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Squibs and replies

*Tohono O'odham stress in a single ranking**

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This paper argues in favour of the analysis of Tohono O'odham stress originally presented in Fitzgerald (1997). This analysis relies on a single grammar in which metrical and rhythmic constraints are interleaved with the MORPHEME-TO-STRESS PRINCIPLE (MSP), a constraint that requires morphemes to be stressed. The single-grammar approach is contrasted with the co-phonology account offered for the same data in Yu (2000). The two analyses use the same basic constraints, with the exception of the MSP. Instead of this constraint, Yu uses three separate co-phonologies. The comparison between the two theories is focused on this difference, the MSP *vs.* the multiple grammars of the co-phonology model. The point made here is that Tohono O'odham does not need co-phonologies.

1 Introduction

Two accounts of Tohono O'odham stress have appeared in the recent optimality-theoretic literature. The earlier one (Fitzgerald 1996, 1997, 2001a) treats all the facts in a single constraint hierarchy, but requires the proposal of a novel constraint. The more recent account (Yu 2000) essentially relies on the metrical constraints used in the earlier analysis, but requires three separate constraint hierarchies (known as co-phonologies). This paper takes the form of a reply to Yu (2000), arguing in favour of the former approach.

I argue that the best optimality-theoretic analysis of Tohono O'odham stress is one that treats all the constraints in a single constraint hierarchy,

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rather than one that allows a series of rerankings that form separate co-phonologies (Yu 2000). Because the co-phonology account (Yu 2000) essentially adopts the descriptive generalisations and constraints from the analysis of Fitzgerald (1997), the major difference between the two analyses is easily identified: three co-phonologies (Yu) *vs.* one ranking plus a novel constraint, the MORPHEME-TO-STRESS PRINCIPLE (MSP), a constraint that forces all morphemes to be stressed. The predictions made with respect to typology and learnability provide better support for the MSP account than for the co-phonology account.

This paper is organised as follows. §2 gives a brief characterisation of O'odham stress. §3 gives the analysis of Yu (2000), while §4 provides the analysis that uses the MSP. §5 makes a comparison between these two analyses in terms of what they predict from the perspectives of typology and learnability. Based on this, I conclude that Tohono O'odham does not need co-phonologies, and that the original analysis, with a single ranking and the MSP, is preferable to the later co-phonology account.

2 The descriptive generalisations of O'odham Stress

Tohono O'odham (or Papago) is a Uto-Aztecan language spoken in southern Arizona and Sonora, Mexico.¹ While the location of primary stress was discussed in the earlier literature on Tohono O'odham, the secondary stress patterns were first reported in Fitzgerald (1996, 1997).

The basic pattern is alternating odd-syllable stress, with the primary stress falling word-initially. Final secondary stresses are allowed if a word is polymorphemic (1b), but not if the word is monomorphemic (1a). (Note that the basic morphology of O'odham is suffixing, with a prefixal reduplicant.) The asymmetric distribution of final stress, absent in (1a) and present in (1b), cannot be attributed to factors other than morphology. Both sets of data include cases in which the final odd syllable is open with a short vowel (a light syllable) or a closed syllable (potentially a heavy syllable). This type of symmetric distribution is not a characteristic of weight-based stress systems. It should be noted that long vowels are restricted to initial syllables, and in no way affect the generalisations about stress.²

¹ Considerable work has been done on various aspects of the language's phonology and morphology, e.g. Hale (1959, 1965), Saxton (1963), Zepeda (1983, 1984, 1987), Hale & Selkirk (1987), Hill (1992) and Hill & Zepeda (1992, 1998, 1999). Two significant dictionaries also exist (Mathiot 1973, Saxton *et al.* 1989). More detailed description and analyses of O'odham prosody can be found in Fitzgerald (1994, 1997, 1998, 1999, 2001a, to appear) and Miyashita (2002). The facts presented here pertain to stress in the Central dialect.

² The rhythmic system is robustly quantity-insensitive, although quantity does play a role in other ways, including the prosodic morphology (Fitzgerald 2002). See also Miyashita (2002).

(1) *Tohono O'odham stress*a. *Monomorphemic words (alternating stress, no final stress)*

píok	'speak IMPF'
táqai	'roadrunner'
músigo	'musician (from Sp. <i>músico</i>)'
ʔásugaɪ	'sugar (from Sp. <i>azúcar</i>)'
pákoʔòɪa	'Pascola dancer (from Sp. <i>Pascuál</i>)'

b. *Polymorphemic words (alternating stress, final stress)*

čú:-čš	'put out fire IMPF PL'
pán-n-t	'make bread IMPF (from Sp. <i>pan</i>)'
pí-pibà	'pipe PL (from Sp. <i>pípa</i>)'
ʔásugàɪ-t	'make sugar IMPF (Sp.)'
mú-msigò	'musician PL (Sp.)'
kóʃi-gà-kam	'one owning a pig'
há-haiwàp-ga-kàd-ma	'will seem to be owning cattle PL'

This paper focuses on the contrast in (1), and the two different accounts offered for it. However, there is another contrast that must also be accounted for: epenthetic vowels are unstressed, except in a morphologically truncated word. These patterns appear in (2). Morphological truncation is used in Tohono O'odham to indicate a change of aspect from the imperfective to the perfective form. Under truncation, the final segment is deleted. In some cases, the final two segments are deleted in order to prevent words from ending in a coronal consonant followed by a high vowel. This is the case below in (2b), where the final suffix [-čud] is truncated to [-č]. Because forms must meet minimal word requirements, truncation may lead to vowel lengthening in monosyllabic forms, although this is not shown below.³ Ultimately, morphological truncation is important because it results in stressed epenthetic vowels. (Epenthetic vowels are underlined in (2) and elsewhere.)

