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Head Dependence in Stress-Epenthesis Interaction*

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1. Introduction

What is the nature of the interaction between stress and epenthesis? Do epenthetic syllables count in word stress, or not? This paper will study these questions from various angles and discuss the theoretical issues they raise.

In SPE style phonology (Chomsky & Halle 1968), stress-epenthesis interaction depends on rule ordering. If vowel insertion is ordered before stress assignment, epenthetic vowels will be counted and stressed according to the regular pattern; conversely, if stress precedes epenthesis, then the inserted vowels will be inactive in stress. While the Rule Ordering theory can account for virtually any pattern of stress-epenthesis interaction, this theory fails to offer an explanation of the phenomena. The behavior of epenthetic vowels in stress is described by stipulating the required rule ordering, leaving us to wonder why the state of affairs could not be different.

Working within theories of Prosodic Phonology, some researchers have tried to improve on the Rule Ordering theory by considering the role of prosodic representations in deriving stress-epenthesis interaction (see Broselow 1982 for example). In this approach, a class of epenthesis rules are identified as syllabically conditioned (as in Selkirk 1981, 1984, Itô 1989), and this kind of epenthesis *must* be counted in stress because of general principles of prosodic organization. In particular, syllables must be dominated by prosodic feet, and this prosodic layering works from the 'bottom-up'. As an example of how the Bottom-Up theory works, consider Broselow's analysis of the interaction between stress and epenthesis in Swahili.

Swahili regularly stresses the penult (1a). Further, epenthetic vowels introduced in loanwords are counted and stressed according to the canonical pattern (1b); in the examples below and throughout, epenthetic vowels are underlined.

(1) Swahili (Ashton 1944, Polomé 1967, Broselow 1982)

a.	jíko	'kitchen'	b.	tíket ~ tikéti	'ticket'
	jikóni	'in the kitchen'		rátli ~ ratíli	'pound'
	nilimpíga	'I hit him'			
	nitakupíga	'I shall hit him'			

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In the Bottom-Up theory, the explanation goes like this. Epenthesis of *i* is syllabically conditioned because it applies in order to syllabify obstruents as onsets (coda obstruents are generally avoided in the language). Working from the bottom-up, epenthetic syllables are inserted to parse the unsyllabified obstruents, and stress feet are then built over these syllables. With this order of events, the interaction between stress and epenthesis could not be otherwise: epenthetic vowels must be active in word stress because they are an automatic by-product of inserting an epenthetic syllable, which in turn forms the building blocks for stress feet.

While the Bottom-Up theory makes a significant improvement on the Rule Ordering approach, there is an empirical problem with this theory. It cannot account for syllabically conditioned epenthesis that is invisible in stress; the assumptions inherent to this theory predict that this class of behavior does not exist. Consider the following example from the Siouan language Dakota as a counterexample to the Bottom-Up theory.

In Dakota, stress regularly falls on the second syllable from the beginning of the word (2a). Yet syllabically conditioned epenthesis into the second syllable (2b) creates exceptions to canonical second syllable stress (see Kennedy 1994 and Sietsema 1988 on a syllable-based analysis of epenthesis in Dakota).

(2) Dakota (Shaw 1976, 1985)

a.	č^{h}ikté	‘I kill you’	b.	/ček/	→ čéka	‘stagger’
	mayákte	‘you kill me’		/khuš/	→ khúša	‘lazy’
	wičháyakte	‘you kill them’		/čap/	→ čápa	‘trot’
	owíčhayakte	‘you kill them there’		cf. /kte/	→ kté	‘s/he, it kills’

This pattern of stress-epenthesis interaction presents a clear counterexample for the Bottom-Up theory: *a*-epenthesis is syllabically conditioned; and since the organization of syllables into stress feet proceeds from the bottom-up, the epenthetic syllable should be stressed according to the regular pattern of peninitial stress. But this is not correct for Dakota, which calls into question the explanation that the theory offers for other languages. In order to account for the Dakota pattern, stress assignment must be ordered after *a*-epenthesis, and once rule ordering is admitted in the theory, the account of the Swahili pattern is no different from the Rule Ordering approach.

We are left, it would seem, with some version of the Rule Ordering theory, and there is a reason for rejecting this theory as well. Epenthetic syllables do not always behave in a uniform way in relation to stress. They can be ignored in some environments, and yet incorporated into the stress pattern in others. Stress-epenthesis interaction in the Papuan language Yimas is like this, and as we will see in detail below, such patterns point to a real flaw in the Rule Ordering approach.

In Yimas, the main stress regularly falls on the initial syllable of a word (3a). Epenthesis into this position, however, creates exceptions to regular initial stress, pushing stress forward a syllable (3b).

(3) Yimas (Foley 1991)

a.	wáŋkaŋ	'bird'	b.	/pkam/	→ pɨ̲kám	'skin of back'
	kúlanaŋ	'walk'		/tmi/	→ tɨ̲mí	'say'
	wúratàkay	'turtle'		/kcakk/	→ kɨ̲cákɨ̲k	'cut'
	mámantàkarman	'land crab'		/nmpanmara/	→ nɨ̲mpánmara	'stomach'

There is a further complication on this pattern, which is that if the vowels of both the first and second syllable are derived by epenthesis, then main stress defaults to the initial syllable (4). (See Foley 1991: 44 ff. for motivation of an epenthetic analysis in words with strings of consonants such as these.)

(4)

/tkt/	→	tɨ́kɨ̲t	'chair'
/klwa/	→	kɨ̲́lɨ̲wa	'flower'
/krmknawt/	→	krɨ̲́mkɨ̲nawt	'wasp'
/tmpnawkwan/	→	tɨ̲́mpɨ̲nàwkwan	'sago plam'

In sum, epenthetic vowels are generally invisible to stress (3b), but in a phonologically defined context, epenthetic vowels are stressed according to the regular pattern (4).

