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Morphological Alignment and Head Projection

Toward a Nonderivational Account of Epenthesis and Exceptional Stress in Dakota

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Recent work in Optimality Theory (Prince and Smolensky 1993, McCarthy and Prince 1993, to appear) has suggested that phonological regularities can be explained without reference to phonological rules, strictly in terms of constraints on representational well-formedness. A unique aspect of Optimality Theory (OT) is that candidates are evaluated in parallel: there is no serial derivation. Given this type of system, a question that immediately arises is whether empirical evidence that has been used to justify ordered sequences of rule applications or ordered lexical levels can be explained without the use of this type of derivational machinery, strictly in terms of constraints on representational well-formedness. This paper will attempt to answer this question by examining a set of epenthesis and stress facts from Dakota that have been presented (in e.g., Shaw 1976, 1985, Kiparsky 1986) as empirical evidence for a derivational phonology.[1]

1 Stress in Dakota

1.1 Regular Stress

Most surface forms in Dakota are characterized by stress on the second syllable from the left edge of the word, as illustrated in (1) (unless otherwise indicated, the data are from Shaw 1976 and 1985).

(1)	č^{h}ikté	'I kill you'
	wič^{h}áyakte	'you kill them'
	owį́č^{h}ayaktepiktešni	'you will not kill them there'

Shaw (1985) analyzes this pattern as the building of a noniterative iambic foot at the left edge of the word, however, both Shaw (1985) and Sietsema (1988) claim that syllable weight plays no role in determining stress in Dakota. Given Hayes' (1987) proposal that quantity insensitive iambic systems do not exist, the apparent absence of quantity sensitivity in Dakota suggests an alternative analysis of the basic stress pattern in terms of trochaic feet and initial syllable extrametricality. Although such an analysis is more complex than an iambic analysis, as Hayes (1987:277-8) notes, the complexity is justified "in that it provides a formal account of the apparently more marked status of these stress systems."

The basic stress pattern in Dakota can be explained in OT terms through the interaction of four constraints, which are stated in (2).

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[1]Dakota, a member of the Mississippian Valley subfamily of Siouan, is spoken in the Northern Great Plains area of the United States and Canada.

(2) NONINITIALITY, ALIGN(Ft,L,PWd,L), PARSE(σ), FTFORM(TROCHAIC)

Initial syllable extrametricality is ensured by NONINITIALITY , which prohibits the head of the prosodic word (PWd) from falling on the initial syllable (cf. NONFINALITY, Prince and Smolensky 1993:41). ALIGN(Ft,L,PWd,L) states that the left edge of every foot must correspond to the left edge of some PWd, PARSE(σ) requires all syllables to be parsed by feet, and FTFORM(TROCHAIC) requires feet to be of the form ($\sigma_s\ \sigma_w$) (cf. Hayes 1987).

In order to ensure second syllable stress, NONINITIALITY must be ranked over ALIGN, as shown by the tableau in (3).

(3) NONINIT » ALIGN(Ft,L,PWd,L)

wič^{h}ayakte	NONINIT	ALIGN
(s w) (a) wi.č^{h}a.ya.kte	*!	
(s w) (b) ☞ wi.č^{h}a.ya.kte		σ

Noniterativity is enforced by ranking ALIGN over PARSE (McCarthy and Prince to appear):

(4) NONINIT » ALIGN(Ft,L,PWd,L) » PARSE(σ)

owį̨č^{h}ayaktepiktešni 'you will not kill them there'	NONINIT	ALIGN	PARSE(σ)
(s w) (a) o.wį̨.č^{h}a.ya.kte.pi.kte.šni	*!		******
(s w) (b) o.wį̨.č^{h}a.ya.kte.pi.kte.šni		σ	******
(s w)(s w)(s w) (c) o.wį̨.č^{h}a.ya.kte.pi.kte.šni		σσ!σσσσσσ σ	**

Although all but two syllables in candidate (4c) are parsed by feet, the second and third feet incur multiple ALIGN violations. The optimal form is (4b), which contains the single ALIGN violation forced by NONINITIALITY.

The relative ranking of FTFORM(TROCHAIC) with respect to ALIGN and PARSE is not crucial, though bisyllabic forms with final-syllable stress such as *č^{h}ikté* ('I kill you') provide evidence that FTFORM is outranked by NONINITIALITY.

To summarize, the basic stress pattern in Dakota is controlled by the constraint ranking shown in (5).

(5) NONINITIALITY » {ALIGN(F,L,PWd,L) » PARSE(σ)}, FTFORM(TROCH)

Although NONINITIALITY is undominated with respect to the other constraints involved in the basic stress pattern, not all occurrences of stress in Dakota obey this constraint. In the following paragraphs, I will present three sets of surface forms in which stress falls on the initial syllable, in violation of NONINITIALITY.

1.2 Irregular Stress

1.2.1 CVC Roots

Bisyllabic surface forms analyzed in Chambers 1974, Shaw 1976, and Sietsema 1988 as underlyingly CVC bear initial stress. Examples (including the proposed underlying representations) are listed in (6).

(6)	čʰap	→	čʰápa	'beaver'
	šuk	→	šúka	'dog'
	ček	→	čéka	'to stagger'

The examples in (6) should be contrasted with those in (7) which are underlyingly CVCV, and in which stress falls regularly on the second syllable.

(7)	tʰaní	'to be old'
	kasá	'to cover with snow'
	tʰaté	'wind'

Evidence that the surface forms in (6) are underlyingly CVC comes from several sources. First, all words in this class end in the same vowel: [a]. Second, the final vowel does not appear when these words function as the first element of a lexical compound, as shown in (8).[2]

(8)	šuk+manitu	šukmánitu	'wolf'	(dog+wilderness)
Cf.	osni+kʰo	osníkʰo	'to portend cold weather'	(cold+foretell')

Third, reduplication never copies the final vowel:

(9)	čéka	'stagger'	
	čekčéka	'to stagger repeatedly'	(*čékaka)
Cf.	ixa	'smile'	
	ixáxa	'to grin'	(*ixíxa)

These data lead us to conclude that the structure of the forms in (7) is CVC[a], where [a] is epenthetically inserted.

