and TONE-LEFT (PARSE H » TONE-LEFT).

It is interesting to consider the behavior of morphemes with a toneless first vowel and a glottal stop in both initial and medial position, because such a configuration yields candidates violating TONE-LEFT differentially. Thus, consider in (28) the Mixteco word for 'five', ʔuʔùn, in the context of a preceding floating high tone.

(28) (H) + ʔuʔùn —› ʔúʔùn (not *ʔuʔún)

In the grammatical output, the floating high tone is parsed on the first vowel, thereby incurring a single TONE-LEFT violation for being one element (a single glottal stop) removed from perfect left alignment. Parsing the floating high tone on the low-tone second vowel of the word (*ʔuʔún) will by contrast create a double TONE-LEFT violation, since the high tone is in this case two elements (two glottal stops) removed from perfect left alignment. The importance of these gradient violations of TONE-LEFT can be seen by examining the tableau in (29) and comparing it with (27) above.

(29) *Single vs. double violations for TONE-LEFT*

Input: (H) + ʔuʔùn	Status	PARSE H	TONE-LEFT	TPFAITH
a. ʔuʔún	†	√	**!	√
b. ʔúʔùn	☛	√	*	*
c. ʔuʔùn	†	*!	√	√

In both tableaux, candidate (c) is ruled out because of a PARSE H violation, and candidates (a) and (b) remain in contention. Candidate (a) wins in (27), but candidate (b) wins in (29). The difference is due to the fact that candidate (a) in (29) is tagged with a double TONE-LEFT violation, which makes TONE-LEFT, rather than TPFAITH, the crucial decision-maker.[13]

To summarize, the so-called universal line-crossing constraint is too powerful, because it must be deemed unviolable within its theoretical framework. By contrast, OT can modulate the power of universal constraints. In the case at hand, OT essentially recasts the inadequately rigid line-crossing constraint into more elementary and more malleable terms pertaining to Alignment Theory (through TONE-LEFT) and constraint interaction (through the hierarchy PARSE H » TONE-LEFT » TPFAITH). In effect, OT renders the line-crossing constraint appropriately violable and thus provides the right mix of restriction and leeway to explain the different behavior of initial and medial glottal stops with respect to transparency.

4 Conclusion

The transparency of Mixteco's mid-tone vowels to the association of floating high tones is an intriguing property. It seems natural to assume that this property is connected to phonological tonelessness, but paradoxically this move flies in the face of conventional wisdom and the long-standing rational assumption that a free tone and a free anchor should automatically bind together, thereby ensuring the prosodic licensing of free tones without tonal disruption to other TBU's. Mixteco shows that such linking is not necessarily automatic and that other natural forces, both morphological (AFFIX) and phonological (TPFAITH), may counteract the ideal state of exhaustive tonal parsing (AFFIX » PARSE H; TPFAITH » PARSE L).

The anti-transparency effect studied here is itself surprising in that Mixteco distinguishes between medial glottal stops, which act as a barrier to floating high tones, in accord with the line-crossing constraint, and initial glottal stops, which do not act as a barrier, in violation of the line-crossing constraint. The puzzle can be resolved, however, again by assuming that conflicting natural forces are at play. When medial glottal stops are involved, the stronger tone-parsing and alignment requirements (namely, PARSE H and TONE-LEFT) can both be accommodated at the expense of transparency (TPFAITH), yielding the effect of the line-crossing constraint being observed. By contrast, when initial glottal stops are part of the picture, the tone parsing requirement (PARSE H) and the alignment demand (TONE-LEFT) are impossible to satisfy concurrently. Something must give, and TONE-LEFT does (PARSE H » TONE-LEFT), yielding the effect of a line-crossing violation.

As I have tried to illustrate here with the case of Mixteco's floating high tones, a theoretical framework combining rules and unviolable universal constraints fails on grounds of both descriptive and explanatory adequacy. By contrast, OT provides a successful approach based on the language-specific prioritization of universal constraints making conflicting demands on linguistic substance.

5 Appendix I: Summary of competing approaches

This appendix provides a synopsis of the rule-based and constraint-based analyses of Mixteco's floating high tones (see Tranel 1995b,c for details).

5.1 Two shared assumptions

(30) a. Mixteco's mid-tone vowels are phonologically toneless
b. High tones and glottal stops share a feature-geometric tier

5.2 Rule-based approach

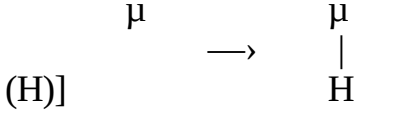
The rule-based approach includes three sets of demands on phonological representations: (i) universal constraints and conventions, (ii) language-specific constraints, and (iii) language-specific rules.