The derivational theory needs to say that Yimas has two rules of epenthesis. One process of *ɨ*-insertion must apply before the assignment of initial stress in order to account for the fact that an epenthetic syllable is stressed when followed by another epenthetic syllable. A second rule of *ɨ*-insertion, on the other hand, must follow stress assignment because of the fact that epenthesis, as the elsewhere case, creates exceptions to regular initial stress. The problems with the Rule Ordering theory, therefore, run deeper than simply failing to explain stress-epenthesis interaction. In cases like Yimas, the rule-ordering approach leads to loss of generalization in the analysis of the epenthesis process itself. Concretely, the epenthesis process yields a uniform structural change and it is motivated as a means of syllabifying consonant clusters according to the phonotactics of the language. But the analysis of Yimas in terms of ordered rules misses these generalizations by positing two rules of epenthesis. The observations regarding the output of epenthesis, and that epenthesis is syllabically motivated, are stated more than once in the grammar.

In this paper, I propose to account for the problematic cases of Dakota and Yimas as constraint interaction within Optimality Theory (Prince & Smolensky 1993, McCarthy & Prince 1993a). The idea developed below is that Universal Grammar has a well-formedness constraint, HEAD-DEP, that bans the stressing (and footing) of epenthetic segments. When HEAD-DEP dominates a set of constraint responsible for 'regular stress', the result is that epenthetic vowels are invisible in stress, as in the case of Dakota. However, if HEAD-DEP is low ranking, a different pattern of stress-epenthesis interaction is predicted, i.e., metrical activity of epenthesis, as in the case of Swahili. Moreover, the constraint interaction theory developed here provides a clear line of analysis for the more complicated cases exemplified above with Yimas. For such cases, the precise details of the system can be directly characterized by interleaving HEAD-DEP with the set of constraints deriving the regular pattern.[1]

The remainder of this article is structured as follows. In section 2, I will develop and motivate HEAD-DEP, the constraint that plays a central role in the OT analysis. The constraint will then applied to the examples of Dakota and Swahili as exemplification of the basic proposal. Section 3 gives a nonderivational analysis of stress-epenthesis interaction in Yimas, and the advantages of the constraint-based approach are discussed. In the final section, section 4, the main results reached in this paper are summarized and some theoretical issues raised in the preceding sections are discussed, namely the role of serial derivation in phonology, the character of input-output faithfulness, and position-sensitive faithfulness.

2. Head Dependence in Stress-Epenthesis Interaction

This section begins with a restatement of stress-epenthesis interaction in Dakota, and then, as a means of motivating the notion of Head Dependence, a comparison is made to stress-related vowel reduction in Russian. The necessary constraints are then formalized and applied to the analysis of particular languages.

Recall from the above discussion that epenthesis in Dakota is invisible to stress: when epenthesis inserts a vowel into the regularly stressed syllable, stress is shifted to avoid stressing the epenthetic vowel. More generally, it seems that in Dakota, the stress system avoids stressing vowels that are not present underlying. As a first approximation of the constraint HEAD-DEP, we can say that noncanonical stress in Dakota is due to the following principle: the stressed vowel must have a lexical counterpart in the input. Applying this constraint to the examples below, stress may be assigned to the canonically stressed syllable, i.e., the syllable to which stress is assigned by the regular pattern, if it contains a lexical vowel (5a). But if the second syllable contains an epenthetic vowel, stress falls elsewhere in the word because of the requirement that stressed vowels have lexical counterparts (5b).

(5) Stress-Epenthesis Interaction in Dakota

a.	/ č^{h} i k t e /	b.	/ č e k /	INPUT
	↑		↑	
	[č^{h} i k t é]		[č é k a̲]	OUTPUT

The stressed vowel is said to be 'input-dependent' in the sense that it must have a counterpart in the input — even though this may lead to exceptions to the canonical pattern of stress, as in *čéka̲*.

This notion of input-dependence makes it possible to construct a clear parallel in the domain of segmental processes sensitive to stress. Stronger faithfulness requirements on stressed vowels are also essential to the characterization of a common form of vowel reduction. Consider the case of Russian, one of a wide range of similar languages (see Beckman 1998 and Flemming 1993 for comprehensive surveys). In tonic positions, Russian licenses six full vowels, i.e., /i ɨ e

[1]Two further constraint-based approaches to stress-epenthesis interaction have been proposed in unpublished work: (i) Kennedy 1994, who proposes to explain cases like Dakota through the alignment of morphological and prosodic structure, (ii) and Ikawa 1995, who deals with the avoidance of stressing epenthetic vowels within the theory of Local Conjunction structured in Smolensky 1993. Unfortunately there is no space in this paper to review these proposals in detail.

a o u/; but in unstressed positions, only the three peripheral vowels surface.[2] This observation holds of lexical forms, and is supported by morphophonemic alternations. For example, the stem-internal mid vowel surfaces under stress in the nominative form *stól*, yet in forms where stress is moved off the stem vowel, underlying /o/ lowers to *a*, e.g., *stal-óf*. This process of vowel reduction, referred to as 'A-Kanje', is exemplified with the nominal and verbal paradigms below.