1.2.2 Clitics

Postnominal and postverbal clitics never receive stress (Shaw 1976:39). When these clitics attach to monosyllabic stems, the surface form bears initial stress:

(10)	mni-kį	mníkį	'the water'	(water+the)
	špą-šni	špą́šni	'it's not cooked'	(cook+Neg)
	čʰi-ke-šni	čʰíkešni	'he is rather disinclined'	(want+qualifier+not)

These examples should be contrasted with other cases of postnominal/postverbal morphology, in which stress is regular. As shown in (11), in examples involving suffixal reduplication of a monosyllabic root stress falls on the second syllable.

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[2] See below (§1.2.3) for a more detailed discussion of compounds.

(11)	ček	čekčéka	'to stagger repeatedly'
	sak	saksáka	'be hard and stiff'

Similarly, when the adverbial suffix *-ya*, which marks subordinate stative complement verbs, is attached to a monosyllabic root, stress falls normally on the second syllable:

(12)	ptus-yá	'bent over'
	ska-yá	'in a white condition'

The data in (11-12) illustrate that it is not a fact about suffixes in general that they do not receive stress. The explanation of the forms in (10) must therefore not only account for initial syllable stress on monosyllabic stems, but also account for the obligatory absence of stress on the functional clitics.

1.2.3 Compounds

Shaw (1976, 1985) distinguishes between two types of compounds: *lexical* and *syntactic*. Lexical compounds are characterized by semantic noncompositionality and phonological opacity, while syntactic compounds are compositional and phonologically transparent. These compounds are further distinguished by stress facts: stress falls regularly on the second syllable in a lexical compound, but syntactic compounds bear two stresses: one on each constituent. The minimal pairs in (13) and (14) illustrate the contrast between the two types of compounds.

(13)	*Lexical Compounds*			
	hą-wak^{h}ą	hąwák^{h}ą	'northern lights'	(night+holy)
	mni-wa-xca-xca	mniwáxcaxca	'water lily'	(water+nom+blossom-RED)
(14)	*Syntactic Compounds*			
	hą-wak^{h}ą	hą́wak^{h}ą́	'holy night'	(night+holy)
	mni-wa-xca-xca	mníwaxcàxca	'water flower'	(water+nom+blossom-RED)

As shown in (14), when the first member of a syntactic compound is monosyllabic, stress falls on the first syllable.

To summarize, each set of data in §1.2 contains examples that appear to violate NONINITIALITY, which requires all polysyllabic words to bear second-syllable stress. As noted in the introduction, a basic claim of Optimality Theory is that a surface form may violate a number of constraints, provided it is the optimal form with respect to other candidates. The task at hand, then, is to uncover the aspects of Dakota grammar that force violation of NONINITIALITY in satisfaction of some higher ranking constraint(s).

2 Morphological Representation

I will adopt the representational model of morphology developed in Selkirk 1983, in which morphological structure, like syntactic structure, is represented by a context free grammar containing word structure rules that assign every word of the language a structural description. Structural descriptions take the form of X-bar theoretic phrase structure trees (Jackendoff 1977) with two additional bar levels below X^0: X^{-1} and X^{-2}. Following Selkirk, I will refer to the morphological constituencies defined by these bar levels as Morphological Word (MWd), Stem, and Root, respectively.

The complex morphological structures that are relevant to this paper are cliticized structures and lexical and syntactic compounds. According to Shaw's (1985) discussion of Dakota Lexical Phonology, cliticization is a Level 3 process: it is part of the word level phonology. Evidence in favor of this analysis comes from morpheme ordering facts: clitics are always postverbal or postnominal, and always appear outside any other postverbal or postnominal morphology, such as *ya-* suffixation and suffixal reduplication:

(15)	a.	*-ya suffixation*	[ptus-yá][šni]	(bent over+not)
	b.	*suffixal reduplication*	[tasák-saka][pi]	(frozen-RED+Pl)

Both *-ya* suffixation and reduplication are lower-level morphology (Shaw 1985); in terms of the system adopted here, these structures involve concatenation of morphemes at the Stem or Root level (exactly which is not crucial to the current analysis). It follows from the architecture of the morphology that the constituent consisting of base plus suffix is dominated by MWd. The distribution of clitics can be accounted for by assuming that cliticization involves adjunction to MWd, as illustrated by the tree in (16).

(16) MWd

MWd Clitic

Both the sister of the clitic and the constituent dominating it are of the category MWd. Because the constituents containing *-ya* or the reduplication suffix are dominated by the lowest MWd node in (16), clitics will appear outside other suffixal morphology.

The second relevant category of morphological structures is compounds. As noted in §1.2.3, lexical compounds are characterized by semantic noncompositionality and phonological opacity, while syntactic compounds are compositional and phonologically transparent. In a representational morphology, the differences between lexical and syntactic compounds should follow from structural differences.

There are a number of contrasts between the two types of compounds that suggest a formulation of their respective structural representations. Clitics never appear on the first member of a lexical compound, but they may appear on the first member of a syntactic compound, as in the syntactic compounds in (17) (the clitics are underlined; the constituents of the compound are enclosed in brackets).

(17)	[yé-kta][ʔiyèč^{h}eča]	'he ought to go'	(go-Fut+ought)
	[t^{h}í-pi][kaɣa]	'to house-build'	(live-Pl+make)

Given the analysis of cliticization proposed above, it must be the case that the first member of the syntactic compound is a MWd. (18) demonstrates that the second member of this type of compound may also be cliticized.

(18) [tók^{h}a-ni][gli-kù-šni] 'he could not come out'
(how-Neg+arrive back-come-Neg)

These facts support the structural representation for syntactic compounds shown in (19).

(19) MWd

MWd MWd

This analysis of syntactic compounds can be used to determine the structure of lexical compounds. Although the latter may occur inside the former, as in (20), there are no examples of the reverse (the lexical compound in (20) is underlined).