(31) *Universal constraints/conventions (unviolable)*
a. OCP
b. Line-crossing constraint
c. UAC (free tones automatically associate to free anchors)
d. Prosodic Licensing (unanchored elements are not phonetically realized)

(32) *Language-specific constraints*
a. No contour tone on single TBU's
b. No MH tonal pattern on C<u>VV</u> words (*<u>MH</u>)

(33) *(H)-Association (language-specific rule)*

a.


b.


(H)-Association has two parts. Part (a) automatically takes precedence over Part (b) (by Kiparsky's 1973 'Elsewhere Condition' or Koutsoudas *et al.*'s 1974 'Principle of Proper Inclusion Precedence').

Part (a) states that a final floating high tone anchors to the first toned mora in the next morpheme (ignoring any toneless vowel that might occur there). This process is blocked by the line-crossing constraint and the *<u>MH</u> constraint. Other constraints make repairs on the output of the process. Thus, if T is a low tone, it is automatically delinked, since Mixteco does not allow contour tones. If T is a high tone, the two high tones merge (by the OCP).

Part (b) states that a floating high tone otherwise anchors to the first toneless mora in that morpheme.

Finally, when (H)-Association cannot apply (i.e. before a pause), the floating high tone does not surface, as it is not prosodically licensed.

5.3 OT approach

The OT approach involves a single set of demands on phonological representations: universal constraints (or constraint schemata).

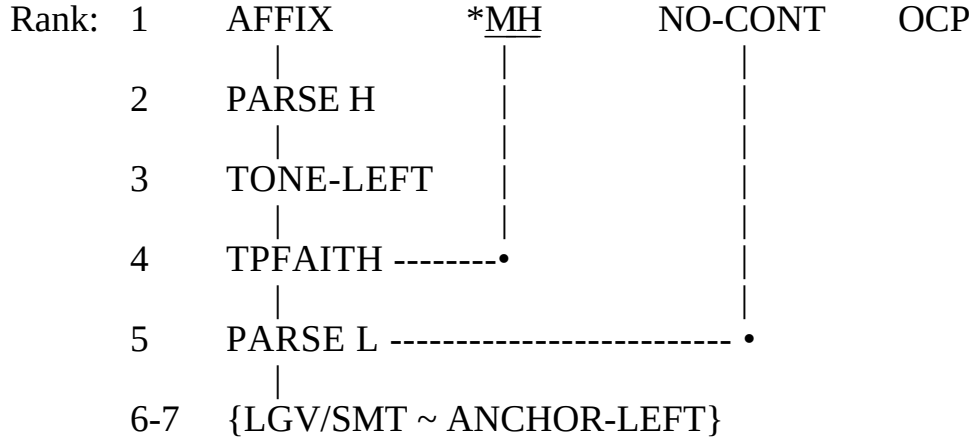
(34) *Relevant universal constraints (potentially conflicting and violable)*

A. Structural constraints
   a. AFFIX: An affix must be morphologically alien to its host
   b. *MH: MH is banned on CVV words (derived from harmonic scale)
   c. NO-CONT: No contour tone on single TBU's
   d. OCP: No identical adjacent anchored tones in a given morpheme
   e. LGV/SMT: No contour tone on long vowels (Long Vowel/Same Tone)

B. Faithfulness constraints
   a. PARSE H: Parse a high tone
   b. PARSE L: Parse a low tone
   c. TPFAITH: Preserve tonal prominence profiles (toneless vs. toned)

C. Alignment constraints (prefix-defining for (H))
   a. TONE-LEFT: (H) must be on the left edge of its host's tonal tier
   b. ANCHOR-LEFT: (H) must be leftmost anchored in its host

(35) *Mixteco's Constraint Hierarchy*



The ten constraints are distributed on 7 ranking levels, from undominated (Rank 1) to lowest ranking (Rank 7). The 4 undominated constraints on Rank 1 are unviolated. Among them, however, only AFFIX can be shown to be ranked with respect to all lower-ranked constraints, either directly or by transitivity. *MH and NO-CONT begin to interact with lower-ranked constraints of Rank 4 and 5 only, respectively, and OCP is not interactive at all. The two lowest-ranking constraints given within curly brackets are variably ranked, i.e. their rankings in the two possible sequences LGV/SMT » ANCHOR-LEFT and ANCHOR-LEFT » LGV/SMT yield two different possible outputs (cf. the option mentioned in (11) above; see Tranel 1995c for discussion).

In addition to language-specific evidence (both direct and transitive), two general principles govern constraint ranking (Tranel 1995a,c): CHAP and the RCC.

(36) *Constraint-ranking principles*

a. CHAP (Constraint Hierarchies Acquisition Principle):

A constraint is dominating unless there is positive evidence to the contrary.

b. RCC (Ranking Cluster Condition):

Two variably ranked constraints behave as a cluster in terms of constraint ranking.

