# THE PHONOLOGY OF MIXTECO'S FLOATING HIGH TONES: THEORETICAL IMPLICATIONS

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## 1. INTRODUCTION

This paper provides 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. Such a case study proves instructive in three major ways. First, it justifies the recent theoretical trend to move away from rule-based phonology to constraint-based phonology. Secondly, it raises interesting theoretical issues within the nascent constraint-based approach. Finally, it brings about new perspectives on our understanding of tonal phonology and the morphology of floating elements.

In a nutshell, the facts of relevance in Mixteco are the following: a morpheme-final floating high tone anchors into the next morpheme (if no pause intervenes), but its landing site varies depending on the host morpheme's own tonal and segmental make-up. Thus, the floating tone does not automatically dock onto the first tone-bearing element of its host, as one might expect in such tone sandhi configurations. Instead, it prefers to attach to the first low-tone or high-tone vowel, even if it requires skipping an intervening mid-tone vowel. This preference can however be thwarted in some cases. For example, a medial glottal stop in effect prevents a floating high tone from ignoring an initial mid-tone vowel in favor of a subsequent low-tone or high-tone vowel. Another important characteristic of floating high tones in Mixteco is that they are never phonetically realized within their own lexical morphemes. Thus, if a pause follows a morpheme containing a final floating high tone, the floating high tone simply does not surface. This situation is not without parallel to French latent consonants, which are never realized within their own morphemes, but require support from a following morpheme in order to surface.

The paper is organized as follows. Section 2, which is based on Pike's published work on Mixteco (see references), provides background information on the segmental and tonal canonical patterns of lexical words, and describes the distribution and association properties of its floating high tones. Section 3 gives in summary form the rule-based analysis of Mixteco's floating high tones proposed in Tranel 1995d, and presents several general and Mixteco-specific problems deemed inherent to the theoretical framework within which the analysis is couched. Sections 4 and 5 constitute the core of the paper. Section 4 proposes an optimality-theoretic treatment of the Mixteco data, and argues that Optimality Theory (OT) allows an account that is preferable to the rule-based analysis on both descriptive and explanatory grounds. Section 5 elaborates on the comparison between the two approaches, discusses several theoretical issues raised within OT, and highlights some results of general interest regarding tonal phonology and morphology. Finally, Section 6 offers a brief conclusion.

## 2. BACKGROUND ON MIXTECO

### 2.1. Some basic characteristics

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

(1) CVV, CVCV

Each mora can bear one, and only one, of three level tones: High (H), Mid (M), or Low (L).[2] Thus, as diagrammed in (2), contour tones do not occur.

```
(2)    No contour tones:   * μ
                              / \
                             T  T
```

For our purposes, it will be useful, as indicated in (3) and (4), to distinguish two phonological classes of words within each of the two categories in (1).

[1] There are in addition a few words of the shape CVʔCV, which exhibit some of the special properties of CVʔV words (see note 4 and (11) below). Interjections (e.g. <u>bidáà</u> 'indeed'; Pike 1948: 88) and Spanish borrowings (e.g. <u>fabóòr</u> 'favor'; Pike 1948: 93) may also have a more complex structure. Finally, [s] can be found word-initially before voiceless stops (the first two examples might be bimorphemic, with [s] the causative prefix; cf. (8b) below) : e.g. <u>stáʔàn</u> 'to light', 'to show', 'to insult' (Pike 1945a: 129), <u>skáɾda</u> 'to toss' (Pike 1945a: 133), <u>staà</u> 'tortilla' (Pike 1945a: 137), <u>stoò</u> 'uncle' (Pike 1945b: 220).

[2] Following Pike's practice in his IJAL articles, I will represent high tones with an acute accent and low tones with a grave accent, mid tones being left unmarked (Pike 1948 marks these with a macron).

(3) Words with contiguous vowels

a. Words with a long vowel (V = V): $C\underline{VV}$

b. Words with vowels in hiatus (V ≠ V): CVV

(4) Words with medial consonants

a. Words with a medial glottal stop: CVʔV

b. Words with no medial glottal stop (medial C ≠ ʔ): CVCV

The distinction in (3) 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 (3a), and on the other hand vocalically bimelodic words, i.e. words with two syllables in hiatus, represented in (3b).[3] The distinction made in (4) separates words containing a medial glottal stop, as in (4a), from words with a medial consonant that is not a glottal stop, as in (4b).[4]

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, explicitly noted by Pike (1944: 124; 1948: 57) and 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'). I will not be concerned any further with this constraint, which remains to be explained if non-accidental.

```
(6)    *LL:          *  L
                       / \
                      μ   μ
```

[3] Where relevant, identical vowel qualities within a single morpheme will be represented by underlining.

[4] Included in the medial glottal stop class in (4a) are words of the shape CVʔCV.

The second tonal gap, not mentioned by Pike, but of significance for our purposes, concerns the MH pattern. As diagrammed in (7), this pattern is not found over words with a long vowel, i.e. CVV words (by contrast, the MH pattern is attested in other CVV words; see (13) below).[5]

(7) *MH:

```
* M    H
  |    |
  μ    μ
   \  /
 Root node
```

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'.[6] (8a) illustrates a lexical minimal pair, (8b) shows the lexical representation of the causative prefix, and (8c) the lexical representation of the continuative prefix.[7]

(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 tabulated in (14) below).[8] In general, it replaces the first low or high tone, skipping an initial

[5] From my search in Pike's writings and Mixteco texts, an underlying MH pattern also appears to be lacking on both CVʔV and CVʔV words, but while the gap seems to be real for CVʔV words, it may be purely accidental for CVʔV words (For details, see Appendix I in Tranel 1995d). The absence of the derived MH pattern in both word types with a medial glottal stop constitutes an important part of the analyses presented below.

[6] I use '(H)' to representy a floating high tone.

[7] The continuative prefix may also have a palatalizing influence on the following morpheme (see Pike 1944: 123; 1948: 94, note 10; Tranel 19995d, note 7).

[8] See also Tranel 1995d, Mak (1950: 83), and my original source, Pike's writings cited in the list of references.

mid-tone vowel if need be. This situation is schematized in (9), where X represents any tone (H, M, or L).

(9) General pattern with words containing a low or high tone:

a. (H) + LX and (H) + HX —› HX

b. (H) + ML and (H) + MH —› MH

(9a) shows that a floating high tone replaces an initial low or high tone. (9b) 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 (3) and (4) above) exhibit the pattern in (9a). The pattern in (9b) is restricted to CVCV words (4b) and CVV words (3b) (excluded are CVʔV words (4a) and CVV words (3a)).

As diagrammed in (10), if the following morpheme has only mid tones, a floating high tone always anchors to its first vowel.[9]

(10) MM words:

(H) + MM —› HM

I now turn to the special cases involving CVʔV words (4a) and CVV words (3a). As shown in (11), with CVʔV 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.[10]

(11) CVʔV 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 CVV or CVV word conforms to the patterns described in (9) and (10) above, except in words containing both a long vowel (CVV

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[9] In CVV words, the floating high tone may optionally link to the second half of the long vowel as well (Pike 1944: 123-124, 1945b: 220, 1948: 80-81; see also Appendix II in Tranel 1995d).

[10] As briefly mentioned in note 5 above, an underlying MH tonal pattern is probably impossible in CVʔV words, but possible in CVʔV words.

words) and the underlying tonal pattern ML. In these cases, the transparency of the mid-tone vowel is again overridden, this time by the *<u>MH</u> constraint given in (7) above, and as shown in (12), the tonal pattern HL surfaces instead of MH.

(12) C<u>VV</u> words with underlying ML tonal pattern:

(H) + <u>ML</u> —› <u>HL</u>

(13) depicts the striking contrast with CVV words.

(13) CVV words with underlying ML tonal pattern:

(H) + ML —› MH

(14) provides in tabulated form data illustrating the canonical patterns in (9)-(13). The blank cells represent impossible patterns.[11]

[11] Examples are provided only for lexical tonal patterns with which the association of the floating high tone makes a phonetic difference in at least some of the word-type paradigms. So, not included in Table (14) are data of the type (H) + HX, because such inputs always come out phonetically as HX. Also, there is no LL column, since LL is not a possible tonal pattern lexically (see Constraint (2) above).

For the CVV row, cells are for the most part filled with canonical forms instead of actual examples. This is due to the fact that words of this general shape are apparently fairly rare (see Appendix II in Tranel 1995d), and appropriate illustrations could thus not always 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 follow the attested patterns of a general non-problematic sort. The crucial case in column D (which provides the important contrast between (H) + z&aù —› z&aú and C<u>VV</u> 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).

For column G in the CVʔV row, see notes 5 and 10 above. Again, the canonical form given in this cell conforms to Pike's descriptions and follows the generally attested pattern for CVʔV words.

(14): Tabulated data on (H)-association

| Inputs: (H) + | A (9a) LM -› HM | B (9a) LH -› HH | C (10) MM -› HM | D (9b, 13) ML -› MH | E (11, 12) ML -› HL | F (9b) MH -› MH | G (11) MH -› HH |
|---|---|---|---|---|---|---|---|
| CVCV (4b) | kìku -› kíku 'to sew' | sùc&í -› súc&í 'child' | z&uku -› z&úku 'mountain' | z&ukù -› z&ukú 'branch' | | kuc&í -› kuc&í 'pig' | |
| CVʔV (4a) | hàʔa -› háʔa 'to give' | ţdèʔé -› ţdéʔ é 'to look at' | beʔe -› béʔe 'house' | | taʔù -› táʔù 'to beat' | | CMʔH -› CHʔH |
| CVV (3b) | CLM -› CHM | CLH -› CHH | CMM -› CHM | z&aù -› z&aú 'cave' | | CMH -› CMH | |
| C<u>VV</u> (3a) | c&ìi -› c&íi 'beneath' | kWàán -› kWáán 'yellow' | kee -› kée~kéé 'to go away' | | koò -› kóò 'snake' | | no lexical MH |

Mixteco's floating high tones do not surface before a pause, i.e. they never get integrated into their own lexical morphemes, even if there are apparently available anchors for them there and nowhere else (see (17) and (18) below). Although perhaps seemingly trivial, this property is actually of serious import, because as we will see later (see also Tranel 1995d), it militates against the generally accepted universal convention that free tones automatically link to free anchors.

## 3. Rule-Based Approach

### 3.1. Summary of analysis

The following is a summary of the rule-based analysis developed in Tranel 1995d.

(i) In order to account for the transparency of mid-tone vowels, the assumption is made that such vowels are underlyingly toneless. In other words, as stated in (15), the mid tone is the default tone in Mixteco.[12]

(15) M-Default: $\mu \longrightarrow \begin{array}{c}\mu \\ | \\ \mathrm{M}\end{array}$

[12] The default rule in (15) has been commonly proposed for other languages with the three level tones High, Mid, and Low (e.g. Pulleyblank 1986).

The lexical tonelessness of mid-tone vowels opens the way for a preceding floating high tone to link to a subsequent toned vowel without line-crossing violations.

(ii) Two rules, given in (16), govern the anchoring of final floating high tones into a following morpheme. Rule (16a) automatically takes precedence over Rule (16b) by virtue of being more specific (cf. Kiparsky's 1973 'Elsewhere Condition' or Koutsoudas, Sanders, & Noll's 1974 'Principle of Proper Inclusion Precedence').

(16) (H)-Association:

```
a.        μ             μ
          |     —›     / \
    (H)]  T            H  T

b.        μ            μ
                —›     |
    (H)]               H
```

Part (a) of (16) is intended to capture the fact that a floating tone's preferred target is the first lexically toned vowel (T) in the next morpheme. It 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. Everything else in this situation results from independent operations. Thus, if T is a low tone, it is automatically delinked, since Mixteco does not allow contour tones (see Constraint (2) above). If T is a high tone, the outcome is simply a high-tone vowel. Part (b) of (16) is intended to capture all other cases of (H)-association. Thus, it states that in case the floating high tone does not find a toned mora in the next morpheme, then it anchors to the first toneless mora in that morpheme.[13]

(iii) The availability of a toned vowel for the operation of Rule (16a) is determined by three

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[13] The following example (Pike 1948: 82) shows that floating high tones only have access to the first morpheme on their right (the floating high tone here is the continuative morpheme; see (8c) above).

```
(i)    (H) +  na  +  kìku  +  ná   —›   ná - kìku - ná ,   * na - kíku - ná
             're'   'to sew'  'I'       'I am re-sewing'
```

In (i), (16b) applies rather than (16a), even though on a purely phonological basis, one might have expected the floating high tone to skip the toneless vowel of na and anchor to the first vowel of kìku. The reason it does not skip the toneless vowel is that it does not have scope beyond the first morpheme to its right. The phrase in (i) can be usefully contrasted with the one in (ii), which shows that the initial syllable in the verb for 'to sew' can otherwise host the continuative floating high tone.

```
(ii)   (H) +  kìku  +  ná   —›   kíku - ná
             'to sew'  'I'       'I am sewing'
```

factors. The first is whether the following morpheme contains a lexically toned vowel at all; if not, Rule (16b) will apply instead (see the cases in (10) above). The second factor is whether the association of the floating high tone would cross the path of a medial glottal stop. The underlying assumption here is that high tones and glottal stops share at least one feature-geometric tier, so that the association of a high tone past a glottal stop creates a line-crossing violation. Again, in such a situation, Rule (16b) will apply instead of Rule (16a), thus accounting for the special cases in (11) above. The third factor is whether the output by Rule (16a) would violate a basic restriction on tonal patterns; one such restriction is the *<u>MH</u> constraint on C<u>VV</u> words given earlier in (7). Once more, such a situation leads to the application of Rule (16b) instead of Rule (16a), yielding the cases in (12) above. All remaining cases, in which a toned vowel is both identified and available, result from the application of Rule (16a) (see the cases in (9) above).

(iv) If neither rule in (16) can apply, that is, if the floating high tone occurs before a pause, then nothing may save it. It remains unanchored and is consequently not realized phonetically.

### 3.2. Some problems with the rule-based approach

#### 3.2.1. General problems

There are two main general problems with the rule-based analysis just summarized. First, the analysis is theoretically heterogeneous, resorting as it does to a combination of rules and constraints. Constraints could of course be eliminated, but at the cost of complicating the rules and their contexts. Constraints were first introduced into the standard rule-based framework precisely in order to capture elementary generalizations, both in the constraints themselves and in the rules (see Kisseberth 1970a,b). One of the main points of this paper is to provide a case study showing that constraints can completely take over the role played by rules and yield more insightful analyses.