(20) [šuk-mánitu][ktèpi] 'they are wolf-killing' ([dog+wilderness][kill-Pl])

This example indicates that lexical compounds involve concatenation of morphological constituents below MWd, otherwise we would expect to find syntactic compounds inside lexical compounds as well. Given the three-tiered morphology that I have adopted, lexical compounds must involve concatenation of Stem or Root constituents. Evidence in support of the former analysis comes from three facts about the distribution of affixes and morphemes in lexical compounds. First, as shown by the data in (21), prefixal affixes may form a constituent with the second member of a lexical compound.

(21)	[t^{h}i][í-yuta]	'guy ropes for tipi'	(live+instrument-strength)
	[pezí][o-gnak]	'hayloft'	(grass+locative-put)

Second, prefixal affixes may also appear in front of the entire compound, as in the forms in (22).

(22)	i-[mní][icu]	'instrument for taking water'	(inst-water+take)
	o-[sní][k^{h}o]	'to portend cold weather'	(loc-cold+fortell)

Third, lexical compounds may consist of more than one constituent:

(23) a-[máni][šųk][ole] 'walking about he looked for horses'
(about-walk+horse+look for)

Assuming that affixation complexes are always dominated by Stem (McCarthy and Prince 1993:26), and that compounding in general involves concatenation of constituents of the same bar level (cf. Selkirk 1983), the distributional facts are explained if we assume that lexical compounds have the structure shown in (24)

(24)
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        Stem
       /    \
   Stem      Stem
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To summarize, the analysis proposed here claims that the crucial difference between lexical compounds on the one hand, and syntactic compounds and cliticization structures on the other, is that the former involve concatenation of Stem-level morphological constituents, whereas the latter involve concatenation of MWd constituents. In the following sections, I will show that the proposed structural representations of these morphological configurations provide a straightforward, nonderivational analysis of epenthesis and exceptional stress in Dakota.

3 Epenthesis and Morphological Alignment

3.1 Epenthesis in Dakota

Before we move to an account of the initial stress facts illustrated in §1.2, we must first provide an analysis of epenthesis. As noted in §1.2.1 (see (6), repeated below), CVC roots surface with a final epenthetic [a].

(6)	č^{h}ap	→	č^{h}ápa	'beaver'
	šuk	→	šúka	'dog'
	ček	→	čéka	'to stagger'

Epenthesis is generally accounted for within OT by ranking the constraints NOCODA, which forbids codas, and PARSE, which requires underlying melodic structure to be associated with prosodic structure in the output, over FILL, a constraint that requires all prosodic structure to be filled by underlying melodic structure. As noted by Prince and Smolensky 1993:93 (the *Coda Theorem*), this ordering prohibits codas in *all* situations.

This seems to be the correct analysis of Dakota. Sietsema (1988), citing Boas and Swanton 1911, Beuchel 1939, and Chambers 1974, concludes that Dakota does not contain coda consonants, an observation that I will take to indicate that NOCODA is an undominated constraint.[3] Ranking of PARSE over FILL ensures that NOCODA is enforced by epenthesis, rather than deletion. The proposed ranking is given in (25), and epenthesis in CVC roots is illustrated by the tableau in (25) (where A represents the epenthetic vowel).[4]

(25) NOCODA » PARSE » FILL

(26) Epenthesis in CVC roots.

čex	NOCODA	PARSE	FILL
(a) čex.	*!		
(b) če.‹x›		*!	
(c) ☞ če.xA.			*

Although epenthesis in CVC roots is straightforwardly explained by the ranking in (25), the complex morphological structures discussed in the previous section indicate that the analysis is not so simple. In cliticized forms, which have the structure $[_{MWd}\,][_{Cl}\,]$, and in

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[3]I present three pieces of evidence cited by Sietsema (1988:339-340) in support of the claim that syllables in Dakota are exclusively light. First, the field researchers cited above explicitly state that syllables in Dakota are light. Second, "Dakota shows no final-syllable reduplication of the form CVCCV → CVCCV-CV" in the morphologically complex forms in (i).

(i)	yamni → yamni-mni (*yamni-ni)	'count by three'	
	ha̧ska → ha̧ska-ska (*ha̧ska-ka)	'are tall'	

This pattern holds of stems with medial consonant clusters as well, indicating that the first consonant of the cluster is syllabified as an onset:

(ii)	u̧spe → u̧spe-spe (*u̧spe-pe)	'to learn'	
	u̧kče → u̧kče-kče (*u̧kče-ke)	'to fart'	

Third, Dakota does not permit sequences of three or more consonants. When morphological concatenation creates clusters of three consonants, the first is deleted:

(iii)	p^{h}et+šniz → p^{h}ešniza	(*phetšniza)	'coals, embers'	(fire+to fade)
	šuk+blok → šubloka	(*šukbloka)	'stallion'	(horse+male)

These facts are straightforwardly explained if we assume that Dakota permits onset clusters of maximally two consonants, but no codas.

It should be noted that there are a small number of consonant-final morphemes, such as the clitics and prepositions in (iv) (Sietsema 1988:341), which appear to present a problem for the claim that NOCODA is undominated in Dakota:

(iv)	k'eš	optative marker
	k'eyaš	'but'
	ob	'with'
	el	'in'

Sietsema proposes that the final consonants in these words are not part of the constituent structure of the syllable, but rather adjoined to the syllable by an appendix rule. As this issue does not bear directly on the current investigation, I will leave it unresolved for now.