(6) Russian A-Kanje (Jones and Ward 1969, Zubritskaya 1995)

a.	Nom. Sg.	stól	slóv-o	b.	glaž-ú	važ-ú	1 per. Sg.
	Gen.	stal-á	slóv-a		glóž-iš	vóz-iš	2 per.
	Dat.	stal-ú	slóv-u		glóž-it	vóz-it	3 per.
	Nom. Pl.	stal-ý	slav-á		glóž-im	vóz-im	1 per. Pl.
	Gen.	stal-óf	slóv		glóž-it'i	vóz-it'i	2 per.
	Dat.	stal-ám	slav-ám		glóž-ut	vóz-ət	3 per.
		'table'	'word'		'gnaw'	'carry'	

The fact that the stressed vowel resists the general pattern of reduction suggests a position-sensitive requirement on a par with the one employed above for Dakota. In particular, suppose that the quality of the stressed vowel must be identical with its lexical counterpart. As illustrated in the input-output mappings below, mid vowels lower generally because of a context-free ban on mid vowels (discussed below), as the stem vowel does in (7b). But this lowering process does not apply if the vowel occurs in an accented position. In such cases, mid vowels remain faithful to their input specification because of the high-ranking identity requirement for stressed vowels.

(7) Vowel Reduction in Russian

a.	/ s t o l /	b.	/ s t o l - o f /	INPUT
	‖		‖	
	[s t ó l]		[s t a l - ó f]	OUTPUT

Characterizing vowel reduction in Russian as such paves the way for relating this observation to the metrical inactivity of epenthesis in Dakota. Both cases involve a constraint on the relation between the stressed vowel and its input counterpart, as restated directly below.

(8) a. Stressed vowels must have counterparts in the input.
b. Stressed vowels must be identical to their input counterparts.

Furthermore, the above constraints have the effect of suppressing general phonological patterns. Hence, the requirement in (8a) effects noncanonical initial stress in Dakota, and the requirement

[2]Russian vowel reduction is more complicated than this, requiring the distinction between three distinct domains (i.e., the tonic syllable, the pretonic syllable, and the complement set of syllables), as mid vowels reduce to a peripheral vowel in the pretonic position, but to a schwa elsewhere (Jones and Ward 1969). See Alderete 1995b for discussion of the theoretical implications of this three-way pattern of vowel reduction.

in (8b) characterizes the fact that stressed vowels fail to undergo vowel reduction. The parallels observed here are striking, and call for a formal basis for relating the two phenomena.

Both of the requirements given in (8) assert stronger requirements for stressed vowels, and in doing so, they require reference to 'counterparts' in related structures. This notion of a counterpart is fundamental to the theory of faithfulness proposed in McCarthy & Prince 1995 (M&P henceforth). As a direct account of the parallels observed between reduplicative copying and faithfulness of input to output, M&P generalize the notion of correspondence developed in McCarthy & Prince 1993a to input-output faithfulness. Correspondence between input and output provides a formal characterization of the concept of a counterpart (read as correspondent) employed in the above descriptions.

(9) Correspondence (McCarthy & Prince 1995)
Given two strings S_1 and S_2, **correspondence** is a relation $\Re$ from the elements of S_1 to those of S_2. Segments $\alpha \in S_1$ and $\beta \in S_2$ are referred to as **correspondents** of one another when $\alpha\Re\beta$.

With this characterization of correspondence, the requirements driving the apparently aberrant patterns in vowel reduction and stress-epenthesis interaction can be stated more formally. Faithfulness of input to output is embodied in a set of constraints on correspondent elements, which in the case of the present study, involves correspondent segments. The constraints given in (8) also involve input-output faithfulness, with special reference to metrically prominent positions, i.e., prosodic heads like the main stressed syllable or the main stress foot of a prosodic word.

(10) HEAD-DEPENDENCE (Alderete 1995b)
Every segment contained in a prosodic head in S_2 has a correspondent in S_1.
If β is contained in a prosodic head in S_2, then $\beta \in$ Range($\Re$).

(11) HEAD-IDENTITY[F] (McCarthy 1995, Alderete 1995b, Zubritskaya 1995, Beckman 1998)
Correspondent segments contained in a prosodic head must be identical for F.
If β is contained in a prosodic head in S_2, and $\alpha\Re\beta$, then α and β agree in the feature F.

The proposed constraints employ the basic faithfulness constraints of M&P, and simply refine their application to certain metrically strong positions. Hence, HEAD-DEPENDENCE (HEAD-DEP henceforth) is a refinement of the anti-epenthesis constraint DEPENDENCE; and HEAD-IDENT(ITY)[F] employs the same modification for the class of featural faithfulness constraints IDENT[F]. The consistent modification to these constraints is therefore the specification of a prosodic target, and with this modification, and nothing more, the two classes of phenomena are explained.[3]

Starting with the first constraint, the effect of HEAD-DEP is that prosodic heads are input-dependent. That is, only segments with input correspondents may occur in metrically strong

[3] It is highly likely that faithfulness constraints defined for prosodic heads have a functional basis in pyscholinguistic theories of lexical access. The prosodic faithfulness constraints employed here ensure preservation of the lexical specification for stressed units. Roughly speaking, both of these constraints protect lexical information from being destroyed in the surface form by regular processes of the language. This accords nicely with pyscholinguistic evidence that strong syllables play an important role in segmentation for lexical access (see Cutler & Norris 1988 for crucial experimental results, and Beckman 1996 for a comprehensive review of the psycholinguistic literature and discussion of its theoretical implications).

positions. Because epenthetic vowels are introduced in the mapping from the input to the output, they have no input correspondents (M&P), and so parsing them internal to the prosodic head of a word will constitute a violation of HEAD-DEP. This notion of Head Dependence will be applied to several cases of stress-epenthesis interaction below.

Similarly, HEAD-IDENT[F] explains resistance to vowel reduction in stressed positions. Vowel reduction is part of a larger distributional pattern whereby a wider range of contrasts are licensed in strong positions than those allowed in metrically weak positions. With HEAD-IDENT[F] high-ranking in the grammar, this distributional asymmetry is explained; and what is more, it extends to the above morphophonemic alternations which involve stress shift. Returning to the example of Russian A-Kanje, /o/ lowers to *a* generally, but this regular pattern of vowel reduction is suppressed in the accented syllable, e.g., /stol-of/ → *stalóf*. As shown in the informal analysis below, HEAD-IDENT[F] plays a crucial role in deriving this fact.