CHAP provides the unmarked status for constraints from the standpoint of learnability, namely that they be dominating. In other words, under CHAP, the task of a child in learning a given Constraint Hierarchy is basically to demote constraints when there is positive evidence to do so (cf. Tesar & Smolensky 1993). CHAP is the basis for placing *MH, NO-CONT, and OCP at rank 1 in (35) (no upper bound).

The RCC establishes that variably ranked constraints share the same rankings with respect to the other constraints in the Constraint Hierarchy. In Mixteco, the ranking of the variably ranked constraints {LGV/SMT ~ ANCHOR-LEFT} obeys the RCC.

6 Appendix II: Independent relevance of TONE-LEFT

TONE-LEFT can be shown to be an active constraint in Mixteco independently of the explanation it provides for the anti-transparency effect of medial glottal stops. Consider the case in (37) and the corresponding tableau in (38).

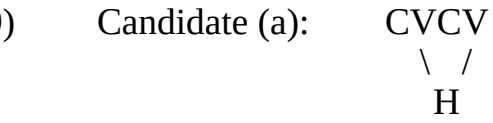
(37) (H) + CLCH —› CHCH (not *CLCH)

(38)

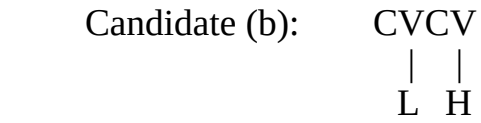
Input: (H) + CLCH	Status	PARSE H	TONE-LEFT	TPFAITH	PARSE L	ANCHOR-LEFT
a. CHCH	☛	√	√	√	*	*
b. CLCH	†	√	*!	√	√	*

The two candidates in this tableau are assumed to have the phonological structures given in (39), and in both the high tone is assumed to have the morphological interpretation given in (40) (see Tranel 1995c for discussion).

(39) Candidate (a):



Candidate (b):



(40) H stands for both the floating high tone and the lexically anchored high tone found in the input (multiple morphological affiliations)

The tableau in (38) shows that candidates (a) and (b) tie on all constraints, except TONE-LEFT and PARSE L, and that TONE-LEFT must be the decision-maker.

NOTES

* For their comments and suggestions at various stages, I would like to thank Nick Clements, Elan Dresher, John Goldsmith, Carole Paradis, Marc Plénat, Paul Smolensky, and Moira Yip.

[1] See references under Pike.

[2] See in particular references under McCarthy and under Prince.

[3] For a fuller discussion, see Tranel (1995c), where I also broach OT-internal issues raised by the Mixteco data.

[4] In examples, I will represent high tones with an acute accent and low tones with a grave accent, mid tones being left unmarked.

[5] I use '(H)' to represent a floating high tone.

[6] In some cases, cells are filled with canonical forms instead of actual examples. This is due to the fact that words of the relevant shape are rare (see Appendix II in Tranel 1995b), and appropriate illustrations could not be found in Pike's writings or texts. However, the canonical forms given strictly abide by Pike's descriptions (see in particular Pike 1944: 123-124; 1948: 79-81, and also Mak 1950: 83), and they follow the attested patterns of a general non-problematic sort. The crucial case in column D (which provides the important contrast between (H) + &aù —› &aú and CVV examples such as (H) + koò —› kóò in column E) is well attested in (apparently different versions of) the story 'The Talking Cave' (Pike 1944: 115-119; 1948: 81).

[7] See Appendix II in Tranel (1995b) for data discussion and Tranel (1995c) for an account of why this option is strictly reserved to CVV words with a lexical MM tonal pattern.

[8] Also unexplanatory is Goldsmith's proposal (1990: 24-26) that a floating high tone metathesizes with a following morpheme-initial mid tone in CVV (2b) and CVCV (3b) words whose second vowel is not mid toned (Goldsmith's rule only specifies a low tone for this second vowel, but high-tone vowels should be included as well).

[9] Which vowel would receive the floating tone would depend on whether the left-to-right or the right-to-left option is selected for the UAC.

[10] For specific applications of such ordering principles to tonal rules and universal conventions, see for instance Clements & Ford (1979) and Pulleyblank (1986).

[11] The implication of this situation for phonological theory is that the convention in question cannot in fact be part of UG. The existence of the UAC in a rule-based framework has been questioned independently by Archangeli & Pulleyblank (1994: Chapter 4), Hyman & Ngunga (1994), and Odden (1995: 459-460). The purported UAC could survive in phonological theory as a parameter, which would happen to be set to 'off' in Mixteco. Neither of these consequences constitutes a positive outcome within the theory. First, the UAC has served insightful purposes in countless analyses, and secondly, the 'parameterization of universal conventions' is really a contradiction in terms indicating that there is nothing universal about so-called 'universal' conventions. For recent discussions on this point, see for instance Archangeli & Pulleyblank (1994) and Hyman & Ngunga (1994).