[4]Although the relative ranking of PARSE and NOCODA is not crucial in (26), the deletion facts exemplified in (fn. 3, iii) provide evidence that PARSE is a dominated constraint (hence dominated by NOCODA, which is undominated).

syntactic compounds, which are of the form [$_{\mathrm{MWd}}$][$_{\mathrm{MWd}}$], if the first MWd is C-final, epenthesis must occur.[5]

(27)a. MWd + Clitic: [$_{\mathrm{MWd}}$...C][$_{\mathrm{Cl}}$ C...] → CAC
[šuk][kį] šúkAkį́ 'the dog' (dog+the)
[hąp][kį] hą́pAkį́ 'the moccasin' (moccasin+the)

(27)b. Syntactic Compounds: [$_{\mathrm{MWd}}$...C][$_{\mathrm{MWd}}$ C...] → CAC
[č^{h}ex][zi] č^{h}éγAzì 'yellow kettle' (kettle+yellow)
[mas][ska] mázAskà 'money' (metal+bright)

Given the proposed status of NOCODA as an undominated constraint, these facts are not surprising. What is surprising is that epenthesis does *not* occur in the same context in lexical compounds, which are of the form [$_{\mathrm{Stem}}$][$_{\mathrm{Stem}}$]. Instead, when the first member of a lexical compound is C-final, the final consonant is incorporated into the onset of the following syllable:

(28) Lexical Compounds: [$_{\mathrm{St}}$ ...C][$_{\mathrm{St}}$ C...] → CC
[č^{h}ex][zi] č^{h}exzí 'brass kettle' (kettle+yellow)
[mas][č^{h}į̌ška] masč^{h}į́ška 'metal spoon' (metal+spoon)

Although both sets of forms satisfy NOCODA, the structures in (27) do so through epenthesis, while the compounds in (28) do so through syllabification.

These facts are explained in a derivational analysis by ordering epenthesis before cliticization and syntactic compounding, but after lexical compounding (see e.g., Shaw 1985). The task faced by a nonderivational account is to provide an alternative analysis strictly in terms of constraints on representational well-formedness. If it can be shown that a representational analysis is explanatorily superior to a derivational account, in addition to being descriptively equal, we will have reason to choose the former over the latter.

In fact, the representational account captures an important generalization that is missed by the derivational analysis. Given the assumption that NOCODA is undominated in Dakota, the basic difference between the forms in (27) and those in (28) must follow from some other constraint. That is, in both (27) and (28), NOCODA is satisfied by incorporating a morpheme-final consonant into a following onset. In the latter case, which does not involve epenthesis, a complex onset is created; in the former case, a complex onset is avoided thanks to the presence of the epenthetic vowel. Complex onsets are excluded in general in OT by the constraint *COMPLEX, defined in (29) (Prince and Smolensky 1993:87).

(29) *COMPLEX
No more than one C or V may associate to any syllable position node.

Given (29), the data in (27-28) can be explained in terms of syllable optimization: epenthesis in the forms in (27) maximizes optimal syllable structure (i.e., CV structure; see Prince and Smolensky 1993:89). Why, then, is epenthesis prohibited in the forms in (28)?

The nature of the facts suggests that an explanation can be stated in terms of Generalized Alignment. McCarthy and Prince (1993, to appear) demonstrate that a wide array of phonological regularities can be explained in terms of the alignment of

[5]Note that the stress facts in CVC roots in morphologically complex structures are identical to the facts discussed in §1.2.1: CVC roots bear initial syllable stress whenever they are followed by an epenthetic [a].

morphological and prosodic constituents. A constraint that plays an important role in a number of languages is ALIGN-R, which is defined in (30).

(30) ALIGN-R: Align(Stem,R,σ,R)
The right edge of every Stem corresponds to the right edge of a syllable.

The epenthesis facts illustrated in (27-28) cannot be explained in terms of ALIGN-R, however, because this constraint is violated equally both in cases of epenthesis (27) and in cases of onset incorporation (28). In both types of examples, a Stem-final consonant is syllabified into the onset of a following syllable, in violation of ALIGN-R.[6] Therefore, some other constraint or constraints must be involved in forcing epenthesis in the forms in (27), but not in those in (28).

The generalization that arises from the data in (27-28) is that epenthesis may occur in structures involving adjunction of a morpheme to MWd in order to maximize CV syllable structure, but not in structures involving adjunction of a morpheme to Stem. In other words, it is more important that morphological constituents at the Stem level be strictly adjacent than it is to obey *COMPLEX, whereas it is more important to have simplex syllables than it is to ensure strict adjacency of morphological constituents at the MWd level. These facts suggest that the most general explanation of the conditions under which epenthesis occurs should be stated in terms of constraints on adjacency; or, in Generalized Alignment terms, alignment of morphological constituents to other morphological constituents.

In fact, such alignment constraints are required as an independent and necessary part of a language's grammar, namely as morphological subcategorization frames. In McCarthy and Prince to appear, morphological subcategorization is handled by alignment constraints of the type shown in (31).

(31) Align(MCat,edge,MCat,edge)

The data in (27) and (28) suggest that the exact ranking of specific morphological subcategorization constraints in the constraint hierarchy is determined by the nature of the third argument of the *Align* function--the category that is aligned to. In particular, the data indicate that morphological alignment constraints in which the third argument is *Stem* outrank morphological alignment constraints in which the third argument is *MWd*. I propose that the generalizations illustrated by these examples should be captured by general constraints that refer to sets of specific morphological subcategorization frames. These constraints, which I will designate ALIGN-TO-STEM and ALIGN-TO-MWD, are defined in (32).

(32) ALIGN-TO-STEM: {x | x is of the form: Align(MCat,edge,*Stem*,edge)}
ALIGN-TO-MWD: {x | x is of the form: Align(MCat,edge,*MWd*,edge)}

ALIGN-TO-STEM and ALIGN-TO-MWD are designed to reflect the hypothesis that specific morphological alignment constraints pattern together with respect to morphological adjacency. The membership of ALIGN-TO-STEM and ALIGN-TO-MWD will vary cross-linguistically, depending on the subcategorization requirements of various morphemes in the language. For example, ALIGN-TO-MWD in Dakota is defined such that it includes specific alignment constraints governing cliticization and syntactic compounds, as in (33).[7]

[6] Align-R is violated in the forms in (27) because MWd dominates Stem.
[7] In (33) and (34), *Head* refers to the rightmost constituent of the compound (cf. Williams 1981 and DiSciullo and Williams 1987).

(33) ALIGN-TO-MWD = {Align(Clitic,L,MWd,R), Align(Head,L,MWd,R),...}

Similarly, ALIGN-TO-STEM in Dakota is defined to include lexical compounds, as in (34).

(34) ALIGN-TO-STEM = {Align(Head,L,Stem,R),...}

Given these definitions, we can now move to an analysis of the epenthesis facts illustrated above. The data in (27-28) show that it is more important for Stem-level morphology to be adjacent than it is for MWd-level morphology, suggesting that the ranking of these constraints is as in (35).