Sketching the basic components of the analysis, I assume a theory, developed originally in Beckman 1995 for vowel harmony, that phonological processes can be motivated as a means of minimizing structural markedness. Specifically, reduction of a mid vowel can be seen as a way of avoiding a violation of the featural markedness constraint *MID, a context-free constraint which yields a "*" for every mid vowel in a form. However, mid vowels fail to undergo vowel reduction in stressed syllables because of high-ranking HEAD-IDENT[F]: faithfulness to the vowel features characterizing mid vowels is ensured by this position-sensitive constraint. This is illustrated in the following OT tableau.

(12) Head Identity in Russian A-Kanje: /stol-of/ → *stalóf*

Input: stol-of	HEAD-IDENT[F]	*MID	IDENT[F]
a. stolóf		**!	
b. staláf	*!		**
c. ☞ stalóf		*	*

The first candidate is fully faithful to the input, but it is ruled out by *MID because it has more violations of this constraint than its competitors, and *MID dominates the context-free faithfulness constraint IDENT[F]. The candidate in (12b) obeys *MID completely by lowering both mid vowels, but in doing so, this form is unfaithful to the featural specification of the stressed vowel, and this results in a fatal violation of top-ranked HEAD-IDENT[F]. The optimal form (12c), therefore, is the one which is both faithful to the features of the stressed vowel, and minimally violates the featural markedness constraint *MID by lowering all vowels elsewhere in the word. To summarize, the driving force behind vowel reduction is given a general account, while avoidance of vowel reduction in stress syllables is described with the head-sensitive faithfulness constraint.

Returning to stress-epenthesis interaction, an application of HEAD-DEP to a concrete example will serve to clarify its interpretation, and to establish the parallel between the two classes of phenomena under discussion. Recall from the introduction that epenthesis is inactive in Dakota stress: surface stress is realized on the peninitial syllable, yet epenthesis into the second syllable correlates with initial stress. In the analysis developed below, noncanonical stress is characterized by ranking HEAD-DEP above a constraint responsible for deriving regular stress.

Before describing the pattern of initial stress, we start first with the constraints governing the canonical stress pattern. Following Shaw 1985 and Hayes 1995, second syllable stress is derived by forming an iambic foot that is properly aligned with the left edge of the word.[4] Iambic structure is ensured by the rhythm type constraint, RHTYPE = I (P&S), and this iamb must be binary by high-ranking Foot Binarity (McCarthy & Prince 1986, Hayes 1995). The fact that stress prominences are not found after the second syllable suggests that foot construction is noniterative (Shaw 1985). And following McCarthy & Prince 1993b, nonrepeating stress is derived by a high-ranking alignment constraint, ALIGN-L (F, PrWd), which prohibits iterative footing by requiring that the left edge of all feet coincide with the left edge of some prosodic word.

These constraints on the location and form of feet enter into conflict with Head Dependence when epenthesis inserts a vowel in a regularly stressed position. The stress foot constraints posit the head syllable of the word peninitially, but stressing an epenthetic vowel in this position leads to a violation of HEAD-DEP. If HEAD-DEP is top-ranked, however, noncanonical stress will be the result, as illustrated in the following tableau.

(13) Metrical Inactivity of Epenthesis in Dakota: /ček/ → *čéka*

Input: ček	HEAD-DEP	RHTYPE = I
{če ká}	á!	
☞ {čé ka}		*

In the candidates above, epenthetic *a* has no input correspondent; this is because epenthetic vowels by definition do not stand in correspondence with underlying vowels. Therefore, parsing *a* internal to the syllable head of an iambic foot, as in the first candidate, fatally violates HEAD-DEP. The optimal candidate is thus the form that satisfies the input-dependence constraint by reversing the rhythm type of the stress foot.[5] In summary, the notion of Head Dependence developed here permits an adequate analysis of Dakota stress-epenthesis interaction in parallelist OT.

We are now in a position to make the comparison between the two phenomena exemplified in Dakota and Russian on a more formal level. In Dakota, the avoidance of epenthetic vowels to participate in stress is derived by ranking the position-sensitive faithfulness constraint HEAD-DEP above the constraint yielding a canonical iambic foot. Likewise, in the case of Russian, the resistance on the part of stressed vowels to undergo vowel reduction is due to high-ranking HEAD-IDENT[F]. Thus, the two classes of phenomena, radically different in surface form, are described with a consistent modification of context-free faithfulness. Some further implications of position-sensitive faithfulness are considered at the end of this paper.

Returning to the role of Head Dependence in stress-epenthesis interaction, in the analysis of Dakota, the avoidance of stressing epenthetic vowels is an effect of HEAD-DEP defined for the syllabic head of the prosodic word. It is a straightforward matter to extend this result to cases in

[4]Dakota stress is not sensitive to syllable weight, which according to standard foot typologies constitutes evidence against iambic rhythm. But see Shaw 1985 for three empirical arguments in favor of the iambic analysis of second syllable stress, and discussion in Hayes 1995 for a historical account for how this ‘defective iambic system’ could have developed.

[5]See P&S for a similar approach to Southern Paiute stress in which the constraint responsible for extrametricality effects, NonFinality, conditions a rhythm type reversal.

which the stress system also fails to *count* the epenthetic vowel in the assignment of stress. In such cases, as exemplified below with the Austronesian language Selayarese, the prosodic head relevant for the meaning of HEAD-DEP is the main stress foot. Failure to count an epenthetic vowel is thus described as a failure to foot the epenthetic material. In other words, the segmentism of the main stress foot is input-dependent.

