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# *Stress assignment in Tohono O'odham**

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## 1 Introduction

The proper treatment of NON-DERIVED ENVIRONMENT BLOCKING (NDEB), also known as the Derived Environment Constraint, has long been the subject of debate by phonologists. Past approaches include the Strict Cycle Condition (Mascaró 1976), the Elsewhere Condition (Kiparsky 1982) and underspecification (Kiparsky 1993). However, since the introduction of Optimality Theory (McCarthy & Prince 1993, 1994, Prince & Smolensky 1993), phonologists have tried to model NDEB in terms of parameterised constraints (e.g. Burzio 1997) or constraint conjunction (e.g. Łubowicz 1998).

In this paper I present a case of NDEB found in the stress patterns of Tohono O'odham words. Secondary stress is assigned to all odd-numbered syllables in derived words, but is blocked on word-final odd-numbered syllables in underived words. I claim that all the presented facts about Tohono O'odham stress can be accounted for in terms of co-phonologies (cf. Orgun 1996, Inkelas *et al*. 1997, Inkelas 1998). By showing the intricate interaction between, on the one hand, stress assignment to latent vowels and, on the other, their behaviour with respect to perfective truncation, I argue that Tohono O'odham stress can be viewed as being assigned 'cyclically' and also as exhibiting the effect of bracket erasure. These facts, as I will show, are captured naturally by the co-phonology model. This co-phonology analysis is contrasted with the

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mono-stratal, non-constituency-based optimality-theoretic account argued for in Fitzgerald (1996, 1997). It is demonstrated that the co-phonology analysis yields a simpler and more explanatory account of the Tohono O'odham facts than Fitzgerald's account.

I begin this paper with an illustration of the stress patterns of both underived and derived forms in §2. I will then provide a co-phonology account for NDEB in §3. An alternative analysis is considered in §3.5. In §4 I illustrate the interaction between stress, latent vowels and perfective truncation, and finally the formal analysis is presented in §5.

## 2 Tohono O'odham stress assignment: some basics

Tohono O'odham (henceforth TO) is a Uto-Aztecan language spoken primarily in southern Arizona and Sonora, Mexico. All the data presented in this paper are drawn directly from Fitzgerald (1996, 1997).

### 2.1 Stress assignment in underived forms

Primary stress in TO always falls on the initial syllable, regardless of whether the form is derived or underived.[1] The distribution of stress in underived forms is shown in (1). No secondary stress is assigned to disyllabic and trisyllabic underived words (1b, c), but secondary stresses are assigned to the odd-numbered syllables of polysyllabic words as long as the syllable is non-final (1d). Note that monomorphemic native TO words are rarely larger than two syllables. The words in (1c, d) are borrowings from Spanish.

| | | | | |
|---|---|---|---|---|
| (1) | a. | σ́ | kíː | 'house' |
| | | | tóːn | 'knee' |
| | b. | σ́σ | píː.ba | 'pipe' |
| | | | hái.waɲ | 'cow' |
| | c. | σ́σσ | ʔá.su.gal | 'sugar' |
| | | | sí.min.ǰul | 'cemetery' |
| | d. | σ́σσ̀σ | pí.miàn.do | 'pepper' |
| | | | pá.ko.ʔò.la | 'Pascola dancer' |

### 2.2 Stress assignment in derived forms

As I mentioned above, primary stress in derived words is always on the first syllable. However, unlike underived forms, secondary stress is allowed in word-final odd-numbered syllables in derived forms. A list of morphologically complex words in TO is shown in (2). The above-mentioned stress pattern stays the same regardless of the morphological

[1] There is also a class of Spanish loans with non-initial primary stress. I assume that these forms have lexical stress and I will have nothing to say about them in this paper.

bracketing, meaning, for example, that primary stress is always on the first syllable, regardless of whether the first syllable is part of the root (2a) or part of the reduplicative prefix (2b). Secondary stresses consistently fall on odd-numbered syllables (2b, c) even in word final-position (as opposed to (1c)). The fact that secondary stress assignment on the word-final odd-numbered syllable is blocked in the underived forms can be seen as a case of NDEB.

| | | | | |
|---|---|---|---|---|
| (2) | a. | $\sigma$ + suffix | hím-ad<br>walking-FUT IMPERF | 'will be walking' |
| | | $\sigma\sigma$ + suffix | číkpan-dàm<br>work-one who | 'worker' |
| | | $\sigma\sigma\sigma$ + suffix | máːginà-kam<br>car-one with | 'one with a car' |
| | | $\sigma\sigma\sigma\sigma$ + suffix | pímiàndo-màd<br>pepper-adding | 'adding pepper' |
| | b. | RED + $\sigma$ | tó-toɲ<br>PL-ants | 'ants' |
| | | RED + $\sigma\sigma$ | pí-pibà<br>PL-pipe | 'pipes' |
| | | RED + $\sigma\sigma\sigma$ | pá-pkoʔòla<br>PL-Pascola dancers | 'Pascola dancers' |
| | c. | RED + $\sigma$ + suffix | hí-him-àd<br>PL-walk-FUT IMPERF | 'will be walking (PL)' |
| | | RED + $\sigma\sigma$ + suffix | hí-hidòḍ-a<br>PL-cooking-nominal | 'the cooking (PL)' |
| | | RED + $\sigma\sigma\sigma$ + suffix | há-haiwàɲ-ga-kàm<br>PL-cow-possession-one who | 'ones having cattle' |

To summarise the TO stress system presented so far, primary stress in derived words is always on the first syllable. Secondary stresses are assigned to the odd-numbered syllables of polysyllabic words. There is no secondary stress on the word-final odd-numbered syllable in underived forms. Secondary stress is allowed on word-final odd-numbered syllables in derived forms.