(2) *Interactions with epenthesis and truncation*a. *Words with epenthesis (stress alternation restarts after epenthetic vowels)*

pán-t- <u>a</u> -kùd	'instrument for making bread (bread pan)'
pán-t- <u>a</u> -kùd-dam	'one with a bread pan'
číkpan- <u>a</u> -čùd	'make someone work IMPF'
gátw-id- <u>a</u> -čùd	'shoot at object for someone IMPF'
číposìd- <u>a</u> -čùd	'make someone brand object IMPF'

b. *Truncated words (alternating stress, final stress on odd syllables)*

gátw-id- <u>ä</u> -č	'shoot at object for someone PERF'
číkpan- <u>ä</u> -č	'make someone work PERF'
číposìd- <u>ä</u> -č	'make someone brand object PERF'

³ The basic approach to O'odham truncation here follows Fitzgerald & Fountain (1995a, b), although the analysis is not given here, due to space considerations. See Hill & Zepeda (1992) for a different account of these facts.

The basic pattern of stress shown in (1) and (2) consists of alternating odd-syllable stress, with primary stress on the leftmost syllable. The presence of stress on both initial and odd syllables signals a trochaic metrical system, which assigns stress using a quantity-insensitive left-headed foot, the syllabic trochee (Hayes 1995). Feet align from the left edge of the word. These two aspects of the stress system are easily handled by two undominated constraints: FOOTFORM ('heads are on the left') and an alignment constraint requiring an initial foot. This is shared by the two competing analyses.⁴ The main difference lies in how to derive the following metrical asymmetry. All non-final feet are binary. However, since the monomorphemic and polymorphemic words contrast in whether they allow a final secondary stress, the final syllable may be either stressed in a degenerate foot, as in (pí-pi)(bà) 'pipe PL', or unstressed and unfooted, as in (músi)go 'musician'. This is determined according to the morphological structure of the word, and is relevant only for words that consist of an odd number of syllables.

3 The co-phonology analysis

Both analyses invoke the same metrical analysis; the difference between these analyses comes in how they simultaneously predict binary feet in monomorphemic words while also predicting that degenerate feet exist in polymorphemic words. This section reviews the treatment of Tohono O'odham in Yu (2000), which relies on three separate rankings of constraints to account for the contrasts in (1) and (2). These three separate rankings, or co-phonologies, operate like levels in Lexical Phonology and Morphology (Kiparsky 1982a, b, 2000).

The co-phonology theory was proposed to account for the interaction between morphological and phonological constructions, especially those interactions that have been characterised as cyclic.⁵ One assumption of this theory is that 'each morphological construction – inflectional affixation, derivation and so on – can have its own associated phonology, which will be called a co-phonology' (Yu 2000: 121). Co-phonologies are linked to morphological levels or constructions, and the phonology associated with each level is dependent on a particular form being subject to the morphological construction(s) of that level. Yu treats the root and affixation levels as separate in Tohono O'odham. This means that there are two distinct co-phonologies, the ϕ_{root} phonology and the ϕ_{affix} phonology (see (4a) and (4b) below).

The co-phonology analysis of Tohono O'odham depends on the notion of Level Economy, as proposed in Inkelas & Orgun (1995), which holds that not all forms are required to be evaluated by all of the co-phonologies

⁴ For this reason, these two constraints, as well as the candidates that fatally violate them, are omitted from the discussions below.

⁵ For more on co-phonologies, see Orgun (1996), Inkelas *et al.* (1997) and Inkelas (1998).

of a language. This allows the co-phonology analysis to make an important distinction between non-derived and derived forms; non-derived forms are not subject to any other co-phonology than the root co-phonology. This is because non-derived forms do not undergo any of the morphological operations that are associated with the affixation level. One implication of Level Economy is that the root co-phonology is a 'terminal' level; that is, the output of this level does not undergo any of the other co-phonologies. The asymmetric distribution of final stress in Tohono O'odham is accounted for in Yu (2000) by two moves: first, two metrical constraints are reranked between the root and affixation levels, and second, Level Economy prevents non-derived words from undergoing the ranking at the affixation level. Derived words undergo both levels; this allows the stress pattern to change from the absence of final stress at the root level to the presence of final stress at the affixation level.

The constraints in (3) are some of those used in the co-phonology account. The metrical constraints in (3a–c) also appear in Fitzgerald (1997), while the constraint STRESSSEGMENT appears only in Yu (2000).