[12] Candidate (c) in (19) satisfies TONE-LEFT vacuously, since the floating high tone has not been parsed, but this candidate is eliminated by PARSE H, which turns out to dominate TONE-LEFT (see (27) below).

[13] TONE-LEFT is a natural constraint to be subjected to gradient violations, since it can be viewed as measuring a distance on the tonal tier in terms of the number of elements separating a (prefixal) high tone from its host morpheme's left edge.

REFERENCES

Archangeli, Diana & Douglas Pulleyblank (1994). *Grounded phonology*. Cambridge, MA: MIT Press.

Clements, G. N. & Kevin C. Ford (1979). Kikuyu tone shift and its synchronic consequences. *Linguistic Inquiry* **10**. 179-210.

Goldsmith, John (1976). *Autosegmental phonology.* PhD dissertation, MIT.

Goldsmith, John A. (1990). *Autosegmental and metrical phonology*. Oxford & Cambridge, MA: Basil Blackwell.

Hyman, Larry M. & Armindo Ngunga (1994). On the non-universality of tonal association 'conventions': evidence from Ciyao. *Phonology* **11**. 25-68.

Kiparsky, Paul (1973). 'Elsewhere' in phonology. In Stephen R. Anderson & Paul Kiparsky (eds.) *A Festschrift for Morris Halle.* New York: Holt, Rinehart & Winston. 93-106.

Kisseberth, Charles (1970a). On the functional unity of phonological rules. *Linguistic Inquiry* **1**. 291-306.

Kisseberth, Charles (1970b). Vowel elision in Tonkawa and derivational constraints. In Jerrold M. Sadock & Anthony L. Vanek (eds.) *Studies presented to Robert B. Lees by his students*. Edmonton, Canada: Linguistic Research, Inc. 109-137.

Koutsoudas, Andreas, Gerald Sanders, & Craig Noll (1974). On the application of phonological rules. *Language* **50**. 1-28.

Mak, Cornelia (1950). A unique tone perturbation in Mixteco. *International Journal of American Linguistics* **16**. 82-86.

McCarthy, John (1993). The parallel advantage: containment, consistency and alignment. Handout, Rutgers Optimality Workshop I (October 1993).

McCarthy, John & Alan Prince (1993a). Generalized alignment. Ms, University of Massachusetts, Amherst and Rutgers University.

McCarthy, John & Alan Prince (1993b). *Prosodic morphology I: constraint interaction and satisfaction*. Ms, University of Massachusetts, Amherst and Rutgers University.

McCarthy, John & Alan Prince (1994). An overview of prosodic morphology. Handout, Workshop on Prosodic Morphology, University of Utrecht (June 1994).

Odden, David (1995). Tone: African languages. In John A. Goldsmith (ed.) *The handbook of phonological theory*. Oxford & Cambridge, MA: Basil Blackwell. 444-475.

Pike, Kenneth L. (1944). Analysis of a Mixteco text. *International Journal of American Linguistics* **10**. 113-138.

Pike, Kenneth L. (1945a). Tone puns in Mixteco. *International Journal of American Linguistics* **11**. 129-139.

Pike, Kenneth L. (1945b). Mock Spanish of a Mixteco Indian. *International Journal of American Linguistics* **11**. 219-224.

Pike, Kenneth L. (1946a). Another Mixteco tone pun. *International Journal of American Linguistics* **12**. 22-24.

Pike, Kenneth L. (1946b). The Flea: Melody types and perturbations in a Mixtec song. *Tlalocan* **2**. 128-133.

Pike, Kenneth L. (1948). *Tone languages*. Ann Arbor: University of Michigan Press.

Prince, Alan & Paul Smolensky (1993). *Optimality theory: constraint interaction in generative grammar*. Ms, Rutgers University and University of Colorado, Boulder.

Pulleyblank, Douglas (1986). *Tone in lexical phonology*. Dordrecht: Reidel.

Tesar, Bruce & Paul Smolensky (1993). The learnability of optimality theory: an algorithm and some basic complexity results. CU-CS-678-93, Department of Computer Science, University of Colorado at Boulder.

Tranel, Bernard (1995a). Exceptionality in optimality theory and final consonants in French. Paper presented at the 25th Linguistic Symposium on Romance Languages, University of Washington, Seattle (March 1995).

Tranel, Bernard (1995b). On the status of universal association conventions: evidence from Mixteco. *Proceedings of the 21st annual meeting of the Berkeley Linguistics Society* (to appear).

Tranel, Bernard (1995c). The phonology of Mixteco's floating high tones: theoretical implications. Ms, University of California, Irvine.