### 2.3 Lexical Phonology

NDEB is traditionally handled in Lexical Phonology in terms of the Strict Cycle Condition (e.g. Kiparsky 1982). The Strict Cycle Condition states that cyclic rules apply only to derived representations. In a standard Lexical Phonology (Kiparsky 1982) analysis of the interleaving between the morphology and phonology, a form is required to undergo the phonologies of all levels, regardless of whether the morphology of a particular level is applied to the form or not. The Strict Cycle Condition is therefore responsible for the blocking of the phonologies being applied at some particular levels to non-derived forms. Earlier works on the

NDEB effects involve structure-changing rules, such as stress deletion (e.g. Mascaró 1976, Kiparsky 1982) or structure-filling rules (cf. Kiparsky 1993). However, traditional Lexical Phonology approaches to NDEB are not applicable to the case here. For the purpose of illustration, I assume that there exist two levels in TO, 1 and 2, for the root and affixation levels, respectively. This line of treatment can correctly predict the final output form of a morphologically complex word (3).

(3) *The derivation of a bimorphemic word* /ʔasugal + t/ 'to make sugar'

| | | |
|---|---|---|
| *input* | /ʔasugal + t/ | |
| *level 1* | ʔasugal | → ʔásugal |
| *level 2* | ʔásugal + t | → ʔásugàlt |
| *output* | ʔásugàlt | |

In (3), the root /ʔasugal/ of /ʔasugal + t/ is assigned a primary stress by the level 1 phonology. It then feeds into level 2, where /-t/ is suffixed and the level 2 phonology applies. As a result, the derivation correctly generates an output form with stress on all odd-numbered syllable positions. This analysis, however, fails in the derivation of the output form of the monomorphemic words. This is illustrated in (4).

(4) *The derivation of a monomorphemic word* /ʔasugal/ 'to make sugar'

| | | |
|---|---|---|
| *input* | ʔasugal/ | |
| *level 1* | ʔásugal | → ʔásugal |
| *level 2* | ʔásugal | → ʔásugàl |
| *output* | *ʔásugàl | |

The input form /ʔasugal/ correctly receives a primary stress in the level 1 phonology. Even though no morphology is required for this monomorphemic word, it is nonetheless forced by the theory to enter level 2 and undergo the level 2 phonology. Consequently, an unattested output is generated because a secondary stress is assigned.

One could stipulate that the level 1 co-phonology assigned ternary feet, thus blocking the binary feet assignment at level 2, since level 2 phonology is stress-preserving. However, this will fail to derive the correct stress pattern in the polymorphemic forms since the ternary foot assigned in level 1 must be preserved, thus preventing secondary stress assignment in trisyllabic words, e.g. /ʔasugal + t/, or forcing the secondary stress to land on the fourth syllable in polysyllabic forms.

## 3 Analysis

In this section, I will provide a formal account for the data presented so far. But before turning to the analysis, I first provide the necessary theoretical background for understanding the theory developed below.

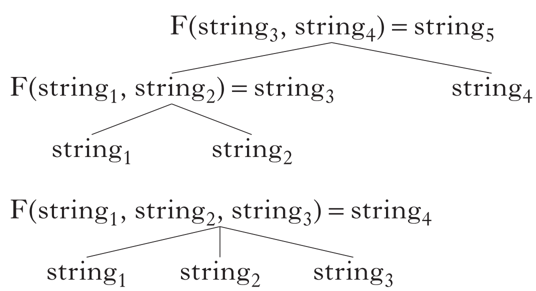
### 3.1 Sign-based Morphology and co-phonologies

The theoretical framework I will be adopting for the analysis of the NDEB effect is Sign-based Morphology, developed by Orgun (1996, 1997, 1998). It is a declarative, non-derivational theory of the morphology–phonology interface which utilises the basic tools one finds in any constituent structure-based unificational approach to linguistics (e.g. Construction Grammar (Fillmore & Kay 1994) and HPSG (Pollard & Sag 1994)). It assumes that both terminal and non-terminal nodes bear features and that non-terminal nodes also include phonological information along with the usual syntactic and semantic information.

Following Orgun (1996), Inkelas *et al*. (1997) and Inkelas (1998), I will assume that each morphological construction – inflectional affixation, derivation and so on – can have its own associated phonology, which will be called a co-phonology. Co-phonologies are then the phonological functions that relate the daughter node to the mother node. In the Lexical Phonology approach to linguistics, co-phonologies are the phonological functions associated with each morphological level. Similarly, co-phonologies are used in Sign-based Morphology to encode all cases of morpheme- or construction-specific phonology.