- (3) a. PARSE- σ
Syllables must be parsed into feet.
- b. FOOTBINARITY (FTBIN)
Feet are analysable as binary on the syllabic level.
- c. *CLASH
Adjacent stresses are not permitted.
- d. STRESSSEGMENT (STRESSSEG)
The nucleus of a stressed mora must be a FULL segment.
'Only a full segment can bear stress.'

The rankings of the three co-phonologies appear in (4). The first co-phonology, (4a), is for roots; all non-derived words are subject to this ranking only, by Level Economy. Derived words are subject to two co-phonologies, (4a) and (4b). The root stress pattern is produced by (4a), and it serves as part of the input to the affixation co-phonology in (4b). The crucial difference between these two co-phonologies lies in the ranking of FTBIN and PARSE- σ , and the addition of STRESSSEG to the affixation level. As a result, the affixation co-phonology produces a final degenerate foot in polymorphemic words, and it disallows the stressing of epenthetic vowels. The analysis also requires a third co-phonology for truncated words, ϕ_{trunc} in (4c). The inclusion of this level is necessary in order to generate stressed epenthetic vowels in the morphologically truncated words. The third co-phonology is different only by adding a series of constraints to account for truncation. Aside from this change, there is no constraint reranking in the truncation co-phonology, nor do the truncation constraints themselves force the need for a third co-phonology. The additional constraints in (4c) used to account for truncation come from Fitzgerald & Fountain (1995a, b).

- (4) a. φ_{root} : *CLASH $\gg$ **FTBIN** $\gg$ **PARSE- σ**
 b. φ_{affix} : *CLASH $\gg$ STRESSSEG $\gg$ **PARSE- σ** $\gg$ **FTBIN**
 c. φ_{trunc} : Truncation constraints⁶ $\gg$ *CLASH $\gg$ STRESSSEG $\gg$ **PARSE- σ**
 $\gg$ **FTBIN**

The thrust of the co-phonologies given in (4) is that reranking marks the difference between the constraint ranking that evaluates monomorphemic words (4a) and the ranking that evaluates polymorphemic words (4b, c). The next several examples show how the different co-phonologies work. Starting with a monomorphemic word evaluated by the root co-phonology, we see that the ranking of **FTBIN** $\gg$ **PARSE- σ** at this level predicts that (5a) is the optimal parse of a trisyllabic form, as it has no final stress and better satisfies **FTBIN**.

(5) *Co-phonology evaluation of a monomorphemic word*

φ_{root} (PasugaI)	*CLASH	FTBIN	PARSE
☞ a. (Pásu)gaI			*
b. (Pásu)(gàI)		*!	

Polymorphemic words are evaluated somewhat differently, both in terms of the constraints (reranked as in (4b)) and in terms of the input. The tableau in (6) evaluates the root /haiwəp/, with a prefixal reduplicant and two suffixes (/ -ga/ and / -kam/). The root appears as an output of the root co-phonology, and so it has stress in the input to the affixation co-phonology. In the affixation stratum, the input consists of the stressed root (perhaps also including its metrical structure) and an ordered listing of the affixes in their lexical forms. This points out one key difference of the co-phonology model from Lexical Phonology. In the co-phonology analysis, words are not subject to every co-phonology ranking stratum. As required by Level Economy, only the root portion of derived words goes through each stratum's constraint hierarchy.

(6) *Co-phonology evaluation of a polymorphemic word*

φ_{affix} (RED, háiwəp, ga, kam)	*CLASH	STRESSSEG	PARSE	FTBIN
☞ a. (há-hai)(wəp-ga-)(kəm)				*
b. (há-hai)(wəp-ga-)kam			*!	
c. (há-)(hàiwəp-)(gà-kam)	*!			*

This accounts for the contrast shown above in (1) between simple and complex words. Now let us turn to the account for the contrast in (2), where epenthetic vowels are unstressed in non-truncated words

⁶ The truncation subhierarchy is L-ANCHOR $\gg$ TRUNC, CONTIG_{IO} $\gg$ *CORHI $\gg$ MAX_{IO}.

and stressed in truncated words. In the complex word co-phonology, epenthetic vowels are underlyingly specified as [+low], and termed 'latent' vowels.⁷ Latent means that they are present in the input form specified by the [+low] feature, and overtly present as segments where output forms are used as the inputs to the truncation co-phonology.⁸ Such vowels are penalised when stressed in the affixation co-phonology, but in the truncation co-phonology, they are treated as overt and are stressed without penalty.⁹ This is shown by the contrast between two different types of morphological candidates with stressed epenthetic vowels: the non-optimal form in (7b), and its optimal truncated counterpart in (8a).