The second general problem has to do with the status of the Universal Association Convention (UAC) linking free tones to free tone-bearing units (TBU's) (Goldsmith 1976). As summarized below from Tranel 1995d, the rule-based analysis requires a rather drastic move, namely the elimination of the UAC from Universal Grammar (UG).[14]

The difficulties caused by the existence of the UAC in UG are tied to the well-motivated view that mid-tone vowels are lexically toneless in Mixteco.[15] Thus, under perturbation by a preceding floating high tone, we saw earlier (see (9a) above) that words with a LM tonal pattern change to HM. This is illustrated in (17a) and (17b) with the word for 'puddle' (Pike 1948: 79). As already mentioned, the linking of the floating high tone to the low-tone vowel by Rule (16a) causes the low tone to delink, since contour tones are banned in the language (Constraint (2) above).

```
(17)      a.     [m i n i       b. m i n i          c. * m i n i
                       |            —›        |         —›          |  |
              (H)]     L         (16a)        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).

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).[16] Alternatively, one could assume on a principled basis that the UAC is preempted by more specific language-particular rules such as

[14] 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).

[15] Recall that the appealing explanation for the transparency of mid-tone vowels to the association of floating high tones is based on this assumption. This approach constitutes in my opinion a superior alternative to Goldsmith's proposal (1990: 24-26) that a floating high tone metathesizes with a following morpheme-initial mid tone in CVV (3b) and CVCV (4b) 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).

[16] 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.

(16a) and (16b).[17] 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 (15) 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.[18] In sum, the purported universal convention automatically associating a floating tone to a free TBU must not apply in Mixteco, despite excellent opportunities. The implication of this situation for phonological theory is that the convention in question cannot in fact be part of UG. The purported UAC could survive in phonological theory as a parameter, which would happen to be set to 'off' in Mixteco. But 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.[19]

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

[18] 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 simply attributed to their unanchored status, their language-specific deletion looks like a devious way to bar the application of the UAC.

[19] For recent discussions on this point, see for instance Archangeli & Pulleyblank 1994 and Hyman & Ngunga 1994.

### 3.2.2. Mixteco-specific problems

In addition to problems of a general nature for phonological theory, the rule-based analysis is also saddled with Mixteco-specific difficulties that have to do with providing satisfactory explanations for the phenomenon under discussion. One of these difficulties is that the analysis offers no explanation for why, given the choice, a floating high tone will prefer to anchor to an already toned vowel rather than a toneless vowel, even when the toneless vowel is in a very clear sense more readily accessible, being not only tonally free, but also closer than the toned vowel.

Another difficulty concerns the account of medial glottal stops as antidotes to the transparency of mid-tone vowels. Recall that the explanation for this behavior was based on a violation of the universal line-crossing constraint (Goldsmith 1976). The problem is that a morpheme-initial glottal stop does not form a barrier to the association of a preceding floating high tone. For example, as schematized in (19), a floating high tone does jump across both an initial glottal stop and the mid-tone first vowel of the next morpheme to replace a low tone on the second vowel of that morpheme.

(19) ʔVCV words with a ML tonal pattern: Initial ʔ is not a barrier

(H) + ʔMCL —› ʔMCH (e.g. (H) + ʔisò 'rabbit' —› ʔisó)

(19) contrasts with (20), a relevant subcase of (11) above indicating that a medial glottal stop acts as a barrier.

(20) CVʔV words with a ML tonal pattern: Medial ʔ is a barrier

(H) + CMʔL —› CHʔL (e.g. (H) + taʔù 'to beat' —› táʔù)

This contrast between (19) and (20) shows that glottal stops are not absolute barriers to the association of floating high tones, and that the line-crossing constraint proposed to account for the situation in (20) is too powerful to explain the fine-tuning that appears to govern the differential behavior of initial and medial glottal stops in thwarting the transparency of initial mid-tone vowels.[20]

[20] In Tranel (1995d: note 19), I attempted to explain away the inert behavior of initial glottal stops by claiming that they are not present underlyingly, but simply surface as a default onset consonant.

A third problem involves the account of CMM words, i.e. words with a long toneless vowel. As mentioned in note 9 above, a preceding floating high tone may optionally link to both moras instead of just the initial one (see (21a) below). This optional pronunciation seems related to the often observed tendency in tone languages to have long vowels carry the same tone on both of their moras. However, as implemented in Mixteco, this tendency cannot be captured by means of a general requirement optionally demanding that a long vowel carry a level tone, because this effect is strictly limited to the specific input listed in (21a). Thus, underlying forms like those in (21b) and their corresponding outputs do not abide by such a constraint, and neither do they when acted upon by a preceding floating high tone, as shown in (21c).[21]

(21) a. (H) + MM —› HM or HH (e.g. (H) + kee 'to go away' —› kée ~ kéé)

b. ML —› ML; LM —› LM; HM —› HM; LH —› LH

c. (H) + ML —› HL; (H) + LM —› HM; (H) + HM —› HM; (H) + LH —› HH

The very narrow context for the possible linking of the floating high tone to the two moras of a long vowel thus requires a case-specific extension of Rule (16b) that can hardly be explanatory with regard to the nature of the phenomenon.[22]

## 4. OT APPROACH

I now turn to an analysis of the Mixteco data within OT. My goal is twofold. First, I would like to show that the tools of OT allow a plausible explanatory account that avoids the problems and insufficiencies encountered in the rule-based analysis. Secondly, I would like to bring up for general consideration some theoretical issues raised within OT by the Mixteco data and the treatment proposed.

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[21] The last example in (21c) does yield the same tone on both moras of the long vowel, but in the regular course of the association of the floating high tone rather than as an implementation of the constraint.

[22] One particular challenge here is to distinguish between the two cases in (i) and (ii):

(i) (H) + MM —› HM or HH

(ii) (H) + LM —› HM, *HH

Section 4.1 provides some background assumptions (to be discussed further in Section 5); Section 4.2 lists the relevant constraints, with a few clarifying comments; Section 4.3 gives the proposed Constraint Hierarchy; and Section 4.4 delivers the analysis per se.

### 4.1. Background assumptions

#### 4.1.1. Mid-tone vowels

Two important elements of the rule-based analysis are retained in the OT treatment proposed, but as we will see, they function quite differently in the two approaches.

First, mid-tone vowels are considered to be lexically toneless. While this assumption serves to explain the transparency of mid-tone vowels in both analyses, it does so in very distinct ways. In the rule-based analysis, the lexical tonelessness of mid-tone vowels was used to avoid line-crossing violations in the process of associating the floating high tone to a subsequent toned vowel. In the OT analysis, its role will be in determining faithfulness at the level of abstract tonal nodes (whether a vowel is toned or not). Another difference between the two analyses is that in the OT approach, the lexical tonelessness of mid-tone vowels will contribute to the explanation of other phenomena, thus receiving independent motivation. In particular, it will be involved in determining the placement of floating high tones in general, in accounting for the special role of glottal stops in this placement, and in motivating the <u>MH</u> restriction on C<u>VV</u> words.

I assume that the surface mid tone that occurs on these vowels is assigned at the level of phonetic implementation, as it is a physiological necessity for a (voiced) vowel to be realized with a tone (the vocal cords must vibrate at a certain rate interpretable as tonally significant in a tone language). In sum, my claim is that these vowels are truly linguistically toneless, and that their phonetic toning is merely a byproduct of our vocal apparatus.[23]

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[23] In a Sapirian experiment, it might be surmised that native speakers would mark high tones and low tones in transcribing Mixteco, but leave mid tones unmarked (cf. the common claim by native speakers of Chinese that there is no tone on words with the so-called neutral tone).

On the fact that lexically toneless vowels may be phonetically realized with different tones (mid or low) across languages with identical contrastive tones (high and low), see Section 5.2.2 below.

4.1.2. High tones and glottal stops

The second element carried over from the rule-based analysis is that high tones and glottal stops share at least one feature-geometric tier.[24] Again, I wish to emphasize at the outset that the use which I make of this assumption in the OT analysis will be entirely different from the one in the rule-based analysis. In the rule-based analysis, this assumption served to implement the mechanism of line-crossing violations. As we will see, within OT, this particular mechanism is not available to rule out candidates, since so-called line-crossing violations simply correspond to candidates exhibiting some sort of metathesis. Rather, left alignment on the shared tonal tier will be the determining factor presiding over the interaction between prefixal floating high tones and glottal stops.

4.1.3. Tonal prominence

Vowels in Mixteco are either toned or toneless. I define toned vowels as tonally prominent and toneless vowels as tonally non-prominent. As already alluded to in Section 4.1.1 above, this notion of tonal prominence will play an important role in determining the faithfulness of candidates with respect to inputs. The general idea is that a candidate will be faithful with respect to tonal prominence only if it parallels the input in terms of the distribution of toneless vs. toned vowels (thus abstracting away from the distinction between low and high tones).

4.1.4. Tier-dependent alignment

The proposed OT analysis will rely importantly on Alignment Theory (McCarthy & Prince 1993a). What I want to point out in these preliminaries is that alignment is tier-dependent, in particular with respect to tones. Thus, given Alignment Theory, a tone may potentially display crucial alignment properties on both the tonal tier, where it resides as an element, and on the moraic

[24] For typographical simplicity, I will place the glottal stop on the tonal tier when relevant to the discussion.

tier, where it is anchored.[25] This observation is illustrated in (22) with two bisyllabic morphemes containing a high-tone vowel and a toneless vowel in reverse order.

```
(22)    a. CVCV     H is both leftmost-anchored
             |
             H      and leftmost on the tonal tier.

        b.  CVCV    H is not leftmost-anchored,
               |
               H    but it is leftmost on the tonal tier.
```

In these two examples, the high tone is leftmost with respect to anchoring only in the first case, since it is attached to the first vowel in (22a), but to the second vowel in (22b). However, the same high tone is leftmost on the tonal tier in both cases, since it is the first element present on that tier, whether it is anchored to the first or second vowel. This state of affairs in (22b) follows from the fact that the first vowel is toneless.

4.1.5. OCP and coalescence

I will assume throughout that the Obligatory Contour Principle (OCP) operates unviolably on tones anchored within a given morpheme. In particular, all forms given for typographical convenience as (23a) are to be interpreted as (23b), i.e. there is a single doubly linked high tone.[26]

```
(23)    a.  CHCH,  CHH

        b.  CVCV,  CVV
              \ /    \/
               H      H
```

I will also assume, against the Principle of Containment proposed by Prince & Smolensky 1993, that candidates may include coalesced phonological elements with multiple morphological affiliations. For example, for an input such as (24a), (24b) will be considered as a possible candidate in which the high tone represents both the floating high tone and the lexically anchored high tone found in the input.

[25] Cf. Archangeli & Pulleyblank's 1987 concept of tier scansion.

[26] The diagrams in (23b) are themselves shorthand notations. As already made clear by the formulations of the constraints in (2), (6), and (7) in Section 2.1 above, I assume that tones are anchored to moras.

(24) a. (H) + CHCL

b. CHCL

This coalescence effect can probably be equivalently achieved within the framework of McCarthy & Prince's recent proposal (1994) to abandon Containment and to replace it with the Theory of Correspondence. Within such a theory, it seems that coalescence can be produced through multiple indexing.[27]

It may be useful here to point out that as a consequence of the combined OCP and coalescence assumptions, a form such as (25b) is a relevant candidate for an input such as (25a).

(25) a. (H) + CMCH