An important corollary in assuming a Sign-based Morphology approach to linguistics is the theory's ability to model the cyclic application of phonology triggered by affixations declaratively. Unlike cyclicity in Lexical Phonology, where each morphological operation triggers the application of the phonology of the associated level, cyclicity and non-cyclicity of phonological processes in Sign-based Morphology can be derived by assuming that the constituent structure can be branching (5a) or flat (5b). Crucially, Sign-based Morphology derives this without invoking the traditional serial interpretation of phonological evaluation, due to the intrinsic declarative unificational architecture of the theory.

(5) a. / b.




Another corollary to Sign-based Morphology is that the theory also readily derives the Bracket Erasure effect (Orgun 1997). Since each morphological construction is assigned a co-phonology in Sign-based Morphology, the internal make-up of the daughters participating in the construction is therefore not accessible to the co-phonology of the mother node.

In what follows, I will show that the NDEB in TO described above can insightfully be handled by a Sign-based Morphology style of co-phonology. Following that, I will present evidence of cyclic stress assignment and the bracket erasure effect in TO. I will show that these phenomena fall out naturally from the co-phonology analysis as conceived in Sign-based Morphology.

### 3.2 Co-phonologies in TO

To capture the generalisations and the NDEB I propose that there are two co-phonologies: a root-specific phonology $\varphi_{root}$ and an affixation-specific phonology $\varphi_{affix}$. The schematic representation of the interaction between the morphology and phonology is illustrated in (6). The forms within the parentheses on the left of '=' are the input to the phonological function. The forms on the right of '=' are the output of the phonological evaluation.

(6) *Evaluation of a bimorphemic word* $\varphi_{affix}$(ʔasugal, t) 'to make sugar'

$\varphi_{affix}$(ʔásugal, t) = [ʔásugàlt]

$\varphi_{root}$(ʔasugal) = [ʔásugal]

ʔasugal t

The stem /ʔasugal/ is subjected to the $\varphi_{root}$ co-phonology. Word-initial stress is assigned. The $\varphi_{affix}$ co-phonology will evaluate the output of the $\varphi_{root}$ co-phonology and the suffix /-t/. Crucially, however, the stem /ʔasugal/ is also a well-formed word by itself, thus /ʔasugal/ will only be subjected to the $\varphi_{root}$ co-phonology (7).

(7) *Co-phonology evaluation of a monomorphemic word* /ʔasugal/ 'sugar'

$\varphi_{root}$(ʔasugal) = [ʔásugal]

/ʔasugal/

This analysis hinges on the intuition captured by the Level Economy analysis proposed in Inkelas & Orgun (1995). Level Economy proposes that not all forms are subjected to the phonology of all levels. Thus the phonology associated with a particular level is applied only when a form undergoes a morphological operation at that level. NDEB can be accounted for naturally within this architecture since the non-derived forms are not required to undergo the phonologies that are associated with levels where morphological operations take place.

The phonology will be treated here in terms of constraints developed in Optimality Theory (Prince & Smolensky 1993, McCarthy & Prince 1993, 1994). The constraints are summarised in (8).

(8) a. FtForm (FtFm)
Heads are on the left edge of the foot.

b. Parse-σ
Syllables must be parsed into feet.

c. *Clash
Adjacent stresses are not permitted.

d. Align-Ft-L (Align)
The left edge of every foot must coincide with the left edge of some prosodic word.

e. FootBinarity (FtBin)
Feet are analysable as binary on the syllabic level.

f. Pros-Faith (P-Faith)
Every prominence in the input must have a correspondent in the output and *vice versa* (see McCarthy 1997, Zoll 1998, Alderete 1999a).

### 3.3 Analysis of underived words

An analysis of the underived word /ʔasugal/ 'sugar' is given in (9). Following the notation employed in Fitzgerald (1997), parentheses indicate feet, while morphemes are indicated by square brackets. Since there is no affixation, /ʔasugal/ only undergoes $\varphi_{root}$ phonology. The constraint hierarchy in (9) exemplifies the $\varphi_{root}$ phonology. It correctly predicts that (9a) wins because it incurs no FtBin violation. On the other hand, (9b), the most serious competing candidate with final secondary stress, and (9c), the candidate with a ternary foot, fatally violate FtBin. Other candidates (9d, e, f, g) fatally violate Align or FtForm, the two most crucially dominating constraints. Any candidate that bears stress will violate the P-Faith constraint since stress is not present in the input. Thus P-Faith must be dominated by Parse-σ in order to guarantee that stress be assigned in the output.

(9)

| $\varphi_{root}$(/ʔasugal/) | Align | FtFm | *Clash | FtBin | Parse-σ | P-Faith |
|---|---|---|---|---|---|---|
| ☞ a. [(ʔásu)gal] | | | | | * | * |
| b. [(ʔásu)(gàl)] | | | | *! | | ** |
| c. [(ʔásugal)] | | | | *! | | * |
| d. [ʔa(súgal)] | *! | | | | * | * |
| e. [ʔasu(gál)] | *! | | | * | ** | * |
| f. [ʔa(sugál)] | *! | * | | | * | * |
| g. [(ʔasú)(gàl)] | | *! | * | * | | ** |

It is important to note that the affixation-specific co-phonology is not invoked here at all, because there is no affixation to begin with (see (7) above). This is, as mentioned earlier, a case of Level Economy (cf. Inkelas

& Orgun 1995) – underived forms need not be subjected to the phonology of the derived forms.