(7) *Co-phonology evaluation of a word with epenthesis*

$\phi_{\text{affix}}(\text{hídoq}_\text{,} [+low]\text{kùd})$	*CLASH	STRESSSEG	PARSE	FTBIN
☞ a. (hídoq_-)a-(kùd)			*	*
b. (hídoq_-)(à-kùd)		*!		
c. (hí)(dòdq_-a-)(kùd)	*!			**

The use of STRESSSEG provides a way to favour forms in which the epenthetic vowel is unstressed. Truncated words with stressed epenthetic vowels are used to claim that an additional co-phonology is required. The argument for the third stratum is based solely on the stress facts, so this stratum is without independent motivation. Under the co-phonology account, the presence of stress on the epenthetic vowel is argued to indicate two things. First, the reassignment of stress to this vowel is cyclic. And second, the vowel must be fully specified as the input to the truncation level, while it is partially specified as the input to the affixation level. Note that the input to the truncation co-phonology is a surface word. This is critical, because this move means that the epenthetic vowel is now fully specified in the input. No violation of STRESSSEG results when a latent vowel is stressed in a truncated word.

⁷ Two points should be made about these vowels in terms of how O'odham speakers treat them. First, speakers also count them in syllable-counting tasks. Second, such syllables are incorporated into the weak portion of the foot if permitted by FTBIN, and into the strong portion of the foot under morphological truncation.

⁸ An additional implication of using [+low] to signify the latent vowels means that the use of subsegments cannot be restricted to lexically specified contexts such as this, due to richness of the base. Another possible input might be one where the segment [u] is replaced by the feature [+high]. Such an input form cannot be ruled out arbitrarily, due to richness of the base, but the co-phonology analysis does not show how the grammar allows the single subsegmental element that falls at the right edge of the morpheme.

⁹ This is because Yu invokes correspondence as a way to capture the difference between full segments and latent segments: 'if the segment is stressed in the output, it must correspond to a segment with a root node in the input'. One might expect that co-phonologies should be able to get the asymmetric behaviour of latent and full vowels as result of the model, rather than as a separate stipulation.

(8) *Co-phonology evaluation of a truncated word with epenthesis*

$\phi_{\text{trunc}}(\text{wákonamìd})$	*CLASH	STRESSSEG	PARSE	FTBIN
a. (wáko)(n-à-m)				*
b. (wáko)n-à-m			*!	
c. (wá)(kòn-à-m)	*!			*

The resulting analysis is three different sets of rankings, or co-phonologies, to account for the Tohono O'odham facts. The only case where reranking of constraints occurs, however, is from the root to affixation co-phonology. There is no reranking in the truncation co-phonology, and the only reason to separate affixation and truncation into separate co-phonologies is the behaviour of epenthetic vowels. Nothing in the truncation constraint set requires this move.

4 The MORPHEME-TO-STRESS PRINCIPLE

The same effects can also be obtained with a single ranking. Besides the constraints (3a–c) adopted in the co-phonology account, two constraints are necessary to account for the asymmetry between monomorphemic and polymorphemic words (the contrast from (1) above). The first constraint, *LAPSE, militates against adjacent weak syllables, while the second constraint, the MORPHEME-TO-STRESS PRINCIPLE, requires that every morpheme must be stressed. The latter constraint requires each morpheme to appear in a stressed syllable by evaluating whether at least one segment of the morpheme appears in the syllable; morphemes and stressed syllables are in a one-to-one relationship.

(9) a. *LAPSE (revised from Elenbaas & Kager 1999)

Adjacent weak beats must precede a word boundary.

b. MORPHEME-TO-STRESS PRINCIPLE¹⁰

Let *M*, a morpheme, consist of a string of segments $s_1, s_2, \dots, s_n$. Assign one violation mark if no segment s_j in *M* appears in a stressed syllable, such that the stressed syllable licenses at most one morpheme.

It should be noted that the original statement of *LAPSE in Elenbaas & Kager (1999) is: 'every weak beat must be adjacent to a strong beat or the word edge'. This is in part because Elenbaas & Kager were attempting to rule out a sequence of three weak syllables between strong syllables (SWWWS). Consequently, this statement is not strong enough by itself to exclude a SWWS sequence. The analysis of Tohono O'odham needs to exclude the lapse in SWWS without excluding a word-final SWW sequence. Word boundaries and stressed segments do not trigger the same

¹⁰ Thanks to the associate editor for this suggested formulation of the constraint, revised here from earlier work.

types of anti-lapse effects in Tohono O'odham, and this is the reason for the reformulation of *LAPSE in (9a) above.¹¹

The constraint hierarchy is shown in (10). This predicts binary footing for monomorphemic words, which never surface with a final secondary stress.¹²

(10)

/ʔasugaɪ/	*CLASH	*LAPSE	MSP	FTBIN	PARSE
a. (ʔásu)(gàɪ)				*!	
☞ b. (ʔásu)gaɪ					*
c. ʔasugaɪ		*!	*		***

Recall from above that polymorphemic trisyllables allow a final secondary stress. This is predicted by the MSP, which requires that every morpheme be stressed. When this constraint outranks FTBIN, a degenerate foot occurs in polymorphemic words. This is shown by the form [mú-msigò] 'musician PL' below. The challenge of this form comes in the fact that morphemes, syllables and feet are not in alignment. Syncope applies to the base so that the first syllable, *mum*, contains all of the first morpheme and some of the second. The first and third candidates satisfy the MSP, because each morpheme can be uniquely mapped to a stressed syllable. In the second candidate, (11b), only the first morpheme appears in its own stressed syllable, so this candidate fatally violates the MSP.