In Selayarese, surface stress regularly falls on the penultimate syllable (14a). But epenthesis into the final syllable, for the purpose of syllabifying certain consonants as onsets, yields irregular antepenultimate stress (14b).

(14) Selayarese (Mithin & Basri 1985)

a.	állo	'day'	b.	ká:tala	'itch'
	allónni	'this day'		pó:tolo	'pencil'
	pá:o	'mango'		maŋkássara	'Macassar'
	paó:ku	'my mango'		lámbere	'long'

Summarizing the facts here, final syllable epenthesis creates exceptions to the canonical pattern of penultimate stress by pushing stress back one syllable.

To sketch an account of this pattern, I assume first that regular penultimate stress in Selayarese is the result of positing a disyllabic trochee at the right edge of the word. To be more concrete, the rhythm type constraint, RHTYPE = T, and Foot Binarity are high-ranking, and the relevant alignment constraint, ALIGN-R, enforces alignment of the right edge of the prosodic foot with the right edge of the word. In sum, the constraints on the form and position of prosodic feet posit the main stress foot at the right periphery of the word to yield the canonical pattern.

Noncanonical antepenultimate stress arises from a different form of constraint interaction, namely constraint conflict between Head Dependence and ALIGN-R. The two constraints enter into conflict in a context where epenthesis inserts a vowel within the domain of the stress foot. Therefore, by defining HEAD-DEP for the main stress foot, and giving this constraint high rank in the system, the invisibility of final epenthesis in stress is directly obtained.

(15) Metrical Inactivity of Epenthesis in Selayarese: /katal/ → *ká:tala*

Input: katal	HEAD-DEP	ALIGN-R
ka {tá:la}	a!	
☞ {ká:ta} la		la

The result illustrated here is that the final syllable is skipped, in violation of ALIGN-R, because parsing it as a weak member of the trochee would violate Head Dependence set for the stress foot. Thus, this pattern of metrical inactivity of epenthesis is characterized by a constraint ranking in which HEAD-DEP is ranked above a constraint deriving a regular stress pattern, as in the case of Dakota stress-epenthesis interaction.

To foreground an important point, the approach to stress-epenthesis interaction that employs the notion of Head Dependence differs fundamentally from the Rule Ordering theory in the way that phonological activity of epenthesis is characterized. In the derivational model, the behavior of epenthesis in stress is a matter of serial derivation: metrically active epenthesis is early in the derivation, while invisibility of epenthesis in the stress system is indicative of a later rule. The parallelist theory proposed here does not allow intermediate stages in the derivation, and so phonological activity of epenthesis cannot be characterized in this way. Rather, activity of epenthesis in stress is simply a matter of constraint ranking, a fundamental property of Optimality Theory. If Head Dependence is high-ranking relative to a set of constraints responsible for deriving regular stress, i.e., 'C_{Stress}', then epenthesis is metrically inactive (16a), as is the case in both Dakota and Selayarese. On the other hand, if HEAD-DEP is low-ranking in the constraint system, then epenthetic vowels will be active in the system (16b).

(16) a. HEAD-DEP >> C_{Stress}: metrical inactivity of epenthesis
b. C_{Stress} >> HEAD-DEP: metrical activity of epenthesis

The point here is that the constraint interaction theory characterizes behavior of epenthesis with the position of Head Dependence in the constraint system. All patterns of stress-epenthesis interaction are thus predictable on the basis of ranking of HEAD-DEP relative to the constraints governing stress. To complete the typology of stress-epenthesis interaction then, let's consider how the schematic ranking given above applies to the case of metrical activity of epenthesis in Swahili.

Swahili has canonical penultimate stress, so for the present purposes, the regular pattern will be derived by the same constraints employed above in the analysis of Selayarese. A syllabic trochee is formed at the right periphery of the word, showing that both ALIGN-R and RHTYPE = T are at play in the system. In contrast to Selayarese, however, epenthetic vowels are active in Swahili stress; they are counted and stressed according to the regular pattern of penultimate stress. Within the framework of ideas developed here, this observation entails that the two stress-related constraints dominate Head Dependence. Thus, ALIGN-R dominates HEAD-DEP, as illustrated in (17a), to account for the fact that word-final epenthesis fails to invoke improper alignment of the stress foot. Furthermore, RHTYPE = T also outranks HEAD-DEP to account for the lack of a rhythm type reversal (17b), as was seen to be the case in Dakota.

(17) a. Metrical Activity of Epenthesis in Swahili: counting of epenthetic vowels

Input: tiket	ALIGN-R	HEAD-DEP
{tíke} ti̲	ti̲!	
☞ ti {kéti̲}		i̲

b. Metrical Activity of Epenthesis in Swahili: stressing of epenthetic vowels

Input: ratli	RHTYPE = T	HEAD-DEP
ra {ti̲lí}	*!	
☞ ra {tí̲li}		i̲

In sum, the activity of epenthesis in the regular stress pattern is accounted for with the schematic ranking proposed above: metrical activity of epenthesis follows from low-ranking HEAD-DEP.

To summarize the empirical results reached this section, the notion of Head Dependence was developed as a means of modeling stress-epenthesis interaction in parallelist OT. The case of metrical inactivity of epenthesis in Dakota was handled with a constraint ranking in which HEAD-DEP dominates the constraint governing the canonical foot. This result was then extended to the example of Selayarese, where the invisibility of epenthesis in stress was derived by ranking HEAD-DEP above the alignment constraint responsible for positioning the stress foot within the word. Finally, the opposite rankings were employed in the analysis of Swahili, where the constraints of the structure and position of feet dominate HEAD-DEP. These rankings account for the fact that epenthetic vowels are stressed and counting according to regular stress in Swahili. In closing, the theory of stress-epenthesis interaction developed here handles straightforwardly the cases shown to be problematic for the Bottom-Up approach discussed in the introduction. In the next section, we turn to the cases that point to a problem for the derivational Rule Ordering theory, namely cases where epenthetic vowels are only partially visible to stress.