(35) ALIGN-TO-STEM » ALIGN-TO-MWD

As noted above, epenthesis in the forms in (27) breaks up a complex onset in order to satisfy the syllable-structure constraint *COMPLEX. Epenthesis may not occur in the forms in (28), however. As shown by the following ranking arguments, these facts follow directly if *COMPLEX is ranked below ALIGN-TO-STEM but above ALIGN-TO-MWD.

The tableau in (36) justifies the ranking of ALIGN-TO-STEM over *COMPLEX for the lexical compounds, which have the structure [$_{\text{Stem}}$][$_{\text{Stem}}$].

(36) ALIGN-TO-STEM » *COMPLEX: *No epenthesis in lexical compounds.*

[$_{\text{St}}$č^{h}ex][$_{\text{St}}$zi]	ALIGN-TO-STEM	*COMPLEX
(a) ☞ [$_{\text{St}}$č^{h}ex.][$_{\text{St}}$zi.]		*
(b) [$_{\text{St}}$č^{h}e.x]A.[$_{\text{St}}$zi.]	*!	

Crucially, epenthesis in the (b) candidate incurs a violation of ALIGN-TO-STEM. This follows from *Consistency of Exponence*, a fundamental principle of Optimality Theory, which entails that epenthetic segments have no morphological affiliation (McCarthy and Prince 1993:21). Thus the inserted vowel breaks the alignment of the constituents in (36b) that is required by ALIGN-TO-STEM.[8]

In contrast, if *COMPLEX outranks ALIGN-TO-MWD, then the optimal forms in the case of the MWd+Clitic structures and syntactic compounds illustrated in (27) are those that satisfy *COMPLEX. This is shown for syntactic compounds in (37).

(37) *COMPLEX » ALIGN-TO-MWD: *Epenthesis in syntactic compounds.*

[$_{\text{MWd}}$č^{h}ex][$_{\text{MWd}}$zi]	*COMPLEX	ALIGN-TO-MWD
(a) [$_{\text{MWd}}$č^{h}ex.][$_{\text{MWd}}$zi.]	*!	
(b) ☞ [$_{\text{MWd}}$č^{h}e.x]A.[$_{\text{MWd}}$zi.]		*

The ranking arguments presented so far can be summarized in the ranking statements in (38) (a) and (b).

(38) (a) NOCODA, ALIGN-TO-STEM » *COMPLEX » ALIGN-TO-MWD
(b) PARSE » FILL

[8]It should be noted that *COMPLEX is routinely violated *within* morphemes (e.g., *kte* 'kill', *šni* 'Neg', etc.). For now, I will assume that there is a high-ranking constraint that preserves the integrity of the morpheme, forcing a violation of *COMPLEX in all cases of underlying CC clusters.

The ranking of PARSE over FILL ensures that syllable structure will be optimized through epenthesis rather than deletion, while the relative ranking of the alignment constraints with the syllable well-formedness constraints in (38a) allows epenthesis to break up complex onsets only in morphological structures involving concatenation of MWd constituents.

The representational analysis of epenthesis developed here captures two important generalizations. First, epenthesis occurs in order to maximize syllable well-formedness. Whenever possible, syllable structures that contain violations of the constraints NOCODA and *COMPLEX are avoided by inserting an epenthetic vowel. Second, adjacency requirements on morphological constituents are enforced differently depending on the type of constituent (Stem, MWd) involved. Specifically, adjacency of constituents in the Stem morphology is more important than adjacency of constituents at the MWd level. This generalization is directly represented in the OT analysis by ranking ALIGN-TO-STEM over ALIGN-TO-MWD.

3.2 Morphological Alignment in Axininca Campa

There is evidence to suggest that the morphological alignment constraints proposed in (32) are active cross-linguistically, and furthermore, that the ranking relation in (35) represents two-thirds of a general, perhaps universal ranking relation. McCarthy and Prince (1993) present a set of facts from Axininca Campa that appear to provide evidence for two levels of lexical phonology in the language, a prefix level and a suffix level. These levels generate two different types of morphological structures: prefix-Root structures, and Stem-suffix structures, respectively. Syllable well-formedness constraints are enforced by apparent deletion of prefixal material in the former case, but by epenthesis in the latter. Since deletion requires ranking of FILL over PARSE, while epenthesis requires the reverse ordering, we seem to be driven towards a level-based analysis, where the constraint hierarchies on the prefix and suffix levels differ minimally in the relative ranking of FILL and PARSE. The relevant facts are given in (39) and (40).

(39) Violation of PARSE at Prefix-Root junctures:

a.	/ir-saik-i/	i‹r›saiki	[isaiki]	'will sit'
b.	/no-ana-ni/	n‹o›anani	[nanani]	'my black dye'

(40) Violation of FILL at Stem-Suffix junctures:

a.	/~cik+wai-i/	~cikAwaiTi	'I will continue to cut'
b.	/iŋkoma+i/	iŋkomaTi	'he will paddle'

As was the case in Dakota, deletion and epenthesis occur in Axininca Campa in order to maximize syllable well-formedness. The active constraint is CODACOND, which requires all codas to be nasals homorganic to a following stop or fricative. CODACOND is unviolated and hence undominated, but, as the facts in (39) and (40) show, it is satisfied in different ways in different morphological configurations.

The discussion of morphological alignment in the previous section suggests a representational account of these facts. Given the proposed constraints ALIGN-TO-STEM and ALIGN-TO-MWD, and the hypothesis that morphological structure is composed of constituents of MWd, Stem and Root bar levels, we would expect to find, in addition to the constraints discussed above, a constraint ALIGN-TO-ROOT, which is defined in (41).

(41) ALIGN-TO-ROOT: {x | x is of the form: Align(MCat,edge,*Root*,edge)}

As for ALIGN-TO-STEM and ALIGN-TO-MWD, ALIGN-TO-ROOT represents a set of morphological alignment constraints; specifically, those whose third argument is of the category *Root*.