### 3.4 Analysis of derived words

Recall that the main difference between the secondary stress assignment of derived and the underived forms is the assignment of final stress. This is easily accounted for by assuming that the $\varphi_{root}$ and $\varphi_{affix}$ phonologies differ crucially on the relative ranking of PARSE-$\sigma$ and FTBIN. This is exemplified in the two constraint rankings in (10).[2]

(10) *Ranking of the two co-phonologies* $\varphi_{root}$ *and* $\varphi_{affix}$

$\varphi_{root}$ ALIGN, FTFM, *CLASH ≫ **FTBIN** ≫ **PARSE-σ** ≫ P-FAITH
$\varphi_{affix}$ ALIGN, FTFM, *CLASH ≫ **PARSE-σ** ≫ **FTBIN** ≫ P-FAITH

To illustrate more concretely how the $\varphi_{affix}$ co-phonology assigns stress, let us look at an evaluation of a derived word in TO. The example considered here is the word /háhaiwàɲgakàm/ 'one owning cows'. The constituent structure of this word /RED, háiwaɲ, ga, kam/ 'PL-cow-owning-agent' is given in (11). Following Orgun (1996, 1998), who argues that morphological structures should be flat by default, I assume that, unless there is clear evidence to suggest otherwise, the morphological structure in TO is flat in general. The flat structure of (11) indicates that the affixation-specific co-phonology will only be evaluated once.

(11) $\varphi_{affix}$(RED, háiwaɲ, ga, kam) = [háhaiwàɲgakàm]

RED   $\varphi_{root}$(haiwaɲ) = [háiwaɲ]   ga   kam

haiwaɲ

The constraint evaluation of this form is given in (12). The inputs to the evaluation in tableau (12) consist of four morphemes: the plural reduplicative prefix RED, the possessive suffix /-ga/, agentive suffix /-kam/ and the stem /háiwaɲ/ 'cow'. Unlike the root-specific co-phonology, the PARSE constraint is crucially ranked above the FTBIN constraint in the affixation-specific co-phonology. This ranking allows the otherwise unparsed final syllable to be footed, which in turns allows the final odd-numbered syllable to be stressed in polymorphemic forms. It is important to note that the stem in (12) is /háiwaɲ/, which has initial stress assigned by the root-specific co-phonology. This evaluation crucially illustrates that the affixation-specific co-phonology is not stress-preserving. That is, since the affixation-specific co-phonology forces the stress to be on the initial syllable of a word due to the high ranking of the ALIGN constraint, as illustrated by the failing candidate (12f), the stress is now 're-assigned' to the syllable of the reduplicant, instead of the first syllable of the root (12a). The constraint P-FAITH is crucially ranked below all the other

[2] Motivation for the ranking of PARSE-$\sigma$ in (10) will be presented in §4.1.3.

constraints, preventing it from enforcing the stress-preservation requirement. Due to space restrictions, the P-FAITH constraint will not appear in the subsequent constraint evaluations related to stress-assignment since none of the co-phonologies in this paper is stress-preserving.[3]

(12)

| $\varphi_{affix}$(RED, háiwaɲ, ga, kam) | ALIGN | FTFM | *CLASH | PARSE-σ | FTBIN | P-FAITH |
|---|---|---|---|---|---|---|
| ☞ a. [(há][hai)(wàɲ][ga)][(kàm)] | | | | | * | **** |
| b. [(há][hai)(wàɲ][ga)][kam] | | | | *! | | *** |
| c. [(há)][(hàiwaɲ)][(gà][kam)] | | | *! | | * | ** |
| d. [(há)][(hàiwaɲ)][(gà)][(kàm)] | | | *! | | *** | *** |
| e. [(há)][(haiwàɲ)][(ga][kàm)] | | *!* | | | * | *** |
| f. [há][(háiwaɲ)][(gà][kam)] | *! | | | | * | *** |

In sum, simple and complex words are subjected to different co-phonologies. The two hierarchies capture the relation between the stress pattern of the monomorphemic and polymorphemic words, namely, they are only minimally different from each other. PARSE-σ and FTBIN are in the reverse ranking with respect to each other in the different co-phonologies. The affixation-specific co-phonology will only affect derived forms. Unaffixed root forms are intrinsically exempted from the $\varphi_{affix}$ phonology. The relative ranking of FTFM, *CLASH and ALIGN is not important as long as they crucially dominate PARSE-σ, FTBIN and P-FAITH.

### 3.5 Fitzgerald (1996, 1997)

In the previous section, I demonstrated how a constituent structure-based co-phonology analysis accounts for the bifurcation in the stress assignment in TO derived and underived words. In this section, I will consider an alternative analysis that attempts to account for the TO data monostratally, without reference to any co-phonology.

3.5.1 *The Morpheme-to-stress Principle*. Fitzgerald (1996, 1997) proposes a morpheme-based treatment in Optimality Theory in which she introduces the Morpheme-to-stress Principle to account for the stress pattern. The Morpheme-to-stress Principle is stated in (13).

(13) *Morpheme-to-stress Principle* (MSP) (Fitzgerald 1997: 120)
For every morpheme, there exists some stressed mora that falls in the domain of that morpheme.