```
b. CHCH, i.e. CVCV
                \ /
                 H
```

Because of the OCP, the high tone in (25b) is doubly linked, and because coalescence is allowed, it may have two morphological affiliations, representing both the floating high tone and the lexically anchored high tone found in the input (25a).

4.2. Relevant constraints

Ten constraints and their interactions will be used to account for the data. All ten constraints are offered as plausible universal constraints, or at least as language-specific implementations of universal constraint schemata.

4.2.1. AFFIX

As seems to be the case with floating consonants in French, and as we will see is true also in the case of Mixteco floating high tones, it can happen that parts of lexical morphemes must function as affixes. By this, I mean that in order to surface, these parts must find a host morpheme that is other than their own lexical morpheme. In other words, they must be morphologically alien to their host. The constraint AFFIX is intended to capture this requirement.

[27] See Section 5.2.4 below for further discussion.

(26) AFFIX: an affix must be morphologically alien to its host

AFFIX can in fact be quite generally viewed as a definition of the notion 'affix', its satisfaction also barring the realization of an affix as an autonomous word (the ultimate situation in being hosted by one's own lexical source).

This constraint may well be universally undominated (unviolable), although an English example like the autonomous comparative word more might be viewed as illustrating a possible violation of AFFIX when the use of the corresponding suffix -er is disallowed in order to satisfy higher-ranked constraints.

### 4.2.2. PARSE H and PARSE L

PARSE H forces the parsing of a high tone, PARSE L the parsing of a low tone. These two constraints can be viewed as members of the PARSE-FEATURE family.

(27) PARSE H: Parse a high tone

(28) PARSE L: Parse a low tone

Because high tones seem to exhibit a greater general resilience than low tones across languages (see for example Tranel 1992-94 for Margi), it is possible that the ranking PARSE H » PARSE L is universal, or at least the unmarked ranking.[28]

### 4.2.3. NO-CONT

The constraint NO-CONT bans contour tones on single moras (cf. Constraint (2) above). Formally, I take this constraint to prohibit the branching of a TBU into the tonal tier.

(29) NO-CONT: A TBU does not branch into the tonal tier

In spirit, NO-CONT is parallel to constraints proposed at the segmental level against long vowels and diphthongs (see for example Rosenthal 1994). These constraints have in common to inventory what are marked options across languages.

[28] The two relevant constraints might thus be PARSE H and PARSE T (T = H or L), if following Kiparsky's suggestion on the Optimality List Network (October 20, 1994), "no constraint can specify unmarked features" (In his message, Kiparsky concurred with related postings of the same day by Rolf Noyer and Thomas M. Green and referred to his 1993 and 1994b conference papers, of which only the handout for the 1993 talk has been available to me).

NO-CONT is relatively high-ranking in languages without contour tones such as Mixteco, but relatively low-ranking in languages with contour tones. As a rough approximation, languages with no contour tones will neglect to parse tones in order to abide by NO-CONT. So, NO-CONT will dominate at least some PARSE T constraint (e.g. NO-CONT » PARSE L). By contrast, languages with contour tones will consider it more important to parse tones than to obey NO-CONT. So, NO-CONT will be dominated by the PARSE T constraints (PARSE T » NO-CONT).

### 4.2.4. LGV/SMT

LGV/SMT, short for LONG VOWEL/SAME TONE, expresses what I take to be a general tendency for long vowels to prefer the same tone spread over their two moras. When obeyed, this constraint results in level rather than contour tones over long vowels. Toneless long vowels satisfy LGV/SMT vacuously.

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

### 4.2.5. TPFAITH

TPFAITH (a coalesced abbreviation for Tonal Prominence Profile FAITHfulness) enforces tonal prominence correspondence between input and candidates.

(31) TPFAITH: Preserve tonal prominence profile

Basically, a tonally prominent vowel (one with a tonal node T) must remain so (i.e. a toned vowel must remain toned) and a tonally non-prominent vowel (one without a tonal node) must remain so (i.e. a toneless vowel must remain toneless).

Note that a Mixteco morpheme may incur at most one TPFAITH violation. This is because lexical words in this language are limited to two TBU's and contour tones are not allowed on single TBU's (see Section 2.1 above). Thus, as illustrated in (32), tonal prominence profiles may only be monodirectional, and there can therefore maximally be just one TPFAITH violation for a given candidate.[29]

| (32) | Tones | Profiles | |
|---|---|---|---|
| | a. M | Ø | (toneless morphemes) |
| | b. T | — | (HH and LL morphemes) |
| | c. TT | — | (HL and LH morphemes) |
| | d. MT | ∂ | (MH and ML morphemes) |
| | e. TM | f | (HM and LM morphemes) |

One important upshot is that while TPFAITH may be violated in different ways in Mixteco (i.e. Ø vs. — vs. ∂ vs. f), the candidates violating the constraint will all violate it equally, i.e. just once. Another inportant outcome reflected in (32) is that because cases (32b) and (32c) have the same tonal prominence profile (—), they do not constitute a TPFAITH violation with respect to each other.

### 4.2.6. TONE-LEFT

Mixteco's final floating high tones must function as prefixes. As such, they are in part defined by the constraint AFFIX given in (26) above. Additionally, as prefixes, they are further defined by two tier-dependent alignment constraints. The first of these two constraints, TONE-LEFT, states that these tones must be the first element on the tonal tier of their host morphemes.

(33) TONE-LEFT: (H) must be on the left edge of its host's tonal tier

TONE-LEFT is potentially subject to gradient violations.[30] This constraint measures the distance from a (prefixal) high tone to its host morpheme's left edge in terms of other items present

[29] Observe by contrast that in a language allowing three or more tonal slots per morpheme, TPFAITH can 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.

[30] See Tableau (65) below for an actual case. For other examples of gradient constraints, see for instance Prince & Smolensky 1993 and McCarthy & Prince 1993a.

on the tonal tier in that stretch. The number of intervening items thus constitutes the degree to which TONE-LEFT is violated.

### 4.2.7. ANCHOR-LEFT

The second constraint defining floating high tones as prefixes is ANCHOR-LEFT. This constraint states that these tones must be anchored to the leftmost vowel in their host morphemes.

(34) ANCHOR-LEFT: (H) must be leftmost anchored in its host

Contrary to what one might expect at first blush, the two prefix-defining constraints ANCHOR-LEFT and TONE-LEFT do not always overlap in their function. They do in the examples in (35): both constraints are satisfied by the parsing of the high tone in (35a) and both are violated in (35b).

```
(35)    a. CVCV     ANCHOR-LEFT (H) satisfied      (= (22a))
             |
             H      TONE-LEFT (H) satisfied

        b.  CVCV    ANCHOR-LEFT (H) violated
              |  |
              L  H  TONE-LEFT (H) violated
```

However, the configuration in (36) shows that the two constraints do not necessarily duplicate each other. In (36), the parsing of the high tone on the second vowel violates ANCHOR-LEFT, but it satisfies TONE-LEFT, since the first vowel is toneless.

```
(36)        CVCV    ANCHOR-LEFT (H) violated(= (22b))
               |
               H    TONE-LEFT (H) satisfied
```

The fourth possible combination (ANCHOR-LEFT satisfied and TONE-LEFT violated) is illustrated by the special configuration in (37), where the initial consonant is a glottal stop and is therefore shown on the tonal tier (see note 24 above).