The deletion and epenthesis facts illustrated by the examples in (39) and (40) can be explained in terms of adjacency of morphological constituents, analogously to the analysis of epenthesis in Dakota. *Consistency of Exponence* entails that "underparsing will not change the make-up of a morpheme, though it will...change how that morpheme is realized phonetically" (McCarthy and Prince 1993:21). As a result, deletion of underlying material does not change the domain of a morpheme, and hence does not affect morphological alignment. As observed in the previous section, this is not true of epenthesis, which breaks morphological alignment. Given these considerations, and the undominated status of CODACOND, the facts in (39) indicate that it is more important to maintain strict adjacency of constituents at the Root level than it is to obey PARSE, and CODACOND is satisfied through deletion. The facts in (40) show that it is more important to obey PARSE than it is to maintain adjacency in the Stem-level morphology, so CODACOND is satisfied through epenthesis. The proposed ranking is shown in (42).

(42) ALIGN-TO-ROOT » PARSE » FILL, ALIGN-TO-STEM

Justification for this ranking is provided by the tableaux in (43) and (44). (43) illustrates the case of deletion at a prefix-Root juncture. All forms must satisfy the undominated constraint CODACOND. Because ALIGN-TO-ROOT outranks PARSE, the optimal candidate is one in which an illicit coda is deleted. The resulting structure satisfies both CODACOND and ALIGN-TO-ROOT.

(43) CODACOND, ALIGN-TO-ROOT » PARSE: *Deletion at prefix-Root juncture*.

[$_{Af}$ir][$_{Rt}$saiki]	CODACOND	ALIGN-TO-ROOT	PARSE
σ σσ (a) [$_{Af}$ir][$_{Rt}$saiki]	*!		
σ σ σσ (b) [$_{Af}$ir]A[$_{Rt}$saiki]		*!	
σ σσ (c) ☞ [$_{Af}$i‹r›][$_{Rt}$saiki]			*

In contrast, because ALIGN-TO-STEM is ranked below both of the faithfulness constraints PARSE and FILL, satisfaction of CODACOND at Stem-suffix junctures is determined solely by the relative ranking of PARSE and FILL. PARSE is ranked over FILL, therefore CODACOND is satisfied through epenthesis:

(44) CODACOND » PARSE» FILL, ALIGN-TO-STEM: *Epenthesis at Stem-suffix juncture*.

[$_{St}$cik][$_{Af}$piro]	CODACOND	PARSE	FILL	ALIGN-TO-STEM
σ σσ (a) [$_{St}$cik][$_{Af}$piro]	*!			
σ σ σσ (b) ☞ [$_{St}$cik]A[$_{Af}$piro]			*	*
σ σσ (c) [$_{St}$ci‹k›][$_{Af}$piro]		*!		

Note the striking difference between epenthesis and deletion with respect to ALIGN-TO-ROOT/STEM. Whereas insertion of an epenthetic segment in the (b) candidates triggers a violation of morphological alignment, deletion of a segment in the (c) candidates does not. This follows from the principle of *Consistency of Exponence*, discussed above, and the definition of Generalized Alignment, which is calculated in terms of the string-theoretic representation of a candidate (see McCarthy and Prince to appear:9-10 for formal definitions of the relations involved in Generalized Alignment). Despite the fact that a deleted (unparsed) segment is not phonetically realized, *Consistency of Exponence* states that it remains an element of the morpheme to which it belongs, and hence is a member of the string-theoretic representation of the candidate. Epenthetic segments, although they have no morphological affiliation, are also part of the string-theoretic representation of a candidate. Therefore, despite (surface phonetic) appearances, both deleted and epenthetic segments are involved in the calculation of morphological alignment. The result is that the failure to parse a morpheme-final segment does not affect alignment, whereas the insertion of an epenthetic segment between morphemes incurs an unavoidable violation.

Tableaux (43) and (44) show that given the ranking proposed in (42), there is no need to postulate separate prefix and suffix levels of Axininca Campa lexical phonology, because the same range of facts can be accounted for strictly in terms of constraints on morphological alignment. Moreover, the representational analysis directly parallels the analysis of epenthesis in Dakota. Both languages enforce satisfaction of high-ranking syllable well-formedness constraints, but the precise way in which these constraints are satisfied depends on the nature of the morphological structures that are involved in the violation. The fact that the same basic analysis accounts for similar phenomena in two unrelated languages suggests that the representation of morphological alignment proposed here captures an important generalization: that sets of specific morphological alignment constraints (subcategorization frames) pattern together with respect to the type of constituent aligned to.

An interesting question is raised by the relative rankings of these constraints. The data discussed in this section showed that ALIGN-TO-ROOT outranks ALIGN-TO-STEM in Axininca Campa, while the facts discussed the previous section led us to conclude that in Dakota, ALIGN-TO-STEM outranks ALIGN-TO-MWD. An open question is whether the ranking shown in (45) is justified, and, more importantly, whether it is universal.

(45) ALIGN-TO-ROOT » ALIGN-TO-STEM » ALIGN-TO-MWD

4 Initial Syllable Stress

We may now move to an analysis of the exceptional stress patterns presented in §1.2. (46-49) review the facts to be explained (where the stressed vowel is underlined), and show the morphological structure of the members of each set.

(46) CVC Roots: [$_{MWd}$C$\underline{\text{V}}$C]A

č^{h}ap	→	č^{h}ápa	beaver
šuk	→	šúka	dog
ček	→	čéka	to stagger

(47) MWd+Clitic: [$_{MWd}$C$\underline{\text{V}}$][$_{Cl}$...]

mni-kį	mníkį	the water	(water+the)
pte-wą	ptéwą	a buffalo	(buffalo+a)
spą-šni	spą́šni	it's not cooked	(cook+Neg)

(48) Syntactic Compounds: [$_{MWd}$C$\underline{\text{V}}$][$_{MWd}$CVC$\underline{\text{V}}$...]

hą-wak^{h}ą	hą́wak^{h}ą́	holy night	(night+holy)
mni-wa-xča-xča	mníwaxčàxča	water flower	(water+nom+blossom-RED)

(49) Lexical Compounds: [$_{St}$CV][$_{St}$C<u>V</u>CV...]
hą-wak^{h}ą hąwák^{h}ą northern lights (night+holy)
mni-wa-xča-xča mniwáxčaxča water lily (water+nom+blossom-RED)

Given the proposed morphological representations, the generalization that arises from this set of data is that *every MWd must include a stressed vowel*. This is the type of generalization that we might expect to be captured by a constraint such as LX≈PR (Prince and Smolensky 1993:43) which requires every MWd to also be a Prosodic Word. This constraint is too general to account for the entire array of Dakota facts, however. Although it might account for a subset of the data in (46-49), it would not explain initial syllable stress in CVC roots. This is because a form such as **šuká* (cf. *šúka*) with final syllable stress, would satisfy this type of constraint, and would moreover satisfy NONINITIALITY.