(14) is a typical tableau using the MSP constraint. Since Fitzgerald collapses the stress patterns of the monomorphemic and polymorphic words into a single phonological mapping, she needs the MSP in order to

[3] Candidates parsed into ternary feet are not considered here, due to space restrictions. However, I am assuming that such candidates would be ruled out by an undominated no-unbounded-feet constraint.

rule out the most serious contender (14b). (14b) would have been the actual winner if it was a monomorphemic word. The MSP correctly rules out (14b) because the stem [paːdo] does not bear any stress.

(14)

| /RED, paːdo/ | FtFm | *Clash | Align | MSP | FtBin | Parse-σ |
|---|---|---|---|---|---|---|
| ☞ a. [(pá][pa)(dò)] | | | | | * | |
| b. [(pá][pa)do] | | | | *! | | * |
| c. [(pá)][(padò)] | *! | | | | * | |
| d. [(pá)][(pàdo)] | | *! | | | * | |
| e. [pa][(pádo)] | | | *! | * | | * |

3.5.2 *Problems with the MSP.* Whereas (14) shows the success of the MSP in some cases, there are quite a few problems with the principle, which I will consider here. The necessity of the MSP is cast into doubt by the existence of the single consonant suffix /-t/ (e.g. [ʔásugal] 'sugar' → [ʔásugàlt] 'to make sugar'). Since the domain of the added morpheme is a non-syllabic consonant, how could one account for word-final stress assignment in cases like this? To account for the final odd-syllable stress after the suffixation of the causative /-t/, Fitzgerald (1997) stipulates a percolation convention, which is claimed to be analogous to a similar convention proposed in Archangeli (1988) for extrametricality of a terminal rhyme element. This percolation convention allows an underlyingly stressed consonantal suffix, which constitutes a stressed mora, to percolate its stress to the syllable which this suffix is a part of, in order to rescue the MSP. Since the exact nature of this percolation convention is not provided in Fitzgerald (1997), it is unclear how viable this mechanism is when the full range of data is considered. In light of this, the cophonology analysis is clearly superior. The final stress assignment induced by the consonantal suffix falls out naturally from the architecture of the model.

In formulating her constraints, Fitzgerald relies heavily on the notion of 'morpheme as morph', akin to the Item-Arrangement approach to morphology (cf. Hockett 1954). This presents problems when one has to deal with a phenomenon such as truncation, where there is no overt 'truncation' morph (see §4.2 for a detailed discussion on the perfective truncation in TO). Since the MSP asserts that for every morpheme there must be some stressed mora that falls in the domain of that morpheme, this requirement will only be effective during the candidate's evaluation if the morpheme that was in the input, or some remnant of it, is present in the output. The prediction under such a principle is that in the case of zero morphology, stress will be assigned similarly to the underived monomorphemic forms since no additional morpheme is present in the output. Although TO has no zero derivation, a case of 'subtractive morphology', namely truncation, would offer us a plausible hypothetical scenario.

One might remedy the situation by reformulating the MSP and stating it in terms of morphological bracketing, rather than referring explicitly to morphs. That is, the MSP could require that each morphological operation induce an addition of a stress mora in the output. An anonymous reviewer points out a similar solution that drops the condition that stress falls within the morpheme's domain. With this weakened version of MSP, every morphological operation must be overtly marked by some stress. However, the MSP can be satisfied by any additional stress that is not in the input. Although the above solutions circumvent the objections to MSP noted, ultimately they are really cyclicity in disguise. The co-phonology analysis assumed here, however, does not have to rely on any stipulation in order to account for cyclicity in phonology. On the contrary, the cyclic effect of phonological application is an inherent part of the model. Crucially, cyclicity is accounted for in Sign-based Morphology non-derivationally, and is thus entirely consistent with Optimality Theory.

## 4 Some arguments for cyclic stress assignment in TO

In the previous sections we have seen the NDEB in underived and derived word stress assignments. The alternative analysis proposed in Fitzerald (1996, 1997) has been rejected on both empirical and theoretical grounds. In this section, I present some data regarding the interaction between stress, the latent vowel and perfective truncation. In the course of the discussion, I will argue further for the co-phonology approach to morphologically conditioned phonological phenomena.

### 4.1 The interaction of the stress and latent vowels in TO

4.1.1 *Basic facts about the latent vowels.* In TO, certain consonant-initial suffixes, when affixed to a base ending in a consonant, prompt the appearance of an [a] between the base and the suffix (15a). No vowel appears when the base is vowel-final (15b).

(15) a. *Distribution of the inserted* [a][4]

| *verb* | *verb + suffix* | |
|---|---|---|
| wákon | wákon-akùḍ | 'go and wash' |
| pá:n-t | pá:n-t-akùḍ | 'instrument for making bread' |
| čikpan | číkpan-adàg | 'good at working' |

b. *Absence of* [-a] *in vowel-final verbs*

| *verb* | *verb + suffix* | | |
|---|---|---|---|
| wáila | wáila-kùḍ | *wáila-akùḍ | 'instrument for dancing' |
| číčwi | číčwi-dàg | *číčwi-adàg | 'be good at playing' |
| wá-pailà | wápailà-kuḍ | *wápailà-akuḍ | 'instruments for dancing' |

Zepeda (1984) and Fitzgerald (1997) argue that the appearance of [a] is due to epenthesis. The epenthetic [a] has no semantic meaning or syntactic function and only occurs in phonologically characterisable restricted environments, namely CC clusters.