```
(37)         VCV    ANCHOR-LEFT (H) satisfied
             |
           ʔ H      TONE-LEFT (H) violated
```

In this case, the parsing of the high tone on the first vowel satisfies ANCHOR-LEFT, but TONE-LEFT is violated because the high tone is preceded by a glottal stop on the tonal tier.[31]

### 4.2.8. *MH

The constraint *MH bans the tonal pattern MH on words with a long vowel (i.e. CVV words) (see Constraint (7) above).

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

At first blush, (38) may look like a rather arbitrary constraint, with little claim to universal status. There is, however, a plausible explanation for why a language could have a constraint involving this specific tonal pattern to the exclusion of any others. 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 be viewed as resulting from a harmony scale coming out of the conjunctiuon of two phonetic scales, one concerning tonal strength and the other positional strength.[32] As already mentioned in Section 2.2.2 above, 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. Regarding long vowels, it has been suggested in the literature that the first mora be viewed as the strong position (or head) of the combination and the second mora as the weak position (or dependent). Assuming that strong elements seek strong positions, the tonal pattern

---

[31] As shown in (i) and (ii), when preceded by a floating high tone, the Mixteco words ?̄n 'one' and ?u?ùn 'five' provide examples of configurations where ANCHOR-LEFT is satisfied and TONE-LEFT violated (the final n's indicate nasalization on the preceding vowels).

(i) (H) + ?̄n —› ?̄!̄n
(ii) (H) + ?u?ùn —› ?ú?ùn

These two schematic examples are abstracted from the constructions in (iii) (Pike 1944: 136; 1945b: 219; 1946: 22) and (iv) (Pike 1944: 131), respectively.

(iii) a. kuní-z*ò (H) 'want-I' + ?̄n-nà 'one-more' —› kuní-z*ò ?̄!̄n-nà 'I want one more'
b. nuù (H) 'for' + ?̄n 'one' + c*àa 'man' —› nuù ?̄!̄n c*àa 'for one man'
c. nì-kà-hinì-de + nuù (H) + ?̄n + ñù-kWii —› nì-kà-hinì-de nuù ?̄!̄n ñù-kWii
'saw-they' 'face' 'one' 'fox' 'they saw one fox'

(iv) nuù (H) + ?u?ùn + ni + kbʕ —› nuù -?ú?ùn-ni -kbʕ
'in' 'five' 'exactly' 'day' 'in five days'

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

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 while others are allowed.[33]

### 4.2.9. OCP

The final constraint of relevance is the OCP, as formulated in (39).

(39) OCP: No identical adjacent anchored tones in a given morpheme

As already mentioned in Section 4.1.5 above, I assume that (39) operates unviolably in Mixteco. It can be viewed as an undominated constraint, or maybe even as part of GEN. I will not include this constraint in any of the constraint tableaux. All candidates exhibiting adjacent TBU's with identical tones will be systematically interpreted as having a single doubly linked tone (see for instance (23) above).

## 4.3. Constraint Hierarchy and ranking principles

I will argue for the partial Constraint Hierarchy in (40).

(40) {AFFIX, *MH, NO-CONT, OCP} » PARSE H » TONE-LEFT » TPFAITH

» PARSE L » {LGV/SMT ~ ANCHOR-LEFT}

The constraint rankings and interactions to be demonstrated in Section 4.4 below are more accurately depicted by the diagram in (41).

[33] 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 intermediate steps would be as roughly depicted in (i), assuming that L is weaker than H (cf. PARSE H » PARSE L as a possible universal; see Section 4.2.2), but obviously stronger than M (since M = no tone) ('>' in (i) denotes greater harmony. ',' indicates uncertain ranking if any; the ranking HH > LL > MM would obtain if it were more important for a head position than a dependent position to be filled with its preferred element).

(i) HM > HL > HH, LL, MM > ML > LM > LH >MH

The prediction made here is that for a given tonal pattern banned in a given language, all less harmonic patterns should also be banned. The scale in (i) interacts with LGV/SMT, which favors level tones on long vowels (see Section 4.2.4 above). Note that in Mixteco, the absence of the LL pattern (see Constraint (6) above) affects all morphemes, not just CVV morphemes. If not accidental, this gap requires a separate explanation.

(41) Rank: 1 AFFIX *MH NO-CONT OCP

2 PARSE H

3 TONE-LEFT

4 TPFAITH

5 PARSE L

6 {LGV/SMT ~ ANCHOR-LEFT}

The ten constraints are distributed on 6 ranking levels, from undominated (Rank 1) to lowest ranking (Rank 6). 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. As we will see, *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. These 3 constraints are nevertheless placed at the top of the Constraint Hierarchy because of the following principle on constraint ranking, which I proposed in Tranel 1995b.

(42) Constraint Hierarchies Acquisition Principle (CHAP):

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

CHAP provides what I believe to be the logical 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). This proposed acquisition process is diagrammed in (43), with successive demotions of {E, F, G} in (43b), {D} in (43c), and {F,G} in (43d).

(43) a. Initial state {A, B, C, D, E, F, G ...}

b. —› {A, B, C, D ...} » {E, F, G}

c. —› {A, B, C ...} » {D} » {E, F, G}

d. —› {A, B, C ...} » {D} » {E} » {F, G}

e. —› final Constraint Hierarchy

In diagram (41), the two curly-bracketed constraints of Rank 6 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.[34] The ranking depth of the partial Constraint Hierarchy is thus really 7 rather than 6. Another principle on constraint ranking proposed in Tranel 1995b is assumed to operate on variably ranked constraints.

(44) Ranking Cluster Condition (RCC):

Two variably ranked constraints each take on the other's relative rankings with respect to other constraints.

In other words, the RCC states that variably ranked constraints behave as a cluster in terms of constraint ranking. The situation is diagrammed in (45).

(45) Given A ~ B (i.e. A and B variably ranked) and X » A » Y,
then X » B » Y, i.e. X » A ~ B » Y

Although there is no inherent necessity for this condition, it reduces the complexity of the learner's task in constructing its language's Constraint Hierarchy and constitutes the natural null hypothesis. As we will see, the ranking prediction made by the RCC regarding the pair of constraint {LGV/SMT ~ ANCHOR-LEFT} vis-à-vis TPFAITH is confirmed by direct ranking evidence.

## 4.4. Analysis

The first main point of the analysis is that a floating high tone must function as an affix. This absolute requirement means that as regards floating high tones, the constraint AFFIX is undominated; in particular, it dominates PARSE H.

(46) AFFIX is undominated (in particular, AFFIX » PARSE H)

As briefly illustrated in Tableau (47), this specific ranking explains why a floating high tone never anchors into its own morpheme, even if a toneless vowel is available. (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.

[34] I symbolize variable ranking among constraints by means of an intervening tilde.

An asterisk followed by an exclamatiom mark indicates a fatal violation. I represent toneless vowels by the symbol M, high-tone vowels by the symbol H, and low-tone vowels by the symbol L).

Tableau (47): AFFIX » PARSE H

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

The input in this tableau is a CVCV morpheme with toneless vowels and a final floating high tone (cf. (18) above). Candidate (a) satisfies AFFIX vacuously, at the expense of violating PARSE H (the floating high tone is not parsed). The other two candidates satisfy PARSE H, but violate AFFIX by integrating the floating high tone into its own lexical morpheme. Since candidate (a) is the grammatical outcome, the conclusion is that AFFIX dominates PARSE H.

Let us now turn to the cases where final floating high tones have an available host, i.e. there is a following morpheme available for anchoring into, which means that AFFIX can be satisfied non-vacuously.[35] One essential characteristic to capture here is the preference of floating high tones for already toned vowels, as opposed to toneless vowels (see (9) above). The relevant constraint is TPFAITH. As an enforcer of the preservation of Tonal Prominence Profiles, TPFAITH guarantees that everything else permitting, toneless vowels will be ignored in favor of already toned vowels as anchors for floating high tones. Tableau (48) illustrates the role of TPFAITH.[36]

[35] AFFIX may also be satisfied vacuously in such configurations, but this entails a PARSE H violation, and as we will see, PARSE H is an otherwise dominant constraint.

[36] At this point, PARSE H and TPFAITH remain unranked with respect to each other, as indicated by the vertical dotted line separating their two columns in Tableau (48). The ranking PARSE H » TPFAITH is introduced in Tableau (52) below.

Tableau (48): Role of TPFAITH

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

The input in this tableau is a floating high tone followed by a CVCV morpheme with a toneless first vowel and a low-tone second vowel. The floating high tone is parsed on the lexically toned vowel in candidate (a) and on the toneless vowel in candidate (b), but it is not parsed in candidate (c). PARSE H ensures that the floating high tone does get parsed, thereby eliminating candidate (c). TPFAITH decides between the two candidates which parse the floating high tone, picking the candidate on line (a), where the toneless vowel has been bypassed by the floating high tone.

The winning candidate in Tableau (48) fails to parse the low tone of the input, whereas the losing candidates (b) and (c) parse it. As illustrated in Tableau (49), this shows that both PARSE H and TPFAITH dominate PARSE L.

Tableau (49): PARSE H, TPFAITH » PARSE L

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

Another candidate of interest for the input in (49) is one where the floating high tone anchors to the low-tone vowel but without displacing the low tone, thus creating a falling tone [HL].[37] Such a candidate must be ruled out. As shown in Tableau (50), the elimination of this candidate can be achieved by NO-CONT (the constraint against contour tones on single TBU's), provided that NO-CONT is ranked above PARSE L.

[37] Contour tones on single TBU's are indicated within square brackets.

Tableau (50): NO-CONT » PARSE L

| Input: (H) + CMCL | Status | NO-CONT | PARSE L |
|---|---|---|---|
| a. CMCH |  | √ | * |
| b. CMC[HL] | † | *! | √ |

Although there is also no evidence that NO-CONT interacts with constraints ranked higher than PARSE L, it also appears that it has no upper bound in the Constraint Hierarchy. Therefore, by virtue of CHAP (see (42) above), NO-CONT must be considered to be among Mixteco's undominated constraints (together with AFFIX, and as we will see later, *MH).

(51) NO-CONT is undominated

Since contour tones are banned in Mixteco not only in derived forms, but also lexically, NO-CONT is unviolated in this language. It is interesting that unviolability is also true of the other two undominated constraints AFFIX and *MH (although there seems to be no formal necessity for undominated constraints to be unviolable).

Consider next the effect of anchoring floating high tones onto following morphemes with toneless moras (cf. (10) above). The association of the floating high tone in such cases will necessarily result in a violation of TPFAITH, as it will change a toneless vowel into a toned one. Since the floating high tone does associate in these cases, in satisfaction of PARSE H, it means that PARSE H must dominate TPFAITH, as shown in Tableau (52).

Tableau (52): PARSE H » TPFAITH

| Input: (H) + CMCM | Status | PARSE H | TPFAITH |
|---|---|---|---|
| a. CHCM |  | √ | * |
| b. CMCM | † | *! | √ |

The input in this tableau is a CVCV morpheme with toneless vowels and a preceding floating high tone. The ranking PARSE H » TPFAITH eliminates candidate (b), which satisfies TPFAITH at the expense of PARSE H.

However, another candidate is available, namely CMCH, which ties the winning candidate in Tableau (52) by satisfying PARSE H and violating TPFAITH. 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 (53), this decision can be entrusted to ANCHOR-LEFT, which correctly selects candidate (a) over candidate (b) as the optimal choice.[38]

Tableau (53): Role of ANCHOR-LEFT

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

As shown by Tableaux (54) and (55), the relative ranking of ANCHOR-LEFT can be established by considering CVCV words containing a toneless first vowel and a toned second vowel.

Tableau (54): TPFAITH » ANCHOR-LEFT

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

The input in this tableau reprises the input from Tableaux (48), (49), and (50) above, namely a floating high tone followed by a CVCV morpheme with a toneless first vowel and a low-tone second vowel. The floating high tone is parsed in both candidates (PARSE H is thus neutralized as a deciding constraint) The fact that candidate (a) must be the winning candidate demonstrates that TPFAITH dominates ANCHOR-LEFT.

Since PARSE H dominates TPFAITH (see Tableau (52) above), it follows by transitivity that PARSE H also dominates ANCHOR-LEFT. This ranking can also be established directly, as shown in Tableau (55).

[38] TONE-LEFT (to be discussed shortly) cannot be a deciding constraint here, since it is satisfied by both candidates (a) and (b) in Tableau (53) (see (22), or (35a) and (36) above).

I note in passing that as reflected by the vertical dotted line in Tableau (53), the relative ranking of ANCHOR-LEFT with respect to PARSE H and TPFAITH has not yet been determined (cf. Tableaux (54) and (55) below).

Tableau (55): PARSE H » ANCHOR-LEFT

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

In this tableau, TPFAITH is neutralized, as both candidates satisfy the constraint. This neutralization is performed in candidate (a) at the expense of ANCHOR-LEFT, and in candidate (b) at the expense of PARSE H. Since candidate (a) is the grammamtical output, PARSE H must dominate ANCHOR-LEFT.

Combining the individual rankings established so far yields the partial Constraint Hierarchy in (56).[39]

(56) {AFFIX, NO-CONT} » PARSE H » TPFAITH » {PARSE L, ANCHOR-LEFT}

ANCHOR-LEFT is one of the two tier-dependent alignment constraints defining floating high tones as prefixes. The other prefix-defining constraint postulated is TONE-LEFT. For many configurations, for example those involving a CVCV morpheme with a toneless first vowel, TONE-LEFT can have no deciding impact. To show this, I provide in (57) some of the inputs and candidates examined in previous tableaux (ungrammatical candidates are preceded by an asterisk).

| (57) | | Inputs | Candidates | Source Tableaux |
|---|---|---|---|---|
| | (i) | (H) + CMCL | CMCH, *CHCL | (48), (49), (54), (55) |
| | (ii) | (H) + CMCM | CHCM, *CMCH | (52), (53) |

The parsing of the floating high tone in the four candidates in (57) satisfies TONE-LEFT, as the high tone is leftmost on the tonal tier in all cases (nothing precedes it on that tier, even when it is anchored to the second vowel, since the first vowel is toneless). TONE-LEFT thus cannot be a deciding constraint for these configurations. By contrast, TONE-LEFT has the potential to play a determining role in cases where the first vowel is toned. Consider first the example in (58).

(58) (H) + CLCH —› CHCH

[39] The relative ranking of PARSE L and ANCHOR-LEFT has not yet been established (cf. Tableau (73) below).

Of all the constraints ranked so far (see (56) above), the output in (58) violates the two lower-ranking constraints {PARSE L, ANCHOR-LEFT} and satisfies the four higher-ranking constraints (AFFIX, NO-CONT, PARSE H, and TPFAITH).[40] However, this candidate could be improved upon by removing the PARSE L violation, yielding the ungrammatical candidate *CLCH. As illustrated in Tableau (59), TONE-LEFT proves crucial here in eliminating this form through its domination of PARSE L.

Tableau (59): TONE-LEFT » PARSE L

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

Consider next the example in (60).

(60) (H) + CLCM —› CHCM

The grammatical output in (60) satisfies all the constraints in (56), except for PARSE L. It also satisfies TONE-LEFT. The competing candidate that would satisfy PARSE L, namely the ungrammatical *CLCH, would violate both higher ranking constraints TONE-LEFT and TPFAITH. Between these two constraints, the actual decision-maker is TONE-LEFT, since as will be shown in the next paragraph, TONE-LEFT dominates TPFAITH.

The relative ranking of TONE-LEFT and TPFAITH can be elucidated by bringing in for consideration CVʔV cases. As already noted, with these words, a preceding floating high tone is strictly limited to docking onto their first vowel, even in cases where one would otherwise expect an initial toneless vowel to be skipped in favor of a subsequent toned vowel (cf. (11) above). Thus, TPFAITH is consistently violated in CVʔV words exactly when it would be satisfied in CVCV words. Given the assumption that glottal stops exist in some fashion on the tonal tier (see Section 4.1.2 above), TONE-LEFT can readily explain why a medial glottal stop constitutes a

[40] CHCH violates ANCHOR-LEFT because it has a single doubly linked high tone with two morphological affiliations (see Section 4.1.5 above). The representative of the floating high tone is therefore linked to the second vowel, which causes the ANCHOR-LEFT violation. CHCH satisfies TPFAITH because its tonal prominence profile is the same as that of the input (see Section 4.2.5 above).

barrier: it dominates TPFAITH. In other words, it is more important for the floating high tone to be parsed initially on the tonal tier than it is to preserve tonal prominence. Tableau (61) illustrates this ranking.

Tableau (61): TONE-LEFT » TPFAITH

| Input: (H) + CMʔL | Status | TONE-LEFT | TPFAITH |
| --- | --- | --- | --- |
| a. CHʔL | ☞ | √ | * |
| b. CMʔH | † | *! | √ |