3. Nonuniformity in Stress-Epenthesis Interaction

The interaction between stress and epenthesis is not always a uniform and across-the-board phenomenon. Thus, epenthetic vowels may be stressed in a specific context, and yet consistently inactive elsewhere in the stress system; epenthesis may be only partially active in word stress. For example in Spanish, epenthesis into initial *sC* clusters is ignored by the stress system (Harris 1970, McCarthy 1980), and yet the same process, applied as a way of resolving triconsonantal clusters, is active in stress (Harris 1977, Alderete 1995b). A second example of partial metrical activity of epenthesis in stress is found in the Iroquian language Mohawk. In this language, syllabically motivated epenthesis generally breaks up obstruent + resonant clusters, but the sensitivity of the process to the basic accent pattern is mixed: epenthesis into biconsonantal clusters is inactive in the system, yet epenthetic vowels which surface in a closed syllable are stressed according to the regular pattern (Michelson 1981, 1988, Piggott 1995). Similar cases of partial metrical activity of epenthesis are observed in the Malayo-Polynesian language Lenakel (Lynch 1978), in Arabic dialect phonology (see especially Farwaneh 1995), and the Papuan language Yimas discussed in the introduction. In this section, the complicated interactions between stress and epenthesis in Yimas will be studied and its implications for the role of derivationalism in phonology will be discussed.

To review the facts fleshed out in section 1, words in Yimas are regularly stressed on the initial syllable, but epenthesis into initial clusters causes two complications for the regular pattern. First, if the initial syllable contains an epenthetic vowel, stress is shifted to the second syllable, e.g., *pi̱kám*. This observation shows that the system avoids stressing epenthetic vowels. However, epenthetic vowels may be stressed in a particular context. When both the first and second syllable contain epenthetic vowels, stress defaults to the canonical position, i.e., the initial syllable, as in *krí̱mki̱nawt*. Any theory of stress-epenthesis interaction needs to account for the mixed behavior of epenthetic vowels in cases like this.[6]

Let us begin the analytical work by considering how partial metrical activity of epenthesis is derived within a derivational model. The basic premise of the Rule Ordering theory is that activity in stress is derived by the presence of some structure at the derivational instant at which stress is assigned. In Yimas, this entails a characterization of epenthesis as a pair of rules along the following lines. One rule of epenthesis, Epenthesis$_1$, applies before the assignment of initial stress, operating essentially in the context of triconsonantal clusters which cannot be incorporated

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[6]Secondary stress is assigned to the third syllable from the beginning of the word, suggesting that stress obeys a binary pattern. Discussion of the interaction of secondary stress and epenthesis is postponed to the end of this section.

into well-formed syllables. An independent rule of vowel insertion, Epenthesis$_2$, which is also motivated in contexts of unsyllabified consonants, must follow stress assignment. This is illustrated for two crucial forms in the following derivation.

(18) Partial Metrical Activity in a Derivational Model

Underlying Representations	/pkam/	/krmknawt/
Epenthesis$_1$	DNA	krɨ̲mknawt
Initial Stress	pkm	krɨ̲́mknawt
Epenthesis$_2$	pɨ̲kám	krɨ̲́mkɨ̲nawt
Surface Representations	[pɨ̲kám]	[krɨ̲́mkɨ̲nawt]

As stated in the introduction, the problem with the derivational approach can be summed up as follows: stress-epenthesis interaction as rule ordering requires the bifurcation of a unitary process of epenthesis. The epenthesis process itself yields a single structural change and is conditioned in essentially the same phonological environments, motivated as a means of syllabifying consonant clusters according to the phonotactics of the language (Foley 1991: 48). Therefore, the rule-ordering approach to stress-epenthesis interaction leads to loss of generalization because the observations that characterize the epenthesis process are stated more than once.

Stress-epenthesis interaction in Yimas shows that a unitary process has divergent effects in the stress system: the behavior of epenthetic vowels in the pattern of primary stress is nonuniform. Patterns of nonuniformity of this kind are well-studied phenomena within Optimality Theory,[7] and I will argue that nonuniformity in stress-epenthesis interaction receives a natural interpretation in parallelist OT. To give a brief sketch of this approach, let us review the schematic rankings employed in section 2. The cases examined above were rather straightforward, involving essentially the ranking of a set of stress constraints relative to Head Dependence. Giving HEAD-DEP high rank in the system yields metrical inactivity of epenthesis, as for example in Dakota. On the other hand, by assigning HEAD-DEP low rank, the opposite result is obtained, as in the case of Swahili. In the more complicated case of Yimas, the intricacies of the system can be directly obtained by combining both of these schematic rankings. In particular, partial activity of epenthetic vowels in stress is derived by interleaving HEAD-DEP with the stress-related constraints as shown below. In this ranking, C_{Stress} represents a set of constraints that yield a regular pattern of stress, and C'_{Stress} is the complement of that set.

(19) Partial Metrical Activity of Epenthesis

C_{Stress} >> HEAD-DEP >> C'_{Stress}

Partial activity in stress is therefore a direct consequence of the basic assumption in OT that grammars are modelled as a totally-ordering of constraints. One component of the constraint system derives the metrical inactivity of the epenthesis, namely HEAD-DEP >> C'_{Stress}. However, an independent set of constraint rankings, i.e. C_{Stress} >> HEAD-DEP, forces a

[7] See Prince 1993 for the first characterization of the phenomena in OT, and Prince & Smolensky 1993, Alderete 1995b, and Pater 2000 for discussion of a variety of examples.

violation of Head Dependence, with the effect of compelling metrical activity of epenthesis in just those contexts governed by C_{Stress}. This schematic ranking will be applied directly below in my analysis of Yimas.