(11)

/RED-musigo/	*CLASH	*LAPSE	MSP	FTBIN	PARSE
☞ a. (mú-msi)(gò)				*	
b. (mú-msi)go			*!		*
c. (mú-m)(sigo)	*!			*	

Another complicated example, [ʔásugàɪ-t], is evaluated in (12), where the consonantal suffix /-t/ forces final stress in a complex trisyllable. The word has two morphemes. The optimal parse of this word is (12a), where each morpheme is licensed by a separate stressed syllable.

(12)

/ʔasugaɪ-t/	*CLASH	*LAPSE	MSP	FTBIN	PARSE
☞ a. (ʔásu)(gàɪ-t)				*	
b. (ʔásu)gaɪ-t			*!		*

This accounts for the asymmetry between simple and complex forms outlined in (1) above. The next contrast analysed here is the fact that

¹¹ Elenbaas & Kager (1999) rule out SWWS sequences with *LAPSE in combination with a foot-alignment constraint. That cannot be the case here. A ranking of ALL- FEET-L » PARSE-σ incorrectly predicts the absence of iterative footing in quadri-syllabic words, e.g. **pímiandò* rather than *pímiàndo* 'pepper'.

¹² The ranking *LAPSE » MSP is necessary to predict alternating stress in the case of a trisyllabic form plus a suffix; for example, the attested (ʔásu)(gàɪ-mad) *vs.* *(ʔásu)gaɪ-(màd) 'adding sugar'.

epenthetic vowels are unstressed, except in truncated words. This is accounted for by incorporating the two constraints below, *HEAD*DEP and *EXPONENCE*. The *HEAD*DEP constraint is violated whenever an epenthetic vowel is stressed. The second constraint, *EXPONENCE*, requires that every morpheme must correspond to some surface element. In other words, morphemes must be overtly realised.

- (13) a. *HEAD*DEP (Alderete 1995, 1999; as stated in Kager 1999)
Every vowel in the output's prosodic head has a correspondent in the input.
- b. *EXPONENCE* (Prince & Smolensky 1993)¹³
Morphemes must be overtly realised.

Unstressed vowels result in forms with a SWWS surface pattern; this tells us that *HEAD*DEP outranks **LAPSE*.¹⁴ However, epenthetic vowels are stressed in morphologically truncated words, showing that *EXPONENCE* dominates *HEAD*DEP. The next two tableaux illustrate these arguments. The tableau in (14) shows that when *HEAD*DEP dominates **LAPSE*, epenthetic vowels are unstressed, even if this creates a sequence of two unstressed syllables (14a). Only one degenerate foot will surface per word, because additional degenerate feet would violate the highly ranked **CLASH* (14c). The word has three morphemes (and an epenthetic vowel); each morpheme has some overt realisation, so *EXPONENCE* is satisfied for the three candidates in (14). This includes the reduplicative morpheme, which is without segmental content in the input, but which has segmental content in the output.

(14)

/RED-čipkan-čud/	<i>*CLASH</i>	EXP	<i>HEAD</i> DEP	<i>*LAPSE</i>	MSP	FTBIN	PARSE
a. (čí-čpka)n-a-(čùd)				*	*	*	*
b. (čí-čpka)(n-à-čud)			*!		**		
c. (čí-čp)(kàn-a-)(čùd)	*!					**	

The form in (15), /čikpan-čud PERF/ 'instrument for cooking', involves a word with morphological truncation, which surfaces with a stressed epenthetic vowel. This input should be considered to have three morphemes: the root, the suffix and the perfective morpheme, which triggers truncation. Like the reduplicative morpheme, the truncation morpheme has no segmental content in the input. However, unlike reduplicative morphemes, the truncation morpheme never has any segmental content.

¹³ Other applications of this constraint can be found in Golston (1995), Rose (1997) and as the similar constraint *MORPH-REAL* (McCarthy 2002: 124, due to Samek-Lodovici 1993).

¹⁴ A ranking where the MSP dominates *HEAD*DEP, as suggested by an anonymous reviewer, will not work. By transitivity, the ranking would be **LAPSE* $\gg$ MSP $\gg$ *HEAD*DEP; if **LAPSE* were to outrank *HEAD*DEP, we would expect **(čí-čpka)(n-à-čud)* rather than *(čí-čpka)n-a-(čùd)* for 'making someone work PL IMPF'.

EXPONENCE forces all morphemes to have some type of overt realisation, not necessarily segmental. I argue that the epenthetic vowel is stressed because this allows there to be some overt realisation of the truncation morpheme. The constraint hierarchy selects as optimal a form with a stressed epenthetic vowel, (15b), because this candidate satisfies EXPONENCE by allowing the input truncation morpheme to have a corresponding surface expression. Candidate (15a) does not stress the epenthetic vowel, thereby fatally violating EXPONENCE by virtue of the unexpressed perfective morpheme.