The input in this tableau is a floating high tone followed by a CVʔV word with a toneless first vowel and a low-tone second vowel. The floating high tone is parsed on the first vowel in candidate (a) and on the second vowel in candidate (b). If it were not for TONE-LEFT dominating TPFAITH, the candidate satisfying TPFAITH - ungrammatical candidate (b) - would be optimal, as is the case with CVCV words with the same tonal configuration on their TBU's (see Tableaux (48), (49), and (54) above). The domination of TONE-LEFT correctly blocks this outcome in Tableau (61) and makes the grammatical candidate on line (a) optimal. It is interesting to note that ANCHOR-LEFT would yield the same correct result if it were ranked above TPFAITH. But such ranking is incompatible with the ranking required to account for the transparency of initial toneless vowels in CVCV configurations (see Tableau (54) above). This potential ranking paradox is avoided thanks to TONE-LEFT.

The two rankings established in Tableaux (54) and (61) yield the partial Constraint Hierarchy in (62).

(62) TONE-LEFT » TPFAITH » ANCHOR-LEFT

If on the right track, this analysis makes three important points: (i) a prefix may require more than one defining constraint, (ii) these defining constraints can be split in the Constraint Hierarchy by other constraints, and (iii) alignment constraints are tier-dependent.

Not only does TONE-LEFT explain why medial glottal stops are a barrier to floating high tones; it also provides a rationale for why, by contrast, initial glottal stops do not form such a barrier (cf. (19) and (20) above). As illustrated in (63), this welcome outcome can be derived from the ranking of PARSE H above TONE-LEFT.

Tableau (63): PARSE H » TONE-LEFT

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

The input in this tableau is a floating high tone followed by a ʔVCV morpheme with a toneless first vowel and a low-tone second vowel. The floating high tone is parsed on the second vowel in candidate (a), on the first vowel in candidate (b), but is not parsed in candidate (c). We can see from examining candidate (c) that TONE-LEFT can be vacuously satisfied by not parsing the floating high tone. The higher ranking of PARSE H rules out this candidate in favor of candidates (a) and (b). The latter two candidates tie on PARSE H, which they both satisfy, and on TONE-LEFT, which they both violate.[41] The final decision between candidates (a) and (b) falls to the next constraint in the Constraint Hierarchy, namely TPFAITH, which legislates in favor of the first candidate (see Tableau (61) above for justification of the ranking TONE-LEFT » TPFAITH).

It is of some interest to consider the behavior of morphemes with a mid-tone first vowel and a glottal stop in both initial and medial position, because such a configuration provides candidates violating TONE-LEFT differentially. Thus, consider the word <u>ʔuʔùn</u> 'five' in the context of a preceding floating high tone (see note 30 above).

(64) (H) + ʔuʔùn —› ʔúʔùn

[41] It is important to emphasize that candidates (a) and (b) violate TONE-LEFT equally. In particular, it is not the case that candidate (a) violates TONE-LEFT worse than candidate (b). Although the floating high tone has landed on the second vowel in candidate (a) and on the first vowel in candidate (b), it is in both instances in second position on the tonal tier, right after the glottal stop. Candidates (a) and (b) do differ with respect to ANCHOR-LEFT, candidate (a) violating this constraint and candidate (b) satisfying it, but this difference is irrelevant, since as observed in the next sentence in the text, TPFAITH, which is ranked above ANCHOR-LEFT (see Tableau (54) above), gets to be the crucial decision-maker.

In the grammatical output shown in (64), the floating high tone is parsed on the first vowel, thereby incurring a single TONE-LEFT violation for being one element removed from perfect left alignment (one glottal stop). Parsing the floating high tone on the second vowel of the word (*ʔuʔún) will by contrast yield a double TONE-LEFT violation, since the high tone is in this case two elements removed from perfect left alignment (two glottal stops). The importance of these gradient violations of TONE-LEFT can be seen by examining Tableau (65).[42]

Tableau (65): Single vs. double violations for TONE-LEFT

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

If candidate (b) in this tableau was not tagged with a double TONE-LEFT violation, it would be tied with candidate (a) on both PARSE H and TONE-LEFT, and the crucial decision would be left to the next constraint in the Constraint Hierarchy, namely TPFAITH, which would make the incorrect selection by eliminating candidate (a). But as observed in Section 4.2.6 above, 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.

In the interaction of floating high tones, toneless vowels, and glottal stops in Mixteco, we see that through Alignment Theory and Constraint Ranking, an OT approach allows the finely-tuned distinction between initial and medial glottal stops that the rule-based analysis was not able to capture with the line-crossing constraint. More generally, it is worth observing that line-crossing violations are in fact not available within the OT framework as a means to rule out phonological representations. Phonological representations displaying so-called line-crossing violations are in fact possible candidates exhibiting some sort of metathesis. The Mixteco case shows that the line-

[42] A third candidate (*ʔuʔùn) is given in Tableau (65), which satisfies TONE-LEFT, but at the expense of higher-ranked PARSE H (see Tableau (63) above).

crossing constraint is too powerful as a unviolable universal, and that Alignment Theory and Constraint Ranking together provide the right mix of restriction and leeway.

The fuller partial Constraint Hierarchy in (66) can now be assembled.

(66) {AFFIX, NO-CONT} » PARSE H » TONE-LEFT » TPFAITH

» {PARSE L, ANCHOR-LEFT}

Two other phenomena remain to be analyzed, both concerning the behavior of long vowels. The first is the fact that CMM words, i.e. CVV morphemes with a long toneless vowel, may optionally parse a preceding floating high tone on both of their moras (67b), rather than just the initial one (67a) (see note 9 above).

(67) (H) + CMM —› a. CHM

b. CHH

The output CHM in (67a) has already been accounted for (see Tableaux (52) and (53) above). To review briefly, consider Tableau (68).

Tableau (68)

| Input: (H) + CMM | Status | PARSE H | TPFAITH | ANCHOR-LEFT |
|---|---|---|---|---|
| a. CHM |  | √ | * | √ |
| b. CMM | † | *! | √ | √ |
| c. CMH | † | √ | * | *! |

The relevant ranked constraints are PARSE H » TPFAITH » ANCHOR-LEFT (see Tableaux (52), (53), and (54) above). PARSE H ensures that the floating high tone is parsed, at the expense of lower-ranked TPFAITH (hence, candidate (a) CHM > candidate (b) CMM). ANCHOR-LEFT ensures that the floating high tone is parsed on the first, rather than the second, toneless mora (hence candidate (a) CHM > candidate (c) CMH).[43]

What must be additionally allowed is the possibility of parsing the floating high tone on both moras (see (67b) above). This is where LGV/SMT, the constraint prohibiting contour tones on

[43] As we will see later, for CVV words, the ungrammatical candidate with the MH tonal pattern given on line (c) is not actually ruled out by ANCHOR-LEFT, but rather by the higher-ranked constraint *MH (see Tableau (75) and Statement (77) below).

long vowels, comes into play. This constraint conflicts with ANCHOR-LEFT. Thus, output (67a) satisfies ANCHOR-LEFT and violates LGV/SMT, whereas output (67b) violates ANCHOR-LEFT and satisfies LGV/SMT.[44] Since both outputs are possible, I take it that ANCHOR-LEFT and LGV/SMT are variably ranked, one ranking yielding output (67a), the other ranking yielding output (67b), as shown in Tableaux (69a) and (69b) below. From the Ranking Cluster Condition (RCC) (see Section 4.3 above), it follows that LGV/SMT automatically abides by the same rankings as its companion ANCHOR-LEFT. In particular, since TPFAITH dominates ANCHOR-LEFT (see Tableau (54) above), TPFAITH also dominates LGV/SMT.[45] Finally, in considering the tableaux in (69a) and (69b), it is important to recall that for language-specific structural reasons, the operation of TPFAITH in Mixteco may yield at most a single violation per morpheme (see Section 4.2.5 above). This means that TPFAITH is violated equally by the candidates, namely just once.[46]

Tableau (69a): ANCHOR-LEFT » LGV/SMT

| Input: (H) + CMM | Status | PARSE H | TPFAITH | ANCHOR-LEFT | LGV/SMT |
|---|---|---|---|---|---|
| a. CHM |  | √ | * | √ | * |
| b. CHH | † | √ | * | *! | √ |

Tableau (69b): LGV/SMT » ANCHOR-LEFT

| Input: (H) + CMM | Status | PARSE H | TPFAITH | LGV/SMT | ANCHOR-LEFT |
|---|---|---|---|---|---|
| a. CHM | † | √ | * | *! | √ |
| b. CHH |  | √ | * | √ | * |

[44] (67b) violates ANCHOR-LEFT because its single high tone anchors to the second mora while standing for the floating high tone of the input (in addition to anchoring to the first mora and standing for the lexically anchored high tone of the input).

[45] The RCC-derived ranking TPFAITH » LGV/SMT is relevant for Tableau (69b), where LGV/SMT could conceivably be ranked above TPFAITH. The ranking TPFAITH » LGV/SMT receives independent direct motivation in Tableau (72) below.

[46] In particular, in Tableau (69b), by comparison with candidate (a), candidate (b) must not be seen as incurring an extra violation of TPFAITH for having the high tone anchored to the second mora (if this were the case, candidate (a) would wrongly best candidate (b)). Rather, candidates (a) and (b) each violate TPFAITH once, candidate (a) for having a TM profile (f) instead of a M profile (Ø), and candidate (b) for having a T profile (—) instead of a M profile (Ø) (see (32) above).

It is interesting to examine in some detail how this approach resolves the problem faced by the rule-based analysis in effectively separating the case of inputs of the form in (67), which end up optionally violating LGV/SMT on the surface, from cases such as (70) and (71), drawn from (21b) and (21c) above, which always violate LGV/SMT.

(70) ML —› ML

(71) (H) + ML —› HL[47]

In order to satisfy LGV/SMT, a candidate for the input ML in (70), such as the ungrammatical LL or MM, would have to violate TPFAITH, which the grammatical output ML satisfies. The ranking TPFAITH » LGV/SMT, independently induced by the RCC above, is motivated directly here and ensures that the grammatical output is also the optimal candidate, as shown in Tableau (72).

Tableau (72): TPFAITH » LGV/SMT

| Input: CML | Status | TPFAITH | LGV/SMT |
|---|---|---|---|
| a. CML |  | √ | * |
| b. CLL | † | *! | √ |
| c. CMM | † | *! | √ |

In the case of the input (H) + ML in (71), compare the grammatical output HL with an ungrammatical candidate such as HH (see Tableau (73) below). Both violate TPFAITH, which therefore cannot be a decision-maker here. Also, HL violates LGV/SMT and satisfies ANCHOR-LEFT, while HH satisfies LGV/SMT and violates ANCHOR-LEFT; but these two constraints cannot be the determining factor either, since as just argued (see Tableaux (69a) and (69b) above), when they are decision-makers, their variable relative ranking will yield two outputs, and only one output is possible here. A higher constraint must therefore be responsible for making the correct selection. The crucial fact here is that the ungrammatical candidate HH additionally violates PARSE

[47] See Tableau (75) below for why the floating high tone does not skip the initial toneless vowel to yield MH instead of HL.

L. The conclusion, then, is that PARSE L must dominate the cluster {LGV/SMT ~ ANCHOR-LEFT}. Tableau (73) illustrates these interactions.[48]

Tableau (73): PARSE L » {LGV/SMT ~ ANCHOR-LEFT}

| Input: (H) + CML | Status | TPFAITH | PARSE L | LGV/SMT ~ ANCHOR-LEFT | |
|---|---|---|---|---|---|
| a. CHL |  | * | √ | * | √ |
| b. CHH | † | * | *! | √ | * |

All cases in (21b) and (21c) above, where LGV/SMT is potentially relevant but must not make a decision (for it would make the wrong one), essentially reduce to the two examples treated in Tableaux (72) and (73) above. That is, as illustrated by the fuller tableaux in (74b) and (74c) below, some constraint (i.e. PARSE H, TONE-LEFT, TPFAITH, or PARSE L), by virtue of dominating the cluster {LGV/SMT ~ ANCHOR-LEFT}, will correctly prevent LGV/SMT from being the decision-maker in these cases, thereby not forcing a level tone on a long vowel. By contrast, as shown in the double tableau in (74a) below (fuller versions of Tableaux (69a) and (69b) above), only in cases such as (21a), where these higher-ranked constraints are 'hors de combat' for making decisions between the relevant candidates, will LGV/SMT be allowed to impose a level tone on a long vowel, provided it is ranked above ANCHOR-LEFT.

[48] Since PARSE L was shown earlier to be dominated by TPFAITH (see Tableau (49) above), PARSE L is thus wedged in-between TPFAITH and the cluster {LGV/SMT ~ ANCHOR-LEFT} in the Constraint Hierarchy.

Tableau (74a) (cf. (21a))

| (H) + MM | Status | PARSE H | TONE-LEFT | TPFAITH | PARSE L | ANCHOR-LEFT | LGV/SMT |
|---|---|---|---|---|---|---|---|
| a. HM | ☞ | √ | √ | * | √ | √ | * |
| b. HH | † | √ | √ | * | √ | *! | √ |

| (H) + MM | Status | PARSE H | TONE-LEFT | TPFAITH | PARSE L | LGV/SMT | ANCHOR-LEFT |
|---|---|---|---|---|---|---|---|
| a. HM | † | √ | √ | * | √ | *! | √ |
| b. HH | ☞ | √ | √ | * | √ | √ | * |

Tableau (74b) (cf. (21b))

| ML | Status | PARSE H | TONE-LEFT | TPFAITH | PARSE L | LGV/SMT~ANCHOR-LEFT | |
|---|---|---|---|---|---|---|---|
| a. ML | ☞ | √ | √ | √ | √ | * | √ |
| b. LL | † | √ | √ | *! | √ | √ | √ |

| LM | Status | PARSE H | TONE-LEFT | TPFAITH | PARSE L | LGV/SMT~ANCHOR-LEFT | |
|---|---|---|---|---|---|---|---|
| a. LM | ☞ | √ | √ | √ | √ | * | √ |
| b. LL | † | √ | √ | *! | √ | √ | √ |

| HM | Status | PARSE H | TONE-LEFT | TPFAITH | PARSE L | LGV/SMT~ANCHOR-LEFT | |
|---|---|---|---|---|---|---|---|
| a. HM | ☞ | √ | √ | √ | √ | * | √ |
| b. HH | † | √ | √ | *! | √ | √ | √ |

| LH | Status | PARSE H | TONE-LEFT | TPFAITH | PARSE L | LGV/SMT~ANCHOR-LEFT | |
|---|---|---|---|---|---|---|---|
| a. LH | ☞ | √ | √ | √ | √ | * | √ |
| b. LL | † | *! | √ | √ | √ | √ | √ |
| c. HH | † | √ | √ | √ | *! | √ | √ |

Tableau (74c) (cf. (21c))

| (H) + ML | Status | PARSE H | TONE-LEFT | TPFAITH | PARSE L | LGV/SMT~ANCHOR-LEFT | |
|---|---|---|---|---|---|---|---|
| a. HL |  | √ | √ | * | √ | * | √ |
| b. HH | † | √ | √ | * | *! | √ | * |
| (H) + LM | Status | PARSE H | TONE-LEFT | TPFAITH | PARSE L | LGV/SMT~ANCHOR-LEFT | |
| a. HM |  | √ | √ | √ | * | * | √ |
| b. HH | † | √ | √ | *! | * | √ | * |
| (H) + HM | Status | PARSE H | TONE-LEFT | TPFAITH | PARSE L | LGV/SMT~ANCHOR-LEFT | |
| a. HM |  | √ | √ | √ | √ | * | √ |
| b. HH | † | √ | √ | *! | √ | √ | * |
| (H) + LH | Status | PARSE H | TONE-LEFT | TPFAITH | PARSE L | LGV/SMT~ANCHOR-LEFT | |
| a. HH |  | √ | √ | √ | * | * | * |
| b. LH | † | √ | *! | √ | √ | * | * |
| c. LL | † | *! | √ | √ | √ | √ | √ |

The final constraint interaction to be examined concerns *MH, the constraint prohibiting the tonal pattern MH on morphemes with a long vowel (i.e. CVV words) (cf. (12) above). Because a preceding floating high tone turns the lexical ML tonal pattern of such words into HL rather than the otherwise expected MH, the constraint *MH must dominate TPFAITH. This ranking is illustrated in Tableau (75).

Tableau (75): *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). In similar CVCV cases (see Tableau (48) above), TPFAITH rules supreme, but we see here that in CVV cases, TPFAITH must be overridden by *MH (i.e. *MH » TPFAITH). Note that the constraints ranked higher than TPFAITH, in particular PARSE H and TONE-LEFT, are satisfied by both candidates, and that ANCHOR-LEFT would reach the same decision as *MH, but is ranked lower than TPFAITH (see Tableau (54) above) and therefore than *MH by transitivity. Consequently, PARSE H, TONE-LEFT, and ANCHOR-LEFT cannot be decision-makers here.

It may be worth observing that another candidate, namely CML, would satisfy both *MH and TPFAITH by failing to parse the floating high tone. As shown in Tableau (76), the already established ranking PARSE H » TPFAITH (see Tableau (52) above) is sufficient to rule this candidate out in favor of the grammatical candidate on line (a).

Tableau (76)

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

This tableau also demonstrates that *MH and PARSE H do not technically need to be ranked with respect to each other. However, since *MH appears to have no required upper bound in Mixteco's

Constraint Hierarchy, CHAP (see Section 4.3 above) will automatically place it among the undominated constraints, together with AFFIX and NO-CONT.

(77) *MH is undominated

Like AFFIX and NO-CONT, *MH is an unviolated constraint in Mixteco.[49]

4.5. Conclusion

I conclude the analysis by listing in (78) all the constraints and their directly established individual rankings, with references to the relevant tableaux.

(78)
a. AFFIX » PARSE H (Tableau (47)) (AFFIX undominated; (46))
b. NO-CONT » PARSE L (Tableau (50)) (NO-CONT undominated; (51))
c. *MH » TPFAITH (Tableau (75)) (*MH undominated; (77))
d. OCP undominated (Section 4.2.9)
e. PARSE H » TPFAITH (Tableau (52))
f. PARSE H » TONE-LEFT (Tableau (63))
g. PARSE H » PARSE L (Tableau (49))
h. PARSE H » ANCHOR-LEFT (Tableau (55))
i. TONE-LEFT » TPFAITH (Tableau (61))
j. TONE-LEFT » PARSE L (Tableau (59))
k. TP FAITH » PARSE L (Tableau (49))
l. TPFAITH » LGV/SMT (Tableau (72))
m. TPFAITH » ANCHOR-LEFT (Tableau (54))
n. PARSE L » {LGV/SMT ~ ANCHOR-LEFT} (Tableau (73))

[49] The unviolable status of *MH in Mixteco makes an interesting prediction regarding borrowings. Suppose a Mixtecan speaker borrows a CVV word with an MH tonal pattern in the source language. The tonal pattern MH being absolutely banned, the prediction seems to be that the high tone will be parsed on the first mora (since PARSE H » TPFAITH) and thus that the phonetic result will be a word with an apparently metathesized HM pattern on its long vowel. Of course, the word can be expected to be quickly restructured with a lexically HM long vowel, but should the existence of such borrowings be ascertained, the expected tonal correspondence between the source language (CMH) and Mixteco (CHM) would provide an appropriate test of the prediction.

o. {LGV/SMT ~ ANCHOR-LEFT} (Tableaux (69a) and (69b))

The final Constraint Hierarchy obtained by transitively combining these individual rankings and applying the RCC and CHAP is given in (79) and in the more detailed diagram in (80).

(79) {AFFIX, NO-CONT, *<u>MH</u>, OCP} » PARSE-H » TONE-LEFT » TPFAITH

» PARSE L » {LGV/SMT ~ ANCHOR-LEFT}

(80) Mixteco's Constraint Hierarchy