Starting with the regular stress pattern itself, initial stress with alternating secondary stress on subsequent syllables diagnoses Yimas as a trochaic language. Hence RHTYPE = T is high ranking, relative to the analogous rhythm type constraint requiring iambic rhythm. Further, Foot Binarity is enforced at the level of the syllable, which together with high-ranking RHTYPE = T, yields a syllabic trochee. Further, the alignment constraint, ALIGN-L (F, PrWd), ensures left-to-right foot construction; iterative footing is accounted for by ranking the syllable-to-foot parsing constraint, PARSE-SYLL, above ALIGN-L, which asserts that all prosodic feet coincide with the left edge (following McCarthy & Prince 1993b). In total, RHTYPE = T and Foot Binarity gives the syllabic trochee, and the alignment constraint, interacting with the syllable parsing constraint, conspire to yield left-to-right iterative foot construction.

With this component of the constraint system fleshed out, we can now move to the constraint rankings which account for noncanonical second syllable stress. Recall that this stress pattern correlates with initial epenthesis. Since the constraints deriving the canonical pattern posit the syllabic head of the main stress foot on the initial syllable, epenthesis into this position puts the stress constraints in conflict with Head Dependence. Hence, parsing the first two syllables as a syllabic trochee, as in the first candidate given below, violates HEAD-DEP for the head syllable. By ranking HEAD-DEP above the alignment constraint, therefore, the right result is obtained.

(20) Metrical Inactivity of Epenthesis: /kcakk/ → *kɨ̠cákɨ̠k*

Input: kcakk	HEAD-DEP	ALIGN-L
{kɨ̠́ca} kɨ̠k	ɨ!	
☞ kɨ̠ {cákɨ̠k}		kɨ̠k

Because the epenthetic vowel *ɨ̠* has no input correspondent, parsing it as the head syllable of the word incurs a violation of the top-ranked HEAD-DEP. Therefore, the optimal form is the one that violates ALIGN-L as a means of satisfying HEAD-DEP. Furthermore, in disyllabic forms such as *pɨ̠kám*, HEAD-DEP compels a rhythm type reversal, by domination of RHTYPE = T. Thus, consistent with the approach taken to metrical inactivity of epenthesis in section 2, failure to stress an epenthetic vowel is derived by ranking Head Dependence above stress-related constraints.

In one context, however, epenthetic vowels are recruited in stress assignment, indicating that Head Dependence is itself dominated in the system. As mentioned above, epenthesis into both the first and second syllable correlates with regular initial stress, e.g., *krɨ̠́mkɨ̠nawt*. While the system shows a general avoidance for stressing epenthetic vowels, it would seem that this imperative cannot compel post-peninitial stress because of a hard constraint enforcing a two syllable stress window. With the assumed trochaic foot structure, the stress window amounts to a general ban on two adjacent unfooted syllables, as defended by the scholars in listed in (21).

(21) PARSE-SYLL-2 (Kager 1994, Alderete 1995b, cf. Green & Kenstowicz 1995)
In adjacent syllables, avoid more than one unfooted syllable.

Failure to foot both the first and second syllable constitutes a violation of PARSE-SYLL-2, and since laying down metrical structure has the effect of assigning stress, the complex syllable parsing constraint will suffice as our stress window constraint.

Applying this to the account of the stressed epenthetic vowels, all that is required is to rank the stress window constraint above Head Dependence, as illustrated in the following tableau.

(22) Metrical Activity of Epenthesis: /krmknawt/ → *krɨ̱́mkɨ̱nawt*

Input: krmknawt	PARSE-SYLL-2	HEAD-DEP	ALIGN-L
a. krɨ̱m {kɨ̱́.nawt}		ɨ̱	krɨ̱m!
b. krɨ̱m.kɨ̱ {náwt}	*!		krɨ̱m.kɨ̱
c. ☞ {krɨ̱́m.kɨ̱} nawt		ɨ̱	

Among the candidates provided above, (22b) is not acceptable because by pushing main stress beyond the second syllable, the first two syllables are left unfooted, resulting a fatal violation of top-ranked PARSE-SYLL-2. This leaves the two alternatives, (22a) and (22c), which tie on HEAD-DEP because both forms posit a syllabic head over a nonlexical vowel. The decision therefore falls to the low-ranking ALIGN-L, which chooses in favor of (22c) because it is perfect with respect to left-edge alignment.

Before moving on, it's worth considering the role of Head Dependence in the placement of secondary stress, and how the rankings employed thus far extend to this pattern. Secondary stress is assigned to every other syllable following the primary stressed syllable, which is the third syllable from the beginning of the word in most cases.[8] As noted by Foley (p. 77), this pattern of secondary stress is disrupted precisely when the third syllable is derived by epenthesis. In such forms, stress falls on the fourth syllable from the beginning of the word, as exemplified by the following data.

(23) /tŋkmpɲawa/ tɨ̱́ŋkɨ̱mpɨ̱ɲàwa 'wild fowl'

/kntkcki/ kɨ̱́ntɨ̱kɨ̱cɨ̱̀ki 'bird (sp)'

This shows us that the role of Head Dependence in the stress system is a rich one, extending beyond the exceptions to primary stress placement. That is, it seems that HEAD-DEP induces a noncanonical pattern of foot parsing by requiring an epenthetic syllable to be skipped when it would otherwise be stressed. The constraint ranking here simply involves ranking HEAD-DEP above the alignment constraint, ALIGN-L, which encourages all prosodic feet to be leftmost in the word. With HEAD-DEP top-ranked, the syllable containing the epenthetic vowel will be skipped in the assignment of the pattern of secondary stress, as shown in the following tableau.

