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Outwards-sensitive phonologically-conditioned allomorphy in Nez Perce

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1 Introduction

When are morphemes realized relative to each other? The question occupies a central place in dividing rival theories of allomorph selection.

The answer in parallel Optimality Theory (Prince and Smolensky 2004 [1993]) is ‘all at once’. In this theory, all aspects of a word’s pronunciation are decided at once, so in principle any portion of the word could affect any other. Theories like Distributed Morphology (Halle and Marantz 1993), Stratal OT (Kiparsky 2000) and Optimal Interleaving (Wolf 2008) present answers that are rather different. These theories appeal to a serial derivation, wherein one affix or block of affixes is realized at a time, and allomorphic choices are made as each additional piece is realized. Some morphemes are realized before other morphemes, and the choice among allomorphs is made on the basis of the limited information available at each derivational step.

These views set up different expectations for the space of possible allomorphic distributions. Suppose, for instance, that the morphemes of a polymorphemic word are realized serially, and that this serial derivation begins with the root and proceeds outward. We then expect that (1) will hold.

- (1) The realization of ‘inner’ morphemes (morphemes closer to the root) cannot be sensitive to the phonological shape of ‘outer’ morphemes.

In theories which realize morphemes serially from the root on out, (1) is derived straightforwardly. We refer to such theories as ‘inside-out serial’. Inner morphemes cannot depend on the shape of outer morphemes in an inside-out serial theory because the outer morphemes will not be realized until later in the derivation.

In this paper, we provide new empirical evidence for an intermediate position regarding (1) and the notion of inside-out seriality. The right theory, we propose, is partly, but not purely, inside-out serial. Cyclic domains are spelled out one at a time, proceeding from inner domains to outer ones. But within a cyclic domain, if the domain contains multiple morphemes, these may be realized in a non-inside-out fashion: either in parallel, or outside-in. Our evidence comes from two case studies of allomorphy in the verbal system of Nez Perce (Penutian). The primary case study involves a functional suffix appearing in contexts of possessor raising.

- (2) a. 'e-ep-**e'ni**-tx siis!
 3OBJ-eat- μ -IMPER.PL soup
 Eat her soup!
 b. 'e-ep-**ey'**-se-0 siis.
 3OBJ-eat- μ -IMPERF-PRES soup
 I am eating her soup.

We argue that the choice between allomorphs *e'ni* and *ey'* represents outward-looking phonologically conditioned allomorphy – a type of effect we would not expect if (1) held in its strongest

form. But we also show that an important echo of (1) persists even in this seeming counterexample. Allomorphy in our case study is sensitive to the phonological shape of outer material only within a limited domain. Material outside this domain is ignored.

Our second example demonstrates sensitivity to the same limited domain. It concerns the allomorphy of the verb root meaning ‘go’, realized either as *kuu* or as *ki*.

- | | |
|--|---|
| (3) a. <i>kuu-se-0</i>
go-IMPERF-PRES
I am going | b. <i>ki-yu'</i>
go-PROSP
I will go |
|--|---|

We show that the choice between *kuu* and *ki* is another case of outward-looking phonologically-conditioned allomorphy. Here, too, phonological material within the local domain matters, and material outside of it does not. We conclude that there is outwards-sensitivity within a cyclic domain, but not across domains.

It is our hope that these case studies shed new light on the debate over (1) in its most stringent form. As the literature stands, we have from Dolbey (1997), Bobaljik (2000), Paster (2006), and Embick (2010) a series of arguments in favor of (1); we have from Anderson (2008), Round (2009), Vaysman (2009), Svenonius (2012), and Wolf (To appear a) a series of arguments against. We join the latter group of authors in maintaining that outward-sensitivity to phonological material does exist. Morphology cannot operate, then, in a fashion that is strictly inside-out serial. But we join the former group of authors in maintaining that outward-sensitivity is tightly constrained by the framework of a serial derivation. A fully parallel morphological theory is not empirically tenable.

The ability to strike a balance between inside-out-serial and non-inside-out-serial aspects of morphological realization is not the exclusive province of any one theory. Therefore, after presenting the case studies of allomorphy by a functional suffix (sections 2 and 3) and by a root (section 4), we show how the new facts can be accommodated both in a version of Distributed Morphology (section 5) and in a version of Optimality Theory (section 6). The DM implementation requires some adjustments to a standard DM model. We call the particular variant of DM assumed here *DM with insertion by phase*. The OT implementation is done within the framework of Stratal OT. In this framework the Nez Perce facts can be accommodated without any need for basic revisions.