[4] The inserted [a] is underlined.

However, the language as a whole allows consonant clusters, and there is no evidence for other epenthesis in the grammar. A minimal pair is shown in (16). The stem in both cases is /čikpan/ 'working'; /-dam/ means 'the one who' and /-dag/ 'ability'. Only /-dag/ induces the insertion. This comparison demonstrates that the insertion cannot be induced by phonological factors alone.

(16) *Regular suffix* vs. *suffix with inserted vowel*

| | | |
|---|---|---|
| /čikpan + dam/ | [čikpandam] | 'one who works' |
| /čikpan + dag/ | [čikpana̱dag] | 'good at working' |

This 'epenthetic vowel' only appears along with a restricted number of suffixes and only surfaces between two consonants. To capture these facts, I argue that the so-called 'epenthetic vowel' is actually a latent vowel (cf. Zoll 1998), which is part of some suffixes, but not others. It surfaces to optimise syllable structures (i.e. to avoid consonant clusters). Otherwise, it is deleted. One advantage of referring to the vowel as latent rather than epenthetic is that the epenthesis analysis makes no claim about the lexical sensitivity of the inserted [a] while the latent vowel analysis captures this idea intrinsically by assuming that the inserted [a] is a latent segment that comes with only certain affixes. Since the exact analysis of the latent vowel is tangential to the main topics of this paper, I refer the reader to Zoll (1998) for a general treatment of latent vowels. I follow Zoll in assuming that the latent vowel in TO lacks an underlying root node. It is analysed as a floating [back] feature that surfaces as a full segment only when it is needed to prevent surface consonant cluster.

In the next section, I will illustrate the stress pattern in forms that have the latent vowel.

4.1.2 *The role of the latent vowel in TO stress assignment.* Fitzgerald (1997) observes that the latent vowel does not get stressed even in odd-numbered syllable positions; this is shown in (17). The expected, but unattested, stress pattern of derived forms, also shown in (17), is for the secondary stress to fall on every odd-numbered syllable:

(17) *Stress distribution of the latent vowel in odd position*

| | *syllable count* | | | |
|---|---|---|---|---|
| a. | σ́σσ̱σ̀ | wákona̱kùḍ | *wákonà̱kuḍ | 'go and wash' |
| b. | σ́σσ̱σ̀σ | číkpana̱kùḍdam | *číkpanà̱kuḍdàm | 'one with a tool' |
| c. | σ́σσ̱σ̀σ | wákona̱kùḍdam | *wákonà̱kuḍdàm | 'one with a basin' |

4.1.3 *Analysis of stress in cases with the latent vowel.* The account of the unstressability of latent vowels in odd-numbered syllable positions can easily be accommodated in the analysis of the polymorphemic forms. Recall the constraint hierarchy for the $\varphi_{\text{affix}}$ phonology in (10). I propose to augment the hierarchy with a StressSegment constraint, which penalises stress-bearing entities that are not full segments.[5] The proposed constraint appears in (18) (cf. Alderete 1999b for a similar proposal).

(18) StressSegment (StressSeg)

The nucleus of a stressed mora must be a full segment.
'Only a full segment can bear stress.'

The evaluation of a suffix with a latent vowel/$^{[+low]}$kuḍ/ 'instrument for', affixed to the stem /hidoḍ/ 'cooking', is illustrated in (19).

(19)

| $\varphi_{affix}$(hídoḍ, $^{[+l}{}_{o}{}^{w]}$kuḍ) | Align | FtFm | *Clash | StressSeg | Parse-σ | FtBin |
|---|---|---|---|---|---|---|
| ☞ a. [(hídoḍ)]a[(kùḍ)] | | | | | * | * |
| b. [(hídoḍ)](à[kuḍ)] | | | | *! | | |
| c. [(hídoḍ)](a[kùḍ)] | | *! | | | | |
| d. [(hí)(dòḍ]a)[(kùḍ)] | | | *! | | | ** |
| e. [hi(dóḍ]a)[(kùḍ)] | *! | | | | * | * |

Stressing the latent vowel which appears in the odd-numbered, syllable position (19b), though conforming with the stress pattern of other polymorphic words, violates high-ranked StressSeg, which prohibits subsegments from getting stressed. It is therefore more optimal to leave a syllable unparsed (19a). Other candidates violate the crucially dominating FtFm (19c), *Clash (19d) and Align (19e).

Now that I have formally accounted for the data regarding the latent vowel and stress assignment, I would like to present one further piece of information regarding the morphology of TO. A comprehensive formal analysis will then be given in terms of the co-phonology approach developed earlier.

### 4.2 Perfective truncation

In TO, one segment is truncated from the right edge of the word to form the perfective (20a, b). Two segments are truncated from the right edge of the imperfective, however, when the antepenultimate is a coronal followed by a high vowel (20c).

(20) *Comparison between imperfectives* (*untruncated*) *and perfectives* (*truncated*)

| | *imperfective* | *perfective* | |
|---|---|---|---|
| a. | híwa | híw | 'rub against object (imperf/perf)' |
| | rubbing | rubbing-perf | |
| b. | síkon | síko | 'hoe object (imperf/perf)' |
| | hoe | hoe-perf | |
| c | čɨpos-ɨ̀d | čɨpos | 'brand object (imperf/perf)' |
| | brand-ben | brand-ben-perf | |

[5] A full segment is defined in terms of correspondence here. Informally, if the segment is stressed in the output, it must correspond to a segment with a root node in the input.