```
Rank:  1   AFFIX*MH        NO-CONT          OCP
              |               |               |
       2   PARSE H            |               |
              |               |               |
       3   TONE-LEFT          |               |
              |               |               |
       4   TPFAITH --------•                  |
              |                               |
       5   PARSE L -----------------------------•
              |
       6   {LGV/SMT ~ ANCHOR-LEFT}
```

## 5. IMPLICATIONS

The aim of this section is to provide a broader perspective on the main results of the proposed OT analysis of Mixteco's floating high tones. The first part of the discussion (Section 5.1) focuses on fundamental premises (in particular regarding constraint violability) separating the rule-based and constraint-based approaches. The second part (Section 5.2) deals with OT-internal theoretical issues. And the third part (Section 5.3) highlights several interesting linguistic properties that have emerged from the discussion of the data.

### 5.1. Constraint violability

The basic conclusion to be drawn from our cross-theoretical comparison of the treatment of Mixteco's floating high tones is that OT provides an overall account which is preferable to the rule-based analysis on both descriptive and explanatory grounds. This section seeks to identify the root reasons for this superiority.

Three main areas in the phonology of Mixteco's floating high tones emerge as litmus tests: (i) the invisibility of mid-tone vowels, (ii) the different roles, qua barriers, played by glottal stops in initial and medial position, and (iii) the specific restrictions on the optional occurrence of level tones on long vowels. Each of these areas are considered in turn below and the differences between the two competing analyses are shown to reduce to a single common denominator, the concept of constraint violability.

5.1.1. The invisibility of mid-tone vowels to tonal associations

In both analyses, mid-tone vowels are assumed to be toneless in order to account for the fact that a Mixteco floating high tone typically by-passes an initial mid-tone vowel to dock onto the following toned vowel. But this natural move made to explain the transparency of mid-tone vowels actually creates serious difficulties in the rule-based analysis, whereas it helps explain additional phenomena within the OT analysis.

The first problem faced by the rule-based analysis is that the rule posited to ensure the appropriate docking in transparency cases (see Rule (16a) above) begs the question of why the situation should be as it is. In particular, the analysis provides no explanation as to why a floating tone should rather anchor to an already toned vowel, in some cases displacing the lexical tone, when there is by all measures a more readily accessible vowel, namely one that is closer and toneless.

The OT analysis provides an answer to this question through TPFAITH, a constraint formalizing the idea that the distinction between toneless and toned vowels can be an active factor in preserving correspondences between inputs and outputs. The relative ranking of this constraint in the Constraint Hierarchy, in particular in relation to the 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, whereas 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.[50]

A relatively low ranking of TPFAITH, which is probably common across languages, basically yields the effect of the so-called Universal Association Convention (UAC) automatically associating a floating tone to a free TBU. But Mixteco clearly shows that the UAC may in fact be violated, hence the second serious difficulty inherent to the rule-based analysis: As we saw earlier (see example (17) above), in its unviolable guise, the UAC creates problematic landing sites in Mixteco for low tones that have been set afloat through delinking. This problem does not occur within the OT approach, thanks to TPFAITH and its dominance over PARSE L (see Tableau (49) above).

As illustrated with example (18) above, floating high tones must also be prevented from anchoring into the toneless vowels of their own morphemes, contra the UAC. The phenomenon is explained in the OT analysis by the undominated constraint AFFIX (see Tableau (47) above). Within OT, AFFIX is thus another constraint tempering the tonal attraction that may be naturally exerted by toneless vowels.

In sum, the invisibility of toneless vowels to tonal association in Mixteco constitutes a fundamental problem for a rule-based framework claiming the UAC as an unviolable operating constraint on phonological representations. While the UAC has proven itself in countless insightful analyses, Mixteco shows that the constraint is in fact not universally applicable. The key to resolving the paradox is the realization, implemented within the proposed OT analysis, that the effects of the UAC conflict with other universal constraints and lose out to them in this language.

While the lexical tonelessness of mid-tone vowels as a means to account for their transparency creates problems for the rule-based analysis, it receives additional motivation within the OT approach by contributing to the explanation for other phenomena, in particular the anti-

[50] Other constraints may of course intervene to modify further the degree of attraction in some contexts. Thus, for Mixteco, we saw that TONE-LEFT and *MH, by virtue of their dominance over TPFAITH (see Tableaux (61) and (75) above), in effect strengthen the normally weak attraction exerted by toneless vowels in this language.

transparency effects of medial glottal stops (see Sections 5.1.2 and 5.2.2 below for further discussion) and the existence of the MH restriction on C<u>VV</u> morphemes (see Section 4.2.8 above).

### 5.1.2. Glottal stops as barriers

The two approaches can also be sharply separated by the startingly different roles played by initial and medial glottal stops in thwarting the transparency of mid-tone vowels. Here again, the basic premise is the same in both analyses, namely that glottal stops and high tones share a feature-geometric tier. But the actual use made of this reasonable assumption is fundamentally distinct in the two frameworks and leads to drastically different results, including a fundamental problem of descriptive adequacy for the rule-based analysis.

To explain the role of medial glottal stops as barriers to the association of floating high tones, it was rather naturally proposed in the rule-based analysis to resort to Goldsmith's 1976 line-crossing constraint (see Tranel 1995d and Section 3.1 above). However, this treatment predicts that initial glottal stops should also act as barriers, contrary to fact (see (19) vs. (20) above). The line-crossing constraint is thus too powerful, since it can actually be violated in some cases.

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 Mixteco shows very well. In the proposed OT analysis, medial glottal stops constitute a barrier to floating high tones because, speaking metaphorically, if such a tone lands past a toneless first vowel and a medial glottal stop, it will be in second position on the tonal tier, behind the glottal stop, thereby violating TONE-LEFT, a fairly high-ranking constraint in Mixteco (in particular, TONE-LEFT » TPFAITH; see Tableau (61) above). By anchoring to the toneless first vowel instead, that is, in front of the medial glottal stop, floating high tones satisfy TONE-LEFT (at the possible expense of lower-ranked TPFAITH). By contrast, 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. But Mixteco prefers to parse a high tone, even if this high tone is a prefix and must in order to be parsed end up in second position on the tonal tier, in violation of TONE-LEFT. This demand in effect creates a line-crossing violation (i.e., in comparison with the input, the candidate in question exhibits a metathesis between the floating high tone and the initial glottal stop), but a violation that is tolerated because of the way in which Mixteco resolves the conflict between PARSE H and TONE-LEFT (PARSE H » TONE-LEFT; see Tableau (63) above).

In sum, the so-called universal line-crossing constraint of the rule-based analysis is too powerful a tool 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 recasts the line-crossing constraint in terms of Alignment Theory (TONE-LEFT) and Constraint Ranking (PARSE H » TONE-LEFT » TPFAITH), in effect making the line-crossing constraint appropriately violable.

### 5.1.3. Long vowels and level tones

The specific restrictions on the optional occurrence of level tones on long vowels illustrate the same general point regarding the violability of universal constraints. It seems clear that the motivation for this option is the fact that across languages, long vowels generally prefer to bear level tones rather than contour tones. This tendency is captured here within OT by the LGV/SMT constraint. However, this constraint operates extremely selectively in Mixteco, affecting inputs of the form (H) + C<u>MM</u>, and nothing else. As shown in detail earlier (see in particular Tableaux (74a-c) above), within OT, constraint ranking and the consequent violability of constraints allow LGV/SMT to function in exactly the requisite surgical fashion in which it operates in Mixteco. Specifically, the low ranking of LGV/SMT with respect to the constraints PARSE H, TONE-LEFT, TPFAITH, and PARSE L explains its ineffectiveness in all cases but (H) + C<u>MM</u> inputs, because LGV/SMT is then removed from contention as a decision-maker (one of the higher-ranked constraints provides a fatal violation for the candidates with a level tone in all situations but (H) + C<u>MM</u>). The variable ranking of LGV/SMT and ANCHOR-LEFT explains the optional occurrence of the phenomenon with (H) + C<u>MM</u> inputs, because the higher-ranking constraints not being decision-makers in such instances, LGV/SMT can then manifest its influence, at least when it dominates ANCHOR-LEFT.

By contrast, in the rule-based analysis, the desired results are difficult to obtain in any natural fashion. As suggested earlier (see Section 3.2.2 above), it appears that what is required is an unilluminating case-specific extension of Rule (16b) that would merely state the fact without explaining it. At best, the tendency responsible for the option must function as an unintegrated local explanation, because it operates in the specific context (H) + CMM and is otherwise violated.

### 5.1.4. Summary

The common thread running through the differences in descriptive and explanatory adequacy separating the rule-based and OT accounts can be seen clearly. The theoretical framework in which the rule-based analysis is couched sets up inherently unviolable constraints regulating phonological representations and the effects of rules. But these constraints are demonstrably too powerful in their assumed unviolability. What OT proposes instead is the intuitively appealing notion that albeit universal, constraints are potentially conflicting in the demands that they make on linguistic substance, and that something must of necessity give. In other words, universal constraints can be violated (an effect obtained through Constraint Ranking).

## 5.2. Issues within OT

The proposed analysis of Mixteco's floating high tones developed in Section 4 above raises several theoretical issues within the nascent OT framework. A number of these issues are discussed here. Section 5.2.1 is devoted to tier-dependent alignment, the concept which allowed the anchoring of floating high tones in Mixteco to be evaluated on two separate scales of leftmostness. I argue that quite generally, tier-dependent alignment phenomena can be expected given the existence of structurally defective segments (e.g. floating consonants in French), underspecification, and privative features. Section 5.2.2 addresses the question of the phonological representation of Mixteco's mid-tone vowels as toneless. I show that an alternative analysis rejecting this hypothesis and assuming a PARSE M constraint instead seriously fails to account for the facts. Section 5.2.3 elaborates on the role of the newly proposed constraint TPFAITH and on its motivation based on the notion of tonal prominence. Finally, Section 5.2.4 is concerned with the three C's: Coalescence, Containment, and Correspondence. I argue that coalescence (or multiple morphological affiliations), which is banned by standard OT's Principle of Containment (Prince & Smolensky 1993), is actually necessary for a descriptively adequate treatment of Mixteco's floating high tones. I speculate that the recent innovation within OT to reject Containment and replace it with the Theory of Correspondence (McCarthy & Prince 1994) may accommodate the concept of coalescence through multiple indices.

5.2.1. Tier-dependent alignment

In previous OT literature, a single alignment constraint appears to have been deemed sufficient to account for affix placement (e.g. McCarthy & Prince 1993a). By contrast, the analysis proposed here argues that the prefixal characterization of Mixteco's floating high tones requires two separate left-alignment constraints, TONE-LEFT and ANCHOR-LEFT. This requirement is justified by the Constraint Hierarchy, which shows that other constraints (namely TPFAITH, PARSE L, and optionally LGV/SMT; see Section 4.5 above)) must intervene between them. The split of the leftmost demand on prefixal floating high tones is made possible by the fact that tonal alignment is measurable with respect to distinct tiers, in particular the tonal tier itself and the anchoring tier (see (22) above).

Tier-dependent alignment depends in the Mixteco case on the assumption that mid-tone vowels are toneless, in other words that TBU's may be completely defective in terms of tonal specification. More generally, one can expect tier-dependent alignment phenomena in connection with floating segments as opposed to fixed segments. Consider for instance liaison consonants in French, which are commonly analyzed as floating segments. For purposes of illustration, assume that as opposed to fixed consonants, floating consonants lack an x-slot, as shown in (81) with the final lexical /t/'s in petit [pœti] and net [nEt] (see Tranel 1992, 1995a,c).[51]

(81) a. floating consonant (e.g. petit 'small') b. fixed consonant (e.g. net 'clear')