(15)

/čikpaŋ-čud PERF/	*CLASH	EXP	HEAD DEP	*LAPSE	MSP	FTBIN	PARSE
a. (čikpa)n-a-č		*!			*		*
b. (čikpa)(n-à-č)			*			*	
c. (čik)(pà)(n-à-č)	**!		*			***	

To summarise this section, the constraints and analysis offered in Fitzgerald (1996, 1997, 2001a) depend on the interleaving of rhythmic and metrical constraints with the proposed new constraint, the MSP. A single constraint ranking is proposed to account for all of the facts, and is given in (16).

- (16) *CLASH » EXPONENCE » HEAD DEP » *LAPSE » MSP » FTBIN »
PARSE-σ

5 Predictions of the two theories

The two theories of phonology reviewed above make very different predictions in terms of typological and learnability implications. The next two subsections consider these issues. The basic difference between the two accounts lies in how they propose to modify Optimality Theory. I argue that the introduction of co-phonologies makes more far-ranging predictions, as compared to the particular predictions created by proposing a new constraint, the MORPHEME-TO-STRESS PRINCIPLE.

Under the MSP account, a new markedness constraint has been added to the inventory. This constraint links up prosodic and morphological structure in its evaluation of well-formedness. The introduction of a new constraint makes predictions about the types of interactions that should occur cross-linguistically; these are discussed below. While not all of these predictions are currently attested in the literature, there are some attested patterns, and the unattested patterns lay out a limited typology of languages to be investigated in future research. In terms of learnability considerations, the MSP should act like other markedness constraints; the only special knowledge required in acquisition is knowledge of the morphological structure. While this may present a challenge, it is the same challenge presented by any other constraint or schema that refers to morphemes, such as Generalised Alignment.

The co-phonology account (Yu 2000) presents a different set of challenges, because it proposes a change that is more relevant to the architecture of Optimality Theory. The use of co-phonologies and reranking expands the predictions about the types of languages that should be attested. By allowing the root and affixation levels to be characterised by different co-phonologies, one might expect widely different constraints and multiple wide-ranging rerankings to be used at the two levels. The actual types of analyses seen in the co-phonology literature are cases where at most two constraints are reranked (Kager 1999). Co-phonologies also offer potential problems in terms of learnability algorithms (Tesar & Smolensky 1993, 1998). The following sections consider these predictions in more detail.

5.1 Typological predictions of the two theories

We begin with the typological predictions made by the MSP, first looking at the general claims about types of stress patterns that should and should not occur, and then turning to a discussion of two specific cases.

In the analysis of Tohono O'odham presented above, the MSP is ranked below both of the rhythmic constraints *CLASH and *LAPSE. There are two types of languages predicted by an undominated MSP. Just as there are languages that stress each word once and stress every heavy syllable (the WEIGHT-TO-STRESS PRINCIPLE (WSP)), there should be languages that stress each word once and stress every morpheme (the MSP). And just as there are languages with binary footing that also stress every heavy syllable (WSP), there should also be languages with binary footing that also stress every morpheme.¹⁵ The current literature on metrical systems does not have any unambiguous examples of these two types of languages, i.e. cases where rhythmic constraints like *LAPSE and *CLASH are not also highly ranked. These examples thus constitute specific predictions that may or may not be borne out by future cross-linguistic studies.¹⁶

An interesting prediction is also made by what the MSP does not predict. There is no ranking of the MSP that predicts a language that is the mirror image of O'odham, where morphologically simple words have degenerate feet while morphologically complex words do not. The presence of degenerate feet is a product of such marked structures being licensed

¹⁵ Much of this paragraph relies on comments made by one of the anonymous reviewers of this manuscript.

¹⁶ I would argue that this may well be due to a paucity of comprehensive rhythmic data for many of the world's languages. Descriptive grammars frequently devote only a small proportion of the overall work to phonology, with the bulk of the focus on morphosyntax. In many cases, phonological details (like stress) may be omitted during the chapters on morphology and syntax. The study of Tohono O'odham stress presented here is provocative in that it suggests how much we could learn from theoretically driven phonological fieldwork.

by the additional morphemes. This contrasts with the different typological predictions made by the co-phonology account; the mirror image of Tohono O'odham should occur because the explanation comes in re-ranking the relevant two constraints in two separate co-phonologies.¹⁷ Thus the original analysis proposed in Fitzgerald (1997) is more restrictive in its predictions than is the analysis of Yu (2000).

The MSP also makes different predictions about word-minimality effects than the standard account. Content words are typically characterised as requiring to have at least one stress (Hammond 1984, McCarthy & Prince 1986, Hayes 1995 and many others). Furthermore, the shape of the minimal word has been argued to directly correlate with whether degenerate feet occur elsewhere in the language in longer words (McCarthy & Prince 1986, Hayes 1995). The connection of these two patterns predicts that languages which allow degenerate feet in disyllabic or longer words and are characterised by quantity-insensitive metrical feet (such as syllabic trochees) should also allow stressed light monosyllables to surface. Similarly, it predicts that a language allowing a stressed light monosyllable to surface as a content word will in fact allow similar degenerate feet (consisting of stressed light syllables) to surface in longer words. In other words, the minimal prosodic shape of the word corresponds with what is allowed in longer words as the minimal prosodic foot. When degenerate footing is allowed for secondary stresses, this is also allowed for main stresses. There should be no language with a pattern other than these two (the strong and weak prohibitions on degenerate feet noted in Hayes 1995). This amounts to a biconditional implicational statement on the relationship between minimal word size and degenerate footing in longer words.