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[8]Secondary stress is only assigned in words greater than three syllables, providing further support for an analysis assuming a syllabic trochee with no mechanism for degenerate feet. This is already accounted for in the analysis with Foot Binarity set of the syllable level.

(24) Inactivity of Epenthesis in Secondary Stress: /tŋkmpɲawa/ → *tɨ̱́ŋkɨ̱mpɨ̱ɲàwa*

Input: tŋkmpɲawa	HEAD-DEP	ALIGN-L
{tɨ̱́ŋkɨ̱m} {pɨ̱̀ɲa}wa	ɨ̱!	σ σ
☞ {tɨ̱́ŋkɨ̱m} pɨ̱ {ɲàwa}		σ σ σ

The analysis based on constraint interaction with Head Dependence, therefore, extends to the pattern of secondary stress in Yimas as well.

To review the basic components of the analysis, partial metrical activity of epenthesis is derived within the proposed ranking schema given at the outset of this section.

(25) Stress-Epenthesis Interaction in Yimas
PARSE-SYLL-2 >> HEAD-DEP >> ALIGN-L, RHTYPE = T

The constraint rankings in which Head Dependence is in a dominating position yield the noncanonical pattern: in these rankings, HEAD-DEP compels violation of the stress constraints responsible for deriving regular initial stress and secondary stress on the third syllable. A different ranking in the system involves the domination of Head Dependence by the stress-window constraint, with the effect that epenthetic vowels are recruited in the assignment of stress just in forms which begin with two epenthetic syllables. In conclusion, the theory of stress-epenthesis interaction proposed here meets the challenge of deriving partial metrical activity of epenthesis in a rather straightforward way.

4. Summary and Implications

In this paper, a theory of stress-epenthesis interaction was developed which relies crucially on the notion of correspondence between inputs and related outputs and the OT assumptions that constraints are ranked and violable. The properties inherent to this theory were shown to have a set of advantages, which I will now summarize.

First, these properties of the theory permit a nonderivational treatment of stress-epenthesis interaction. Correspondence between related strings is essential in the formal characterization of HEAD-DEP, and by reranking this constraint in relation to the constraints governing stress, the range of different patterns are derived without the use of serial derivation. The theory is therefore consistent with recent research that outlines the strengths, both empirical and theoretical, of the parallelist approach (McCarthy 1993, 1996, Benua 1997, Alderete 1995a; see Potter 1994 for a different view).

The second advantage of the approach taken here is an empirical one, stemming from the principles of OT. The properties of constraint ranking and domination were used effectively in the analysis of Yimas, which exemplified the common pattern of partial metrical activity of epenthesis. The mixed behavior of epenthesis in this case was handled straightforwardly by ranking HEAD-DEP both above and below the constraints deriving regular stress. The important point is that the OT approach contrasts sharply with the rule-based theory, which was shown to lead to loss of generalization in the characterization of the epenthesis process itself.

The theory developed here also has a theoretical advantage over plausible alternatives in that it paves the way for relating patterns of stress-epenthesis interaction to other phenomena, namely segmental processes like metrically-conditioned vowel reduction. In the analysis of Dakota, noncanonical stress pattern is the result of ranking HEAD-DEP above a constraint that derives a regular pattern of stress. Resistance to vowel reduction in stressed syllables is derived in a parallel fashion by employing the related constraint HEAD-IDENT[F]. In both cases, a head-sensitive faithfulness constraint is given high rank in the constraint hierarchy, with the effect of suppressing regular phonological patterns. The theory of faithfulness to prosodic heads therefore covers considerable empirical ground, with very limited resources.

Before closing, it is worth mentioning some related work that has surfaced in the past year. In the above analyses, two classes of faithfulness constraints are specified for a prosodic target, i.e., the anti-epenthesis constraint, DEP, and the featural faithfulness constraint, IDENT[F]. A number of researchers have modified other faithfulness constraints along similar lines, and I will review them briefly here as a way of sketching some further implications of this basic idea.

One interesting application of position-sensitive faithfulness is developed in Kager (this volume) as an account of the resistance of stressed vowels to undergo syncope. Rather than characterizing vowel deletion as a process that specifically operates on unstressed vowels, a more general account of syncope is given in this work, with the stability of stressed vowels explained as an effect of a position-sensitive HEAD-MAX constraint. Thus, consistent with the approach taken here to vowel reduction, the resistance on the part of stressed vowels to undergo a regular linguistic process is handled with high-ranking head faithfulness.

A second modification of the MAX family of constraints is explored in Beckman 1998 in an account of various syllable structure asymmetries. Different from Kager's HEAD-MAX, Beckman formulates a constraint MAX-*Position*, which requires that all underlying segments be realized in a prominent position in the output. The result of this constraint, when it is properly ranked in relation to the constraints governing syllable shape, is that certain prominent syllables may license a wider range of syllable shapes than the complement set of syllables in a word.

A third application of position-sensitive MAX is given in Yip 1999 for the distribution of tone in Chinese dialects. Developing a strong parallel to the case of Russian examined above, the preference for certain tonal units to dock with a head syllable are explained with a HEAD-MAX[F] constraint for tonal features. Thus, the important innovation here is that Yip's theory completes a positional faithfulness family in input-to-output correspondence by proposing a MAX-type constraint and employing it as a featural faithfulness constraint.

A different form of faithfulness, originally proposed in McCarthy 1995, involves 'matching' of correspondent segments in head positions. McCarthy's HEAD-MATCH asserts that if two segments stand in correspondence, and one segment is in a prosodic head, then its correspondent must be in a head as well. Variants of this constraint have been used in nonderivational approaches to prosodic circumscription effects (McCarthy 2000, McCarthy & Benua in progress, cf. Itô, Kitagawa, & Mester 1996) and in the characterization of faithfulness to underlying prosody in lexical stress systems (Alderete 1996, McCarthy 2000, Pater 2000).

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