### 4.3 The interaction of stress, latent vowels and perfective truncation

4.3.1 *Stress in the truncatum: cases without latent vowels.* The stress pattern in the truncatum is essentially the same as its non-truncated counterpart: only odd-numbered syllables get stress (21). Like other morphologically complex forms, the truncatum also allows a final odd-numbered syllable to receive secondary stress.

(21) *Stress in imperfectives* (*untruncated*) *and perfectives* (*truncated*)

| | *imperfective* | *perfective* | |
|---|---|---|---|
| a. | síkon<br>hoe | síko<br>hoe-PERF | 'hoe object (IMPERF/PERF)' |
| b. | čɨpos-ìd<br>brand-BEN | čɨpos<br>brand-BEN-PERF | 'brand object (IMPERF/PERF)' |
| c. | wáčuwì-čud<br>bathe-CAUS | wáčuwìč<br>bathe-CAUS-PERF | 'make someone bathe (IMPERF/PERF)' |

The facts regarding the latent vowels and the perfective truncation are explicated above. In the following section, I show how secondary stresses are assigned to a truncatum that contains a latent vowel.

4.3.2 *Stress in the truncatum: cases with latent vowels.* Recall that the latent vowel does not receive stress even when it is in the odd-numbered syllable position. Interestingly, when the latent vowel is in the truncatum, it receives stress even though it is supposedly unstressable.

(22) *Stress distribution of the truncatum with the latent vowel*

| | *no truncation* | | *with truncation* | |
|---|---|---|---|---|
| a. | wákon-a̲mɨ̀ḍ<br>wash-to go | 'go and wash' | wákon-à̲m | 'went and washed' |
| b. | číkpan-a̲čùd<br>work-CAUS | 'make someone work' | číkpan-à̲č | 'made someone work' |

To illustrate this point more clearly, two forms are given in (22). Without truncation, both forms contain an unstressable latent vowel, even though the latent vowel is in the odd-numbered syllable position. Thus, in both cases, secondary stress falls on the fourth syllable rather than the third. With the formation of the perfective, however, stress is reassigned in both forms and the supposedly unstressed latent vowel receives stress. The fact that the latent vowel receives stress during truncation demonstrates that stress is reassigned after truncation. Such reassignment is a strong indicator that stress is assigned cyclically, and the fact that stress is assigned to the supposedly unstressed latent vowel by the phonology induced by the truncation suggests that the subsegmental status of the latent vowel is opaque to the stress assignment of the truncatum, which is evidence for the effect of Bracket Erasure. That is, the latent vowel is already realised as a full segment when it is subjected to the truncation-specific phonology. The internal morphological information of the output forms with the latent vowel is therefore no longer accessible to the stress assignment incurred by the perfective truncation. These points will be explicated more clearly in the next section, where the formal characterisation is considered.

## 5 Final analysis

In this section, I will first formally account for the perfective truncation construction. This is followed by the analysis of secondary stress assignment with respect to the truncatum.

### 5.1 Analysis of the truncation

For the analysis of the perfective, I will follow the treatment of truncation based on that proposed in Fitzgerald (1997), but with some technical modifications. Fitzgerald (1997) argues that the perfective morpheme is a subtractive morpheme and is present in the input as an empty morpheme TRUNC. I differ from her on this point by assuming that the truncation construction is associated with a co-phonology $\varphi_{\text{trunc}}$. A TRUNC constraint is proposed, which is similar to the RED constraint employed in most analyses of reduplication (e.g. McCarthy & Prince 1995). This constraint, like the *STRUC constraint (Zoll 1998), penalises the existence of structure in the output candidates. However, unlike *STRUC, the effect of TRUNC is categorical, not gradient. It only requires the output string to contain fewer segments than the input. The actual size of the winning candidate will be determined by the constraints summarised in (23). This co-phonology will consist of the hierarchy proposed in (23), appended to the $\varphi_{\text{affix}}$ hierarchy. Since most stress-assigned outputs are faithful to the input segmentally, with the exception of the truncatum, $\text{MAX}_{\text{IO}}$ must be crucially ranked above the constraint relevant to the stress assignment. Thus, by transitivity, the constraints in (23) must also dominate the stress-assignment constraints, i.e. the constraint ranking in (18).

(23) *Summary of constraints for the truncation construction*

a. L-ANCHOR
The left edge element of the Input corresponds to the left edge of Output (= TRUNC).

b. TRUNC
The Output string, TRUNC, must contain fewer segments than the Input (cf. Fitzgerald 1997).

c. *COR-HI
No sequence of features [+coronal][+high] (Fitzgerald 1997).

d. $\text{CONTIG}_{\text{IO}}$
The portion of $S_j$ and $S_0$ standing in correspondence forms a contiguous string (McCarthy & Prince 1995).

e. $\text{MAX}_{\text{IO}}$
Every segment in $S_j$ has a correspondent in $S_0$.