```
                                                x
                                                |
          root node                         root node
              |                                 |
              t                                 t
```

From the diagrams in (81), we can see that as opposed to a morpheme ending in a fixed consonant, one ending in a final floating consonant can never concurrently satisfy any right-alignment constraint on the x-tier and on the Root Node tier (see Tranel 1995b for an exploitation of these observations).

Tier-dependent alignment phenomena are a logical consequence not only of the existence of structurally defective segments such as floaters. Underspecification in general and privative features also potentially give rise to detectable tier-dependent alignments, which could serve as motivation for such representations if actually exploited.

### 5.2.2. Phonetic default vs. PARSE M

Although phonologically toneless under our proposed OT analysis, Mixteco's mid-tone vowels are phonetically toned. As mentioned earlier (see Section 4.1.1 above), the phonetic mid tone that shows up on these vowels is taken to be the result of phonetic implementation. That is, since in this language vowels are always voiced and vocal cord vibrations play a contrastive role on vowels, these toneless vowels will necessarily carry a linguistically interpretable tone when actually uttered, and mid is this default tone. However, we know that languages with a high vs. low vs. toneless lexical distinction do not always realize their toneless vowels as mid. For onstance, in Margi, such vowels eventually acquire a low tone (see Pulleyblank 1986, Tranel

[51] For different implementations of the notion of floating consonant in French, see Scullen 1993 and Zoll 1994.

1992-94). Tonal default for toneless vowels must therefore be language-specific (at least in part).[52] I would tentatively propose that this language specificity be viewed as falling under the scope of the widely and tacitly accepted phonetic implementation regarding pronunciation details such as the precise articulation of vowels and consonants in different languages. For example, although the vowel /i/ and the consonant /t/ each fulfil parallel functions in the phonological systems of English and French (in both languages, /i/ is the highest and frontest vowel and /t/ the sole voiceless coronal stop), neither an English [i] and a French [i], nor an English [t] and a French [t] have exactly the same articulations (Tranel 1987). It is widely and tacitly assumed that phonetic implementation takes care of these differences across languages.

A conceivable and worth considering alternative to phonological tonelessness for Mixteco's mid-tone vowels would be to assume that mid tones are lexically present and that instead of TP FAITH, there is in this language an active constraint PARSE M on a par with the already posited PARSE H and PARSE L constraints of the PARSE T family. I explore this option in some detail here, but I will ultimately discard it because of its apparent inadequacy. If correct, this outcome constitutes an important argument for at least one variety of underspecification to be allowed in OT.[53]

Viewing mid-tone vowels as lexically toneless, as was done in Section 4 above, served the purpose of explaining, through TPFAITH, the usual transparency of these vowels with respect to the association of floating high tones (see also Section 5.1.1 above). It also played a role, through TONE-LEFT, in treating the anti-transparency effect of medial glottal stops (see also Section 5.1.2 above), and it turned out to be effective as well in accounting for the restricted optional occurrence of level tones on long vowels (again through TONE-LEFT and TPFAITH; see Tableaux (74a-b-c) above). Finally, it contributed half of the explanation for the existence of the constraint *<u>MH</u> (the

[52] To my knowledge, languages do not seem to choose 'high' as a possible phonetic default tone.

[53] Note at any rate that it does not seem possible to assume in general that lexically toneless vowels are a theoretical impossibility. For example, the situation in Margi clearly requires the three-way contrast high vs. low vs. toneless (see Inkelas 1995, Pulleyblank 1986, Tranel 1992-94).

'M' part; see Section 4.2.8 above). We therefore need to assess how these four phenomena would be handled within an analysis abandoning the idea that there are no lexically toneless vowels in Mixteco.

Under the PARSE M option, the transparency of mid-tone vowels can be accounted for by assuming that a mid tone has parsing priority. In particular, PARSE M must dominate PARSE L in order to account for the case in (82).

(82) (H) + CMCL —› CMCH

This case also shows that PARSE H must dominate PARSE L. The necessity for these two rankings is simply illustrated in Tableau (83), without further comments.[54]

Tableau (83): PARSE H, PARSE M » PARSE L

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

As illustrated in Tableau (84), the case in (82) shows in addition that PARSE H and PARSE M must dominate TONE-LEFT.[55]

Tableau (84): PARSE H, PARSE M » TONE-LEFT

| Input: (H) + CMCL | Status | PARSE H | PARSE M | TONE-LEFT |
|---|---|---|---|---|
| a. CMCH | ☞ | √ | √ | * |
| b. CHCL | † | √ | *! | √ |
| c. CMCL | † | *! | √ | √ |

PARSE H and PARSE M are thus both dominant over PARSE L and TONE-LEFT. The case in (85) and the accompanying tableau in (86) show that PARSE H must dominate PARSE M.[56]

[54] These rankings parallel the rankings PARSE H, TPFAITH » PARSE L established in Section 4 under the hypothesis that mid-tone vowels are lexically toneless (see Tableau (49) above).

[55] In the analysis in Section 4, TONE-LEFT has to dominate TPFAITH (see Tableau (61) above).

(85) (H) + CML —› HL

Tableau (86): PARSE H » PARSE M

| Input: (H) + CML | Status | PARSE H | PARSE M |
|---|---|---|---|
| a. CHL |  | √ | * |
| b. CML | † | *! | √ |

The relevance of TONE-LEFT as a deciding constraint can be established by considering the case in (87) and the accompanying tableau in (88).[57]

(87) (H) + CMCM —› CHCM

Tableau (88): Relevance of TONE-LEFT

| Input: (H) + CMCM | Status | PARSE H | PARSE M | TONE-LEFT |
|---|---|---|---|---|
| a. CHCM |  | √ | √ | √ |
| b. CMCH | † | √ | √ | *! |

As illustrated in Tableau (90), the case in (89) shows that TONE-LEFT must dominate PARSE L.

(89) (H) + CLCH —› CHCH

Tableau (90): TONE-LEFT » PARSE L

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

The partial Constraint Hierarchy established so far under the PARSE M option is given in (91).

(91) PARSE H » PARSE M » TONE-LEFT » PARSE L

[56] The transparency of mid-tone vowels in this case (i.e. the candidate CMH) can be thwarted by the undominated constraint *MH, as in the analysis in Section 4.

[57] In the analysis in Section 4, the decision reached here by TONE-LEFT was made by ANCHOR-LEFT, because the lexical tonelessness of mid-tone vowels rendered TONE-LEFT inoperative in CMCM morphemes (TONE-LEFT was satisfied whether the floating high tone was parsed on the first or the second vowel).

The transparency of mid tone vowels is explained here by the dominance of PARSE M over both TONE-LEFT (see Tableau (84) above) and PARSE L (see Tableau (83) above). The overall dominance of PARSE H ensures that floating high tones get realized, even if it means parsing them in second position on the tonal tier, in violation of TONE-LEFT (see Tableau (84) above), or leaving a mid tone unparsed, in violation of PARSE M (see Tableau (86) above), or leaving a low tone unparsed, in violation of PARSE L (see Tableau (83) above).

The first problem associated with the PARSE M option explored here concerns the behavior of CMM words, which is illustrated again in (92), repeated from (67) above.

(92) (H) + CMM ⟶ a. CHM

b. CHH

(92) shows that when preceded by a floating high tone, CMM words yield two possible outputs. As illustrated in Tableau (93), the output in (92a) is already predicted (cf. Tableau (88) above).

Tableau (93)

| Input: (H) + CMM | Status | PARSE H | PARSE M | TONE-LEFT |
|---|---|---|---|---|
| a. CHM | ☞ | √ | √ | √ |
| b. CHH | † | √ | *! | √ |

In Section 4, the possibility of having the output in (92b) was attributed to the variable ranking of the constraints in the cluster {LGV/SMT ~ ANCHOR-LEFT}, coupled with the fact that the two candidates under consideration tied on all the constraints dominating this cluster, including TPFAITH (see Tableaux (69a) and (69b) above). Under the present analysis, as shown by Tableau (93), PARSE M is the first constraint in the Constraint Hierarchy distinguishing between the two relevant candidates.[58] Therefore, in order to derive (92b) as a possible output, LGV/SMT must be variably ranked with PARSE M, as illustrated by the two tableaux in (94).

[58] If TONE-LEFT and ANCHOR-LEFT are both actively required in this analysis, ANCHOR-LEFT would be satisfied by candidate (a) and violated by candidate (b) in Tableau (93), but PARSE M would have to dominate ANCHOR-LEFT, just as it must dominate TONE-LEFT. Tableau (84) above established the ranking PARSE M » TONE-LEFT. Replacing TONE-LEFT by ANCHOR-LEFT in Tableau (84) suffices to demonstrate that PARSE M would also have to dominate ANCHOR-LEFT, since ANCHOR-LEFT would yield the same violation and satisfaction patterns as TONE-LEFT.

Tableau (94a): PARSE M » LGV/SMT

| Input: (H) + CMM | Status | PARSE H | PARSE M | LGV/SMT |
|---|---|---|---|---|
| a. CHM |  | √ | √ | *! |
| b. CHH | † | √ | *! | √ |

Tableau (94b): LGV/SMT » PARSE M

| Input: (H) + CMM | Status | PARSE H | LGV/SMT | PARSE M |
|---|---|---|---|---|
| a. CHM | † | √ | *! | √ |
| b. CHH |  | √ | √ | * |

However, it can be independently established that LGV/SMT must be dominated by PARSE L. Consider the case in (95) and the accompanying Tableau (96).

(95) (H) + HL —› HL, *HH

Tableau (96): PARSE L » LGV/SMT

| Input: (H) + CHL | Status | PARSE H | PARSE L | LGV/SMT |
|---|---|---|---|---|
| a. CHL |  | √ | √ | * |
| b. CHH | † | √ | *! | √ |

Since PARSE M must dominate PARSE L (see Tableau (83) above), by transitivity, PARSE M must also dominate LGV/SMT. Therefore LGV/SMT cannot be allowed to optionally dominate PARSE M, leaving no account for output (92b) (see Tableau (94b) above).

The PARSE M alternative analysis thus leads to a ranking paradox concerning the constraints PARSE M and LGV/SMT and the account of the restricted optional level tone on long vowels.

The second problem regarding the PARSE M alternative analysis concerns the account of the anti-transparency effect of medial glottal stops. Recall that in the analysis where mid-tone vowels are assumed to be toneless, TONE-LEFT was crucial in the account of cases such as (97), in which medial glottal stops thwart the transparency of mid-tone vowels (see Tableaux (61) and (63) above).

(97) (H) + CMʔL —› CHʔL, *CMʔH

The reason TONE-LEFT could play an explanatory role was that mid-tone vowels were considered toneless. If they are assumed to be toned, then the left-alignment requirement on the anchoring of floating high tones is no longer available as an explanation. Instead, some constraint or set of constraints must be assumed to act against /ʔH/ as a sequence.

As shown in Tableau (98), */ʔH/ (a shorthand notation for the demand against /ʔH/) must be ranked higher than PARSE M.

Tableau (98): */ʔH/ » PARSE M

| Input: (H) + CMʔL | Status | */ʔH/ | PARSE M |
|---|---|---|---|
| a. CHʔL |  | √ | * |
| b. CMʔH | † | *! | √ |

A third candidate, namely CMʔL, would satisfy both /ʔH/ and PARSE M, but violate PARSE H. As shown in Tableau (99), the already established ranking PARSE H » PARSE M (see Tableau (86) above) suffices here to exclude this candidate (with */ʔH/ and PARSE H remaining unranked with respect to each other).

Tableau (99)

| Input: (H) + CMʔL | Status | */ʔH/ | PARSE H | PARSE M |
|---|---|---|---|---|
| a. CHʔL |  | √ | √ | * |
| b. CMʔH | † | *! | √ | √ |
| c. CMʔL | † | √ | *! | √ |

The case of the Mixteco word ʔuʔùn 'five' given in (100) (repeated from (64) above; see also note 31 above) shows that PARSE H must in fact dominate /ʔH/ in order to rule out the candidate where the high tone is not parsed, as illustrated by the accompanying Tableau (101).

(100) (H) + ʔuʔùn —› ʔúʔùn

Tableau (101): PARSE H » */ʔH/

| Input: (H) + ʔuʔùn | Status | PARSE H | */ʔH/ | PARSE M |
|---|---|---|---|---|
| a. ʔúʔùn |  | √ | * | * |
| b. ʔuʔùn | † | *! | √ | √ |

But more interesting is the candidate where the floating high tone has been parsed on the second vowel, which appears as candidate (b) in Tableau (102) below. This ungrammatical candidate, which ties the grammatical candidate on line (a) on both PARSE H and */ʔH/, incorrectly emerges as the optimal output (hence the asterisks preceding the status symbols † and ), as the decision-making is passed on to the next constraint in line, namely PARSE M.

Tableau ( 102): Optimal candidate ≠ grammatical candidate

| Input: (H) + ʔuʔùn | Status | PARSE H | */ʔH/ | PARSE M |
|---|---|---|---|---|
| a. ʔúʔùn | *† | √ | * | *! |
| b. ʔuʔún | * | √ | * | √ |

In the analysis in Section 4, the interesting case illustrated by <u>ʔuʔùn</u> was resolved as shown in Tableau (103) (repeated from Tableau (65) above).

Tableau (103): Single vs. double violations for TONE-LEFT

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

Candidate (b) in this tableau is correctly eliminated because it incurs a double TONE-LEFT violation (the high tone being two elements away from perfect left alignment), compared to the single TONE-LEFT violation incurred by the grammatical candidate on line (a) (the high tone being just one element away from perfect left alignment).

In sum, the PARSE M analysis can be faulted into descriptive inadequacy for having to view the special interaction of floating high tones and glottal stops as involving a sequential restriction (of uncertain universal plausibility) rather than an alignment question. In contrast, by relying on the phonological tonelessness of mid-tone vowels, the alignment analysis of Section 4 can make the appropriate selection among candidates, based on relative distance to perfect tonal leftmostness.

Regarding the *<u>MH</u> constraint, which is needed as an active participant in the Constraint Hierarchy of both OT analyses, we saw in Section 4.2.8 above why a language could exclude such a tonal pattern, and no other, on long vowels, but the explanation relied crucially on mid-tone vowels being phonologically toneless. Basically, MH represents the least harmonic tonal pattern possible on a long vowel, by including no tone in a strong position and a strong tone in a weak position. This kind of account could carry over to the PARSE M approach if it could be demonstrated that M is the weakest of all three tones. However, although the required ranking PARSE H » PARSE M (see Tableau (86) above) can be taken as an indication that M is weaker than H, the other required ranking PARSE M » PARSE L (see Tableau (83) above) would seem to suggest that M is stronger than L. One would therefore expect that if MH is blocked on long vowels, then LH should also not occur. But the two cases in (104) show that the LH pattern is attested over long vowels, although admittedly extremely rarely.[59]

| | | |
|---|---|---|
| (104) | kWàán | 'yellow' |
| | pàáN | (onomatopeia) |

It is worth observing that under the harmony scale suggested in Section 4 (see note 33 above), LH is the second worse pattern possible over long vowels. The absence of <u>MH</u> and the extreme rarity of <u>LH</u> are thus expected under an analysis assuming that Mixteco's mid-tone vowels are phonologically toneless, but constitute a reversal of predictions under the PARSE M approach.

To summarize, the PARSE M option, by abandoning the idea that Mixteco's mid-tone vowels are phonologically toneless, produces a constraint ranking paradox in the account of the restricted optional occurrence of level tones on long vowels, an inaccurate treatment of the interaction between floating high tones and glottal stops, and an inadequate account of the MH ban on C<u>VV</u>

[59] The two words given in (104) are the only examples I could find in all of Pike's publications listed in the references (see Tranel 1995d, note 15).

words. By contrast, all three phenomena are straightforwardly explained under the tonelessness hypothesis of the analysis in Section 4.

### 5.2.3. TPFAITH and Tonal Prominence

The constraint TPFAITH is defined in relation to the notion of tonal prominence, i.e. the distinction between lexically toned and toneless TBU's. What TPFAITH does is regulate the tonal attraction exerted by TBU's as a function of their tonal prominence. Basically, TPFAITH attracts tones to already toned vowels, as opposed to toneless vowels, thereby preserving the prominence profiles of morphemes. TPFAITH could thus be seen as a faithfulness constraint operating at the level of the abstract tonal tier dominating tonal specifications. If on the right track, the toneless vs. toned distinction required for the expression of TPFAITH provides interesting independent motivation for the existence of an abstract tonal node dominating (the features of) H and L and contrasting with the absence of such a tonal node for toneless TBU's (cf. Odden 1995: 453; Yip 1995: 478-479).

TPFAITH might also be viewed as part of a general pattern whereby strong positions are preferentially selected as hosts of a particular linguistic marker (cf. Prince & Smolensky 1993 and Section 4.2.8. above). Thus, from a tonal perspective, a toned vowel in a given morpheme constitutes a preferential host compared to a toneless vowel.