2 The Nez Perce morpheme μ

Our first case study of outward-looking phonologically-conditioned allomorphy concerns a Nez Perce suffix that is obligatory in cases of object possessor raising, such as (4). In this example the suffix in question is realized as *e'ny*.¹

- | | |
|--|-------------------------------|
| (4) <i>haama-pim hi-nees-wewkuny-e'ny-\emptyset-e</i> | <i>ha-haacwal-na lawtiwaa</i> |
| man-ERG 3SUBJ-O.PL-meet- μ -P-REM.PAST | PL-boy-OBJ friend.NOM |
| The man met the boys' friend. | |

We take this suffix to instantiate a functional category we call μ . In this section, we prepare the ground for our case study of allomorphy by showing how the realization of μ is affected by general properties of Nez Perce phonology and morphosyntax.

¹ Here and throughout, we provide Nez Perce examples in the standard orthography in use by the Nez Perce Tribe of Idaho. Note that e = IPA æ; y = IPA j; c = IPA ts; \hat{x} = IPA χ .

2.1 Phonological background

The realization of μ is affected by two important phonological processes of Nez Perce. The first is glide formation. In example (4), the exponent of μ ends with a glide. In other examples, it ends with the vowel /i/. Consider the minimal pair in (5).

- (5) a. 'e-ep-**e**'ni-tx 'aayato-na siis!
 3OBJ-eat- μ -IMPER.PL woman-OBJ soup
 Eat the lady's soup!
 b. 'e-ep-**e**'ny-u' 'aayato-na siis.
 3OBJ-eat- μ -PROSP woman-OBJ soup
 I am eating the lady's soup.

When μ is followed by a vowel, it takes the form *e'ny*; followed by a consonant, it takes the form *e'ni*. We take this behavior to instantiate a regular phonological pattern in Nez Perce – one that tells us something helpful about the underlying form of μ .

The /i/~/y/ alternation is attested across a variety of lexical items. It occurs quite frequently at the right edge of verb stems, as in the examples below. Here, too, /i/ occurs before a consonant and /y/ before a vowel.

- (6) a. hi-nees-wewkuny-u' b. hi-nees-wewkuni-s-0
 h-nees-wewkuni-u' h-nees-wewkuni-s-0
 3SUBJ-O.PL-meet-PROSP 3SUBJ-O.PL-meet-P-PRES
 (7) a. pe-hinewy-0-e b. pe-hinewi-se-ne
 pe-hiinewi-0-e pe-hiinewi-se-ne
 3/3-try-P-PRES 3/3-try-IMPERF-REM.PAST

According to Aoki (1970), the underlying forms of verb stems in Nez Perce may end either in a single consonant or in a single vowel. They may not end in a consonant blend such as /ny/ or /wy/. If Aoki is correct, then examples (6) and (7), which show /i/~/y/ alternations in verb stems, should be analyzed as showing glide formation from an underlying vowel; this is not a case of vocalization of an underlying glide. Gliding of short unstressed /i/ occurs in prevocalic position in order to resolve hiatus. Nez Perce does not permit hiatus in its surface forms.

This analysis immediately extends to μ . Once we recognize a general phonological process resolving short unstressed /i/ to /y/ in contexts of hiatus, we need only say for μ that its underlying representation ends in short unstressed /i/. The alternation in (5) is simply a case of regular Nez Perce phonology at work.

Glide insertion is also used to resolve hiatus in a further regular way that affects μ . In the examples above, the suffix follows a consonant and begins in a vowel, /e/. When μ follows a vowel other than short, unstressed /i/, this creates a hiatus which is resolved by insertion of /y/. This occurs, for instance, with the many verbs that end in stressed /i/.

- (8) a. 'e-'wí-ye'ny-0-e b. pee-tqe-nuxsí-ye'ny-0-e
 'e-'wí-e'ni-0-e pee-teqe-nuxsí-e'ni-0-e
 3OBJ-shoot- μ -P.ASP-REM.PAST 3/3-quickly-smell- μ -P.ASP-REM.PAST

This type of hiatus resolution is also totally generalized, as the examples below help show.

- (9) a. hanii-yin' b. hi-kuu-ye
 hanii-in' h-kuu-0-e
 make-PASSIVE 3SUBJ-go- μ -P.ASP-REM.PAST

is not predictable phonologically, as Crook (1999) shows. Second, in intransitive verbs, verb class seems to correlate with unaccusativity, a clearly syntactic distinction (Deal 2011).

Class features condition allomorphy of the *immediately following suffix*. The imperfective, for instance, has form *se* after an S-class item, and *ce* after a C-class item.