*Ranking :* L-ANCHOR $\gg$ TRUNC $\gg$ $\text{CONTIG}_{\text{IO}}$ $\gg$ *COR-HI $\gg$ $\text{MAX}_{\text{IO}}$

An evaluation of $\varphi_{trunc}$(čɨ́posìd) 'branded object' is shown in (24). It correctly predicts that candidate (24a) is optimal because it only incurs two $\text{Max}_{IO}$ violations while minimising the violation of the *Cor-Hi constraint. $\text{Contig}_{IO}$ is only violated when a segment is deleted morpheme-internally (cf. (24f)).

(24)

| $\varphi_{trunc}$(čɨ́posìd) | L-Anchor | Trunc | $\text{Contig}_{IO}$ | *Cor-Hi | $\text{Max}_{IO}$ |
|---|---|---|---|---|---|
| ☞ a. čɨpos | | | | * | ** |
| b. čɨposi | | | | *! | * |
| c. čɨposid | | *! | | ** | * |
| d. čɨpo | | | | * | *!** |
| e. posid | *! | | | ** | ** |
| f. čɨ́posd | | | *! | * | |

## 5.2 Analysis of stress in truncation and Bracket Erasure

Finally, for the perfective truncation, the stress pattern in the truncatum is assigned according to the $\varphi_{trunc}$ co-phonology. However, since the only difference between $\varphi_{trunc}$ and the general affixation-specific $\varphi_{affix}$ co-phonology is the additional constraints required by the truncation construction, I will only supply the constraints relevant to the evaluation of stress assignment in the rest of the presentation. A sample evaluation of the stress assignment on the truncatum is given in (25).

(25)

| $\varphi_{trunc}$(wákona̲mɨ̀ḍ) | Align | FtFm | *Clash | StressSeg | Parse-σ | FtBin |
|---|---|---|---|---|---|---|
| ☞ a. [(wáko)(nàm)] | | | | | | * |
| b. [(wáko)nam] | | | | | *! | |
| c. [(wá)(kònam)] | | | *! | | | * |

The fact that the unstressed latent vowel receives stress during truncation suggests that the effect of Bracket Erasure is at work here in the stress assignment of TO. The latent vowel will not be stressed if stress is assigned only once, after all morphological constructions, since the subsegmental status of the latent vowel will be accessible to the phonology. However, by adopting a constituent structure-based analysis and evaluating the phonology in terms of co-phonologies, the cyclic nature of stress assignment and the related bracket erasure effect fall out neatly from the analysis, since each morphological construction can be assigned a co-phonology. The internal phonological information of the daughters participating in the construction is not accessible to the co-phonology of the mother node. Thus, even though the unstressable latent vowel escapes stress assignment during regular suffixation, its status as a latent vowel is no longer available to the co-phonology associated with truncation. As a result, secondary stress is assigned to the latent vowel. To illustrate this more concretely, let us look at an example. The constituent-structure representation of the formation of the form /číkpanàč/ 'to make someone work' is given in (26).

(26) $\varphi_{trunc}$(číkpana̲čùḍ) = [číkpanàč]

$\varphi_{affix}$(číkpan, $^{[+low]}$čuḍ) = [číkpana̲čùḍ]

$\varphi_{root}$(číkpan) $^{[+low]}$čuḍ

Considering (26) from the bottom up, the first morphological construction is the suffixation of the morpheme /$^{[+low]}$čuḍ/, which has an inherent latent vowel, to the root /čikpan/. This operation yields the output [čı́kpana̲čùḍ]. The crucial 'bracket-erasure' stage of the whole operation is illustrated next. The output form, [čı́kpana̲čùḍ], is taken as the input to the truncation construction. The tableau in (27) illustrates the evaluation of the truncation co-phonology.

(27)

| $\varphi_{trunc}$(číkpana̲čùḍ) | Align | FtFm | *Clash | StressSeg | Parse-σ | FtBin |
|---|---|---|---|---|---|---|
| ☞ a. [(číkpa)(nàč)] | | | | | | * |
| b. [(číkpa)nač] | | | | | *! | |
| c. [(čík)(panàč)] | | *! | | | | |
| d. [(čík)(pànač)] | | | *! | | | * |

Crucially, the subsegmental nature of the latent vowel is no longer accessible to the co-phonology associated with the truncation construction. With respect to the truncation co-phonology, the formerly latent vowel is now treated as a full segment. As a result, StressSeg is never violated by any of the candidates considered here, because the histories and the internal make-up of the input strings are not available to this phonological function. Secondary stress is therefore assigned as in any other derived forms and the formerly latent vowel is stressed in the output (27a).

## 6 Conclusion

This paper first demonstrated non-derived environment blocking in TO, i.e. no secondary stress on the word-final odd-numbered syllable is found in underived forms. Secondary stress is allowed in word-final odd-numbered syllables in the derived forms. I then put forward a new treatment of the so-called epenthetic [a] as a latent vowel that comes with certain TO suffixes. In the course of the discussion regarding the interaction between stress, latent vowels and perfective truncation in TO, it was argued that TO stress is reassigned after each morphological operation. Ordinarily unstressable latent vowels receive stress in the truncatum, thus demonstrating the effect of Bracket Erasure. Assuming a constituent structure-based analysis, I propose that there are at least three co-phonologies in TO: root-, affixation- and truncation-specific phonologies. The NDEB and Bracket Erasure fall out naturally from a constituent structure-based analysis which handles morphologically conditioned phonology in terms of co-phonologies.

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