Nevertheless, the connection between the generalization that every MWd must contain a stressed vowel and Prince and Smolensky's LX≈PR is not accidental. The basic relation that LX≈PR is designed to govern is the relation between a prosodic word and a morphological word, which can be thought of as the *projection* of a prosodic constituent onto a morphological constituent. What this constraint does not control is the relation between the head of the prosodic word and the lexical head, both of which constitute independent members of the prosodic and morphological domains, respectively. The Dakota facts suggest that there is a close relation between the lexical head--which in Selkirk's (1983) X-bar theoretic model of morphological structure corresponds to MWd--and the head of the prosodic word, namely that the head of the prosodic word must be realized (through stress) on segmental material that is affiliated to MWd. Put another way, a lexical head must *project* a prosodic head. This relation is enforced by the following constraint:

(50) HEAD PROJECTION (HEADPROJ): [$_{MWd}$... Head(PWd) ...]

HEADPROJ should be understood as involving universal quantification over MWd constituents: every MWd must be such that it contains a prosodic head (i.e., Head(PWd) must be realized at the segmental level on material affiliated to MWd). In the case of a language like Dakota, with noniterative stress, this constraint forces every MWd constituent to include a stressed vowel.

Because prosodic and morphological theory entail the existence of prosodic and lexical heads as constituents of higher prosodic/morphological structures, HEADPROJ is logically independent of LX≈PR. That is, LX≈PR could be satisfied, but HEADPROJ violated, as in the hypothetical form **šuká* discussed above. The epenthetic vowel in this form has no morphological affiliation, so the prosodic head is not instantiated on MWd, in violation of HEADPROJ.

Consideration of the powerful role that Generalized Alignment constraints play in the grammar suggests that there is redundancy in a theory that assumes both HEADPROJ and LX≈PR, however. According to Generalized Alignment, the correspondence of PWd and MWd is controlled by the set of alignment constraints governing configurational relations between prosodic and morphological constituents. By establishing the basic relation between PWd and MWd, these alignment constraints perform the bulk of the work accomplished by LX≈PR. The addition of HEADPROJ permits independent control of the specific relation between prosodic and lexical heads. The consequence of this division of labor is that LX≈PR is unnecessary as an independent element of the grammar. This is a significant result, which should be examined in greater detail than is possible here. I will leave this as a point for future work.

A second result of the introduction of HEADPROJ--one more specific to the current investigation--is that we can provide a straightforward, general account of exceptional stress in Dakota. Recall that in §1.1 it was shown that the regular Dakota stress pattern follows from the constraint ranking given in (5), and repeated below.

(5) NONINITIALITY » {ALIGN(Ft,L,PWd,L) » PARSE(σ)}, FTFORM(TROCH)

Each case of initial syllable stress discussed in §1.2 and repeated above can now be shown to follow from a single adjustment to the grammar: if HEADPROJ is ranked over NONINITIALITY, both the regular and irregular stress patterns are correctly generated. This ranking reflects the generalization drawn from the data in (46-49): it is more important for a lexical head to project a prosodic head than it is to avoid building a head-initial PWd. The final ranking of the constraints governing stress in Dakota is given in (51).

(51) HEADPROJ » NONINITIALITY » {ALIGN » PARSE(σ)}, FTFORM

The interaction of these constraints in generating the observed stress patterns is illustrated in the following set of tableaux.

In the case of CVC roots, HEADPROJ forces initial syllable stress because, according to *Consistency of Exponence*, the epenthetic [a] is not part of MWd. In order for MWd to project the head of PWd, then, the initial syllable must be stressed, in violation of NONINITIALITY. The optimal form is the one that least violates the other constraints; in particular, the optimal form is the candidate in which both syllables are parsed by a foot, in satisfaction of PARSE(σ) (compare (52a) and (52b) below):[9]

(52) CVC Roots: $[_{MWd}$CVC]A

$[_{MWd}$šuk]	HEADPROJ	NONINIT	PARSE(σ)
F σ_s σ (a) $[_{MWd}$šu.k]A		*	*!
F σ_s σ_w (b) ☞ $[_{MWd}$šu.k]A		*	
F σ_w σ_s (c) $[_{MWd}$šu.k]A	*!		

This analysis contrasts with derivational accounts such as the one presented in Shaw 1985, which must assume that the syllable containing the epenthetic vowel is unfooted and that CVC roots contain degenerate feet. This is because the rule that builds iambic feet is ordered before epenthesis, generating structures like (52a).[10]

[9] ALIGN(Ft,L,PWd,L) and FTFORM(TROCHAIC) do not play crucial roles in determining the optimal candidates in the three sets of forms manifesting exceptional stress, so, these constraints are not represented in tableaux (52-54).

[10] (52) demonstrates that initial syllable stress in CVC roots can be accounted for in nonderivationally; it should however be noted that Kiparsky (1986) discusses a set of deverbal nouns that appear to provide strong evidence for a cyclic phonology in Dakota. The nouns are derived from verbal roots that are standard members of the CVC root class: they bear initial syllable stress and have a final epenthetic [a]. The

Monosyllabic MWd plus clitic constructions are treated similarly. In order to satisfy HEADPROJ, the initial syllable--which corresponds to a MWd constituent--must project the head of PWd. Because cliticization structures involve recursion of MWd, the fact that the lowest MWd is stressed ensures that all dominating MWd constituents satisfy HEADPROJ, resulting in a form that bears a single stress on the first syllable. Thus the fact that clitics never receive stress, which was noted in §1.2.2, follows directly from the proposed analysis. (53) illustrates stress assignment in monosyllabic MWd plus clitic constructions.