The problem is that there is a language which exhibits these contradictory (according to Hayes 1995) characteristics. Dalabon (Capell 1962, Hayes 1995) requires the use of syllabic trochees, with feet aligned starting from the left edge of the word; an additional complication is that secondary stress is not permitted on final syllables. Consequently, trisyllabic words have the pattern $\sigma\sigma\sigma$. Additionally, light syllables are permissible stressed words. In other words, there is no minimal word size for Dalabon. The stress pattern of trisyllabic words suggests the ranking $\text{FTBIN} \gg \text{PARSE-}\sigma$, but the stress facts for monosyllables suggest the opposite ranking. If minimal word facts are connected to the MSP, the ranking in (17) should predict the behaviour of Dalabon.

(17) *Dalabon*

$\text{MSP} \gg \text{FTBIN} \gg \text{PARSE}$

Under other accounts in Optimality Theory, minimality effects are generally obtained by combining a constraint that requires lexical words to equal prosodic words ($\text{LEXICALWORD} = \text{PROSODICWORD}$), ranked with

¹⁷ Thanks to the associate editor for raising this point.

other constraints on metrical structure.¹⁸ $LxWD = PrWD$ should not be able to be ranked so as to predict a language that allows monosyllabic minimal words and disallows degenerate feet elsewhere. The advantage of including both the MSP and $LxWD = PrWD$ (or some similar constraint, such as *HEADEDNESS(FT)*) is that the latter constraint is satisfied by the presence of metrical structure, but does not necessarily require the presence of a metrical head (a stressed syllable). For example, Somali is a language that does not have stress, but does appear to have bimoraic minimal words. This, together with the Dalabon facts, suggests that word minimality may be better approached by separating stress and metrical structure. This separability occurs by virtue of separate constraint evaluation of these two elements. Other versions of metrical theory may forbid such separation (i.e. Hammond 1984, Hayes 1995).

Finally, a brief mention of another dialect of Tohono O'odham is in order. The reranking of the MSP above **CLASH* predicts the dialect variation that occurs between the two rhythmic systems.¹⁹ Furthermore, it also gives us an example of a system that does stress every morpheme, so long as no stress lapses result. While the scope of this paper is too narrow to go into all the facts of the Western dialect of Tohono O'odham, some representative data appear in (18). The basic observation is that stress clash is tolerated throughout words (except with respect to the main stress), as long as all morphemes are stressed.²⁰

(18) *Western Tohono O'odham Stress*²¹

- a. *Same pattern as Central dialect (final stress in polymorphemic words)*

pá:do-gà 'to own a duck (Sp.)'

mú-msigò 'musician PL (Sp.)'

- b. *Different pattern than Central dialect (subsidiary stresses can clash)*

pá:do-gà-kàm 'someone who owns a duck (Sp.)'

č́ipos-íd-à-č́ 'made someone brand PERF'

há-haiwâp-gà-kâm 'someone who owns cattle PL'

The tableau in (19) shows the prediction made by reranking the constraints so that the MSP dominates **CLASH*. The reranking predicts that (19b) will be optimal, and this is exactly what we find in the Western dialect. (The ranking used in §4 above for the Central dialect of Tohono O'odham would instead predict (19c) as optimal.) Note that there is no

¹⁸ Prince & Smolensky (1993) go so far as to suggest that $LxWD = PrWD$ may be universally undominated. There are languages without minimal word effects, as presented in Hayes (1995), although such languages may not necessarily involve violation of $LxWD = PrWD$.

¹⁹ For an unrelated case of reranking to account for dialect variation, see Kennedy (2001).

²⁰ For more on the Western dialect, see Fitzgerald (2001b, c).

²¹ Western Tohono O'odham distinguishes between secondary (˘) and tertiary (˙) stress.

reranking of the co-phonology account in Yu (2000) that would predict the patterns in the Western dialect. For Yu there can only be at most one degenerate foot per word, not two, as in the optimal (19b).

(19) *Reranking in Western Tohono O'odham*

/RED-háiwān-ga-kam/	HEAD DEP	*LAPSE	MSP	*CLASH	FTBIN	PARSE
a. (há-hai)(wān-ga-)(kām)			*!		*	
☞ b. (há-hai)(wān-)(gà-)(kām)				**	***	
c. (há-hai)(wān-)(gà-kam)			*!	*	*	

To summarise the results, some of the typological predictions made by the MSP are attested. While not all systems are attested, the typological predictions made by proposing such a constraint are testable. They are also constrained insofar as we can rerank the MSP with other prosodic and metrical constraints to determine what types of systems are predicted to exist.