While preserving toned vs. toneless distinctions and respecting the power of attraction of strong positions, the enforcement of TPFAITH has the drawback of eliminating or merging tones. Thus, in Mixteco, as illustrated again in (105), the linking of a floating high tone past a toneless vowel and onto a subsequent toned vowel in effect eliminates a low tone or merges two high tones.

(105) a. (H) + CMCL —› CMCH (elimination of a low tone)

b. (H) + CMCH —› CMCH (merging of two high tones)

TPFAITH thus conflicts with tonal preservation, which is potentially enforced by the PARSE T constraints (PARSE H and PARSE L). From the perspective of tonal preservation, the situation in (106) would be preferable to that in (105).[60]

(106) a. (H) + CMCL —› CHCL (low tone is preserved)

b. (H) + CMCH —› CHCH (high tones on distinct vowels)

This outcome can be enforced to the detriment of TPFAITH, on a language-specific basis, by ranking all PARSE T constraints above TPFAITH, which thus basically becomes an inactive constraint.

### 5.2.4. Coalescence, Containment, Correspondence

The effect of a floating high tone on a following morpheme may have no detectable phonetic correlate. This situation happens with morphemes containing lexically anchored high tones in positions that correspond to the expected landing sites for the floating high tones. These cases, as they occur in CVCV words, are listed exhaustively in (107).

(107) a. (H) + CMCH —› CMCH

b. (H) + CHCM —› CHCM

c. (H) + CHCL —› CHCL

d. (H) + CHCH —› CHCH

The general question here is how to interpret the single high tone found in the outputs with respect to the parsing of the input's two high tones (the floating high tone and the lexically anchored high tone). One possibility is to consider that the output's high tone satisfies the realization of both input high tones. In other words, the output's high tone has a double morphological affiliation. As a result, the outputs in question incur no PARSE H violation. This option, labelled here 'coalescence', was the tack taken in the analysis presented above in Section 4 (see Section 4.1.5 in particular). The other possibility, labelled by contrast 'no coalescence', is to

[60] The outcome in (106) is the one predicted by the so-called UAC automatically associating a free tone to a free TBU.

consider that the output's high tone represents only one of the two high tones in the input, the other one failing to be parsed. Under this interpretation, the outputs in question incur a PARSE H violation.

As pointed out independently by Sakai 1994 and Russell 1995, coalescence has not been allowed as a possible GEN operation in standard OT practice.[61] The ban is due to the fact that coalescence violates two of the main principles regulating GEN, Containment and Consistency of Exponence (McCarthy & Prince 1993a,b). Containment states that "No element may be literally removed from the input form", and Consistency of Exponence states that "No changes in the exponence of a phonologically specified morpheme are permitted". In our tonal case, under coalescence, one high tone present in the input is missing in the candidate (a Containment violation) and the remaining high tone has two morphological affiliations (an apparent problem vis-à-vis Consistency of Exponence). By contrast, under Containment, there can be no coalescence, in the sense that for our examples in (107), there can be no candidate with a single high tone: the two high tones present in the input are also present in all the possible candidates. In each grammatical candidate in (107), only one of them is parsed, as the representative of either the floating high tone or the lexically anchored high tone of the input (Consistency of Exponence is thus definitely obeyed).

Coalescence allows a straightforward account of the cases in (107), as shown in the four tableaux grouped in (108).[62]

[61] See in particular McCarthy & Prince's 1993b treatment of Axininca Campa's epenthesis across heteromorphemic consonants such as /m/ and /p/, as discussed in Russell 1995.

[62] In considering these tableaux, recall from Section 4.1.5 above that all forms of the type CHCH are assumed to obey the OCP, thus that they contain a single doubly linked high tone. As a result, CHCH candidates violate ANCHOR-LEFT whenever their high tone includes a morphological interpretation as the floating high tone of the input.

Tableau (108) (Assumption: coalescence is allowed by the theory)

| A. (H) + CMCH | | PARSE H | TONE-LEFT | TPFAITH | PARSE L | ANCHOR-LEFT |
|---|---|---|---|---|---|---|
| a. CMCH | ☞ | √ | √ | √ | √ | * |
| b. <H>  CMCH | † | *! | √ | √ | √ | √ |
| c. CMCH <H> | † | *! | √ | √ | √ | * |
| d. CHCH | † | √ | √ | *! | √ | * |
| B. (H) + CHCM | | PARSE H | TONE-LEFT | TPFAITH | PARSE L | ANCHOR-LEFT |
| a. CHCM | ☞ | √ | √ | √ | √ | √ |
| b. <H> CHCM | † | *! | √ | √ | √ | √ |
| c. CHCM <H> | † | *! | √ | √ | √ | √ |
| d. CHCH | † | √ | √ | *! | √ | * |
| C. (H) + CHCL | | PARSE H | TONE-LEFT | TPFAITH | PARSE L | ANCHOR-LEFT |
| a. CHCL | ☞ | √ | √ | √ | √ | √ |
| b. <H> CHCL | † | *! | √ | √ | √ | √ |
| c. CHC<H>L | † | *! | √ | √ | √ | √ |
| d. CHCH <L> | † | √ | √ | √ | *! | * |
| D. (H) + CHCH | | PARSE H | TONE-LEFT | TPFAITH | PARSE L | ANCHOR-LEFT |
| a. CHCH | ☞ | √ | √ | √ | √ | * |
| b. <H> CHCH | † | *! | √ | √ | √ | √ |
| c. CHCH <H> | † | *! | √ | √ | √ | * |

In these four tableaux, each candidate on line (a) is the optimal candidate, as desired. In each case, PARSE H is satisfied, because the high tones are interpreted as having a double morphological affiliation, one for the floating high tone and another for the lexically anchored high tone found in the inputs. These candidates contrast with those on lines (b) and (c), where the high tones are interpreted as having a single morphological affiliation, and which therefore incur a PARSE H violation.[63] In the first three tableaux in (108), a fourth candidate is shown on line (d), which ties the candidates on line (a) with respect to PARSE H and TONE-LEFT, but which is eliminated by a lower-ranked constraint (TPFAITH in Tableaux A-B and PARSE L in Tableau C).

In a theory where coalesced candidates are ruled out by GEN, the optimal candidates in the tableaux in (108) - the ones on line (a) - are not possible candidates. For Tableaux A-B-C, the candidates on either line (b) or line (c), whose phonetic forms are of the appropriate shape, must come out as optimal. For Tableau D, an alternative interpretation of the candidate on line (a) is necessary. In the latter case, what is required is an analysis where this candidate violates the OCP and where the first H corresponds to the input's floating high tone and the second H corresponds to the input's lexically anchored high tone. PARSE H must thus dominate the OCP, as illustrated in Tableau (109).[64] (For ease of interpretation, the floating high tone and the lexically anchored high tone are indexed as H1 and H2, respectively).

[63] For all candidates on line (b), PARSE H is violated because the input's floating high tone has not been interpreted. For all candidates on line (c), PARSE H is violated because the input's lexically anchored high tone has not been interpreted. For the sake of clarity in the tableaux, the candidates's uninterpreted high tones are shown within angled brackets as unparsed.

[64] In accordance with CHAP (see Section 4.3 above), Tableau (109) shows the OCP in its highest possible position in the Constraint Hierarchy: PARSE H is its upper bound. In the analysis in Section 4, the OCP is by contrast an undominated constraint in Mixteco, or possibly even part of GEN (see Section 4.2.9 above). Obviously, the OCP could not be part of GEN under the Containment-based analysis explored in the present section, since it is dominated.

Tableau (109): PARSE H » OCP (cf. Tableau D in (108) above)

| (H1) + CH2CH2 | | PARSE H | OCP | TONE-LEFT | TPFAITH | PARSE L | ANCHOR-LEFT |
|---|---|---|---|---|---|---|---|
| a. CH1CH2 | ☞ | √ | * | √ | √ | √ | * |
| b. <H1> CH2CH2 | † | *! | √ | √ | √ | √ | √ |
| c. CH1CH1 <H2> | † | *! | √ | √ | √ | √ | * |

Coming back to the Tableaux A-B-C in (108) above, the candidates on line (d) must somehow be ruled out in favor of the ones on line (b) or line (c). A constraint ranked higher than PARSE H, and satisfied by the (b) or (c) candidates but violated by the (d) candidates, would achieve this result. Observe that in Tableaux B and C, the input's lexically anchored high tone is not parsed in situ in the (d) candidates (otherwise, these candidates would violate TONE-LEFT). Therefore, a faifulness constraint (say, F/ACORR for Feature/Anchor CORRespondence) demanding in general that parsed features in candidates be matched with their lexical anchors could have the desired effect. Applied to tones as T/ACORR, this constraint would in effect prohibit the 'movement' of a lexically anchored tone to another TBU, if it were ranked sufficiently high.[65] In Mixteco, T/ACORR would have to be ranked above PARSE H, as shown in Tableaux (110) and (111).[66]

[65] Note that floating features would not violate this constraint when parsed, since by definition floating features don't have a lexical anchor.

[66] By contrast, T/ACORR would have to be ranked lower than the PARSE T constraints in languages exhibiting tonal stability and pushing delinked tones down the string of TBU's. More precisely, the possible interleafings of T/ACORR among the various PARSE T constraints would predict cross-linguistic differences in terms of which tones exhibit stability.

Note that the existence of T/ACORR would not eliminate the need for TPFAITH. As already observed (see note 65 above), T/ACORR would only be relevant to lexically anchored tones, when parsed and at their most specific level of featural distinctions (e.g. H vs. L). By contrast, TPFAITH is concerned with the abstract tonal tier of any anchored tone, whatever its source (lexically free tones, such as Mixteco's floating high tones, delinked lexical tones such as Mixteco's low tones displaced by the docking of a floating high tone, or any other tone freely generated by GEN). T/ACORR and TPFAITH would additionally need to occupy different rankings in Mixteco's Constraint Hierarchy (in particular, T/ACORR » PARSE H » TPFAITH).

Tableau (110): T/ACORR » PARSE H (Case #1) (cf. Tableau B in (108) above)

| (H1) + CH2CM | | T/ACORR | PARSE H | OCP | TONE-LEFT | TPFAITH | PARSE L | ANCHOR-LEFT |
|---|---|---|---|---|---|---|---|---|
| a. <H1> CH2CM | ☞ | √ | * | √ | √ | √ | √ | √ |
| b. CH1CM <H2> | ☞ | √ | * | √ | √ | √ | √ | √ |
| c. CH1CH2 | † | *! | √ | * | √ | * | √ | √ |

Tableau (111): T/ACORR » PARSE H (Case #2) (cf. Tableau C in (108) above)

| (H1) + CH2CL | | T/ACORR | PARSE H | OCP | TONE-LEFT | TPFAITH | PARSE L | ANCHOR-LEFT |
|---|---|---|---|---|---|---|---|---|
| a. <H1> CH2CL | ☞ | √ | * | √ | √ | √ | √ | √ |
| b. CH1<H2>CL | ☞ | √ | * | √ | √ | √ | √ | √ |
| c. CH1CH2 <L> | † | *! | √ | * | √ | √ | * | √ |

These two tableaux do not reach a decision between the candidates on lines (a) and (b), since they tie on all the constraints. But the main point here is that in each case, either candidate delivers the correct phonetic output.[67]

The case given in Tableau A in (108) above presents a more serious challenge for the Containment-based analysis, because as shown in Tableau (112), a candidate such as CH1CH2 on line (c) remains better than either candidate on line (a) or (b), since it would satisfy both T/ACORR and PARSE H. It would of course violate the OCP, but the ranking OCP » PARSE H cannot be used to rule it out, since we saw earlier that the reverse ranking is otherwise required (see Tableau (109) above).

[67] As things stand, the grammar delivers an ambiguity as to which lexical tone is represented in the phonetic output. The issue here is whether this ambiguity is psychologically real or whether native speakers know which lexical high tone the surface high tone stands for (in which case an additional constraint not contemplated here would be required to separate out the two competing candidates. For example, if native speakers viewed the surface high tone as standing for the floating high tone rather than the lexically anchored tone, it might be plausibly suggested that this interpretation is governed by a constraint disfavoring the complete surface elimination of an underlying morpheme). Note that the coalescence analysis of Section 4 makes an altogether different claim here, namely that the two lexical high tones are represented by the single surface high tone.

Tableau (112): Problematic case for Containment-based analysis (cf. Tableau A in (108) above)

| (H1) + CMCH2 | | T/ACORR | PARSE H | OCP | TONE-LEFT | TPFAITH | PARSE L | ANCHOR-LEFT |
|---|---|---|---|---|---|---|---|---|
| a. <H1> CMCH2 | *† | √ | *! | √ | √ | √ | √ | √ |
| b. CMCH1 <H2> | *† | √ | *! | √ | √ | √ | √ | √ |
| c. CH1CH2 | *☞ | √ | √ | * | √ | * | √ | √ |

In sum, under the no-coalescence alternative enforced by Containment, a constraint-ranking paradox appears to arise with respect to the account of forms where a floating high tone has no phonetically detectable consequences on a following morpheme because this morpheme contains a lexically anchored high tone whose position coincides with the floating high tone's expected landing site.

Containment has recently been abandoned by the main proponents of OT (McCarthy & Prince 1994).[68] Its replacement, the Theory of Correspondence, seems able to accommodate coalescence (i.e. multiple morphological affiliations) through multiple indexing, without raising a problem vis-à-vis Consistency of Exponence, since morphological affiliations would be preserved by the indices and thus not altered by GEN. Under this new perspective, all cases under consideration can be analyzed as they are in (108) above under the coalescence hypothesis. Specifically, all the optimal candidates on line (a), including in the problematic case for Containment in Tableau A (see Tableau (112) above), are now possible candidates with the interpretation that their high tone is indexed for both the floating high tone and the lexically anchored tone of the input. In essence, the abandonment of Containment and its replacement with the Theory of Correspondence can be seen as allowing coalescence, a welcome result for the treatment of Mixteco's floating high tones.

[68] See also Orgun 1995 and several 'Containment' postings on the Optimality List Network in July 1994, in particular by Orhan Orgun (July 5) and Alan Prince (July 20), among others.

5.3. General remarks on tonal phonology and morphology

This section highlights very briefly a few of the general points established, reinforced, or simply hypothesized in the course of our discussion on Mixteco's floating high tones, and which seem to go beyond any particular theoretical viewpoint.

From this broad perspective, one important result is confirmation of the idea that tone languages do not have phonological tone on all potential TBU's. Tone languages may thus exhibit not only tonal contrasts (e.g. H vs. L), but also a contrast between toned and toneless TBU's. In Mixteco, phonetically mid-tone vowels are linguistically toneless, their phonetic tone resulting from the mere physiological fact that voiced vowels must be produced with a tone.

Another important outcome is the clear exemplification of the fact that languages may have portions of morphemes that cannot be realized phonetically within the confines of their own lexical affiliations, but rather on a morphologically alien host. Thus, in Mixteco, floating high tones exist as part of certain morphemes (cf. kee (H) 'to eat' vs. kee 'to go away'), but must for their phonetic realization depend on the presence of a following morpheme, with which they act as prefixes. This behavior seems to parallel the case of liaison consonants in French, which are final segments in their lexical affiliations, but must function as phonological prefixes in order to be phonetically realized and thus require a following host.[69]

The behavior of Mixteco's floating high tones also aligns with several related tendencies or intuitions regarding connections between tones, in particular that tones may be ranked on a strength scale (H > L > no tone) and that they may accordingly have a predilection for different sites (heads vs. dependents). Finally, the interaction between Mixteco's floating high tones and glottal stops feeds the general issue of the relationship between tones, glottal consonants, and voicing.

[69] I ignore here the special case of 'liaison sans enchaînement' (see for example Encrevé 1988, Tranel 1995c).

## 6. Conclusion

On both descriptive and explanatory grounds, OT allows an account of Mixteco's floating high tones that is superior to the treatment possible in a rule-based framework. The fundamental differences between the two analyses ultimately boil down to OT's innovative central concepts of conflicting universal constraints and of resolution through constraint violability.

The Mixteco data also raise interesting theoretical issues within OT, in particular with regard to tier-dependent alignment, tonal unspecification, and coalescence.

Finally, from a broader perspective, this paper's detailed investigation has revealed an interesting combination of factors presiding over the "perturbations" caused by the anchoring of floating elements.

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