(53) MWd+Clitic: [$_{MWd}$CV][$_{Cl}$...]

[$_{MWd}$mni][$_{Cl}$kį]	HEADPROJ	NONINIT	PARSE(σ)
F σ_s σ (a) [$_{MWd}$mni][$_{Cl}$kį]		*	*!
F σ_s σ_w (b) ☞ [$_{MWd}$mni][$_{Cl}$kį]		*	
F σ_w σ_s (c) [$_{MWd}$mni][$_{Cl}$kį]	*!		

As noted in §1.2.3, syntactic compounds actually bear *two* stresses--one on each member of the compound. When the first member is monosyllabic, the first syllable must be stressed. Both of these facts follow from the constraint ranking in (51). The optimal form is one in which each member of the compound receives stress because each member of the compound corresponds to a MWd, and so must project a prosodic head:

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deverbal nouns, however, follow the regular Dakota stress pattern: they surface with *second* syllable stress. In addition, in most forms the final [a] is ablauted to [e]. (i) illustrates the paradigm.

(i) lež → léža 'urinates'
ležé 'urine'

I refer the reader to Kiparsky 1986 for a detailed discussion of the reasons why these forms provide evidence for the cycle; my concern here is simply to point out that the contrast between the verbs and the derived nouns can also be accounted for within the nonderivational framework that has been adopted in this paper. The alternative analysis is basically an adaptation of Kiparsky's account. Following Kiparsky (1986:143), we may assume that there is a nominalizing affix that combines with a verbal stem to form a noun. The affix, in addition to its role as a nominalizer, is involved in two crucial functions. First, as in Kiparsky's analysis, it contains the ablaut-inducing features that ensure the proper form of the final vowel in the derived nominals. Second, because it is dominated by MWd, it provides stressable material affiliated to MWd (the ablaut-inducing features can be taken as evidence for this material), with the result that second-syllable stress satisfies HEADPROJ. The derived nouns are treated like other CVCV stems: in order to satisfy NONINITIALITY, they must receive second-syllable stress.

(54) Syntactic Compounds: [$_{MWd}$CV][$_{MWd}$CVCV...]

[$_{MWd}$hą][$_{MWd}$wak^{h}ą]	HEADPROJ	NONINIT	PARSE(σ)
F σ_s σ_w σ (a) [$_{MWd}$hą][$_{MWd}$wak^{h}ą]	*!	*	*
F F σ_s σ σ_s (b) ☞ [$_{MWd}$hą][$_{MWd}$wak^{h}ą]		*	*
F F σ_s σ_s σ_w (c) [$_{MWd}$hą][$_{MWd}$wak^{h}ą]		**!	

Note that in order to satisfy HEADPROJ, both candidates (54b) and (54c) violate NONINITIALITY by building a foot on the first member of the compound. When two competing candidates satisfy HEADPROJ, the optimal form is determined by the constraint hierarchy in (5). (54b) prevails over (54c) because the second member of the compound in the latter candidate incurs a second, fatal NONINITIALITY violation.

This example emphasizes the fact that stress in Dakota follows the general pattern--as controlled by the basic constraint ranking in (5)--*except when* doing so would violate the highly-ranked constraint HEADPROJ. The syntactic compounds in (48) should be contrasted with the lexical compounds in (49), which follow the general pattern: because lexical compounds form a single MWd, stress on any underlying vowel satisfies HEADPROJ. Like other polysyllabic words, the optimal form is the one that satisfies NONINITIALITY, resulting in second-syllable stress.

The analysis developed here has an interesting interaction with the discussion of epenthesis in the previous section. Recall that epenthesis occurred in order to break up complex onsets in MWd morphology, but not in Stem morphology. These facts were illustrated by the examples in (27-28), which are repeated below.

(27)a. MWd + Clitic: [$_{MWd}$...C][$_{Cl}$...]

[šuk][kį]	šúkAkį́	'the dog'	(dog+the)
[hąp][kį]	hą́pAkį́	'the moccasin'	(moccasin+the)

(27)b. Syntactic Compounds: [$_{MWd}$...C][$_{MWd}$...]

[č^{h}ex][zi]	č^{h}éγAzì	'yellow kettle'	(kettle+yellow)
[mas][ska]	mázAskà	'money'	(metal+bright)

(28) Lexical Compounds: [$_{St}$..C][$_{St}$...]

[č^{h}ex][zi]	č^{h}exzí	'brass kettle'	(kettle+yellow)
[mas][č^{h}įška]	masč^{h}į́ška	'metal spoon'	(metal+spoon)

It was noted at the time (fn. 5) that the CVC roots in the complex morphological structures in (27a-b) behave exactly like simplex CVC roots with respect to stress assignment: stress falls on the underlying vowel, never on the epenthetic vowel. This follows directly from the analysis proposed here, because the CVC roots in these structures are of the category MWd, and must therefore project a prosodic head. In contrast, the CVC roots in the lexical compounds in (28) are of the category Stem. Although the entire compound must project a prosodic head, it need not be realized on the first CVC constituent.

5 Conclusion

This paper developed two specific arguments about Dakota phonology, but the conclusions reached have general consequences. First, it was shown that the conditions under which epenthesis may occur as a syllable-strengthening device are dependent on *morphological alignment*, as formulated in §3.1. The analysis was extended to a nonderivational account of similar facts in Axininca Campa, providing support for the basic claims and suggesting that the role of morphological alignment in producing apparently derivational effects should be investigated in other languages. Second, it was argued that exceptional stress in Dakota is not exceptional at all, but is the result of *head projection*, a relation between morphological and prosodic structure that requires every lexical head to project a prosodic head. This analysis led to the more general claim that head projection and Generalized Alignment derive LX≈PR, and that the latter should not be included in the grammar as an independent constraint. Finally, the central result of the analyses of epenthesis and exceptional stress developed here is to demonstrate that facts that have been interpreted as empirical evidence for derivational models of phonology can be elegantly explained in the representational framework provided by Optimality Theory.

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