In fact, the typological predictions made by the co-phonology account are quite different from and much broader than those made by the MSP. The predictions made by the MSP are limited to prosody; the co-phonology model has larger implications for the phonology of simple and complex words. One reason for this is that the co-phonology account depends upon Level Economy (Yu 2000: 122):

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 [non-derived environment blocking] 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.

Consequently, the model predicts that there could be simple and complex forms in which completely different phonologies occur, including different phoneme inventories for the two types of forms.²² Simple forms would go through the root co-phonology, and while these forms would be part of the input to the affixation co-phonology, the affixes would go through just the affixation co-phonology (and where required, any additional co-phonologies). Under the co-phonology analysis, it is just as likely that Tohono O'odham will allow degenerate feet in simple forms as it is for complex forms. Therefore, Tohono O'odham stress cannot be analysed as a case of non-derived environment blocking; under the co-phonology model, both types of systems are predicted to occur.

²² Again, thanks to the associate editor for this point.

The symmetrical typologies predicted by the co-phonology model are a result of the types of pairwise rerankings attested in such analyses. Kager (1999) observes that language-internal rerankings are extremely limited, seen typically as just a pair of constraints that rerank, rather than extensive rerankings throughout the grammar. This is certainly the case in Yu (2000), where reranking affects FTBIN and PARSE- σ (although even reranking fails to differentiate the affixation and the truncation strata). Since co-phonologies always seem to involve reranking pairs of constraints, they predict a symmetrical language with the opposite effects.²³ Since in different languages, each ranking might be associated with non-derived forms, while the opposite ranking would be associated with some set of derived forms, there is no way to mitigate against the prediction for the appearance of both types of languages by recourse to non-derived blocking effects.

5.2 Learnability predictions of the two theories

An additional way to compare these two analyses is in terms of the predictions they make for learnability. One way to assess this is by using the Recursive Constraint Demotion algorithm of Tesar & Smolensky (1993, 1998). This approach to learnability starts with a known input and output pair and determines how the constraint ranking is learned. This algorithm faces problems in two situations, when one input can be paired with two outputs (a variation issue) or when constraints are not completely ranked (as in tied constraints) (Tesar & Smolensky 1993, 1998, McCarthy 2002).

In the case of the MSP, this constraint should act like other markedness constraints in universal grammar. The ranking $\text{MSP} \gg \text{FTBIN} \gg \text{PARSE-}\sigma$ means that these constraints appear in a single, ranked hierarchy; in other words, the grammar is consistent in terms of data and constraint rankings.

The co-phonology model does not present consistency, because it requires the data to be analysed as having both the ranking $\text{FTBIN} \gg \text{PARSE-}\sigma$ (root co-phonology), and its opposite, $\text{PARSE-}\sigma \gg \text{FTBIN}$ (affixation and truncation co-phonologies). This creates inconsistency in the constraint ranking. This should lead to problems in learnability under the Tesar & Smolensky model, which has demonstrated problems learning inconsistent data. Thus far, no one has shown how to extend Tesar & Smolensky's result to multi-stratal or co-phonology models.

The learnability issue thus raises another problematic aspect of the co-phonology account, while the MSP presents no novel challenges to learnability models.²⁴

²³ A point made by the associate editor.

²⁴ There is the issue of learning the morphemes and their boundaries, but this problem is inherent in not just this analysis, but also the co-phonology analysis, and any analysis with output constraints that refer to morphemes.

6 Conclusion

Two competing theories present two competing views of the stress system of Tohono O'odham. One view relies on the MORPHEME-TO-STRESS PRINCIPLE, which requires morphemes to be stressed. This account uses a single constraint hierarchy to account for the range of interactions between stress and morphology in this language. An alternative account (Yu 2000) eliminates the MSP in favour of using three separate constraint hierarchies, or co-phonologies. There appears to be little empirical difference between these two accounts of the Central dialect of Tohono O'odham, most likely because of the overlap in the set of metrical constraints. (They do, however, make very different predictions for the Western dialect.) The theoretical difference in the two analyses comes because Yu uses co-phonologies to rerank FTBIN and PARSE- σ , while this account argues for a novel constraint, the MSP.

I have shown that proposing three co-phonologies is unnecessary and, in the case of the truncation co-phonology, stipulative as well. One phonological grammar is shown to be sufficient to account for Tohono O'odham stress. Furthermore, the introduction of the MSP as a proposed constraint creates a finite set of empirically testable predictions, while the co-phonology account is shown to generate a potentially unknowable number of complex grammatical systems. Additional evidence from Dalabon and Western Tohono O'odham supports the use of the MSP as a constraint active in other systems. With respect to learnability, the proposed MSP is seen to be unproblematic, because it is simply a markedness constraint much like many others proposed under Optimality Theory. By contrast, the co-phonology account makes a wide range of predictions beyond stress systems, and requires an inconsistent analysis of the O'odham data because contradictory rankings are required in the co-phonologies. This is exactly the type of account predicted to create learnability problems based on the algorithm proposed in Tesar & Smolensky (1993, 1998). On these grounds, the preferred analysis of Tohono O'odham stress consists of a single constraint hierarchy that incorporates the MSP.

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