- (17) C-class root
 paay-ca- \emptyset
 come-IMPERF-PRES
 I am coming / arriving

- (18) S-class root
 kuu-se- \emptyset
 go-IMPERF-PRES
 I am going

The most typical pattern is for items to appear as *X* after class S, but *n(V)X* after class C. Compare the choice between *nu'* and *u'* (prospective aspect), *naqaw* and *qaaw* (adverbial suffix):

- (19) C-class verbs
 a. cukwe-**nu'**
 know_C-PROSP
 I will know.
 b. la'am-**naqaw**-ca-qa
 finish_C-on.thru_C-IMPERF_S-REC.PAST
 I am emptying it right through.

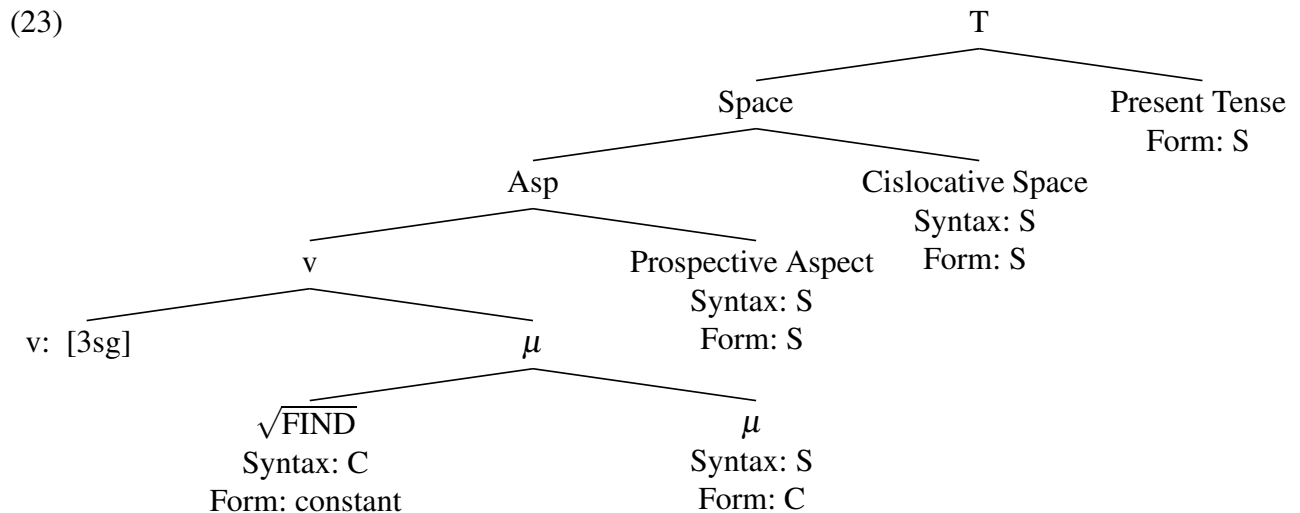
- (20) S-class verbs
 a. 'e-ep-**u'**
 3OBJ-eat_S-PROSP
 I will eat it.
 b. 'inp-qaaw-ca-qa
 grab_S-on.thru_C-IMPERF_S-REC.PAST
 I am grabbing as I go.

The shape of μ follows this pattern: it begins with an /n/ after a C-class item. The class of μ itself can be ascertained by considering the shape of the affix immediately following it. The prospective aspect suffix appearing in (21) and (22) shows us that the class of μ is S.

- (21) 'aw-'yáx-**nan'y**-o'-(kom-)qa
 3OBJ-find_C- μ _S-PROSP-(CS-)REC.PAST
 I could find his/her (shirt).

- (22) 'a-ap-**an'y**-o'-qa
 3OBJ-eat_S- μ _S-PROSP-REC.PAST
 I could eat his/her (soup).

Class allomorphy can be handled as inward-looking dependence on morphosyntactic features of adjacent elements. Suppose the verb word in (21) has the structure in (23). Object agreement is analyzed as an exponent of *v* (Deal 2010).²



² On the optional category of Space marking, see Deal 2009 and Deal 2010, pp 101-102.

The root and each suffix bears a class feature, which we have recorded as its syntax. The root itself appears in a constant form, but the form of each suffix is determined with reference to the syntax of the node immediately to the left. Thus the form of μ reflects the syntax of the root; the form of aspect reflects the syntax of μ ; the form of space marking reflects the syntax of aspect; the form of tense reflects the syntax of space marking.

3 Outward-looking phonologically-conditioned allomorphy of μ

Now we come to the heart of our first case study. In addition to the general phonological and morphosyntactic conditions we have just reviewed, the form of μ is also affected by a third, morpheme-specific factor. We will show that the realization of μ is dependent on the phonological shape of the material to its right. This outward sensitivity determines the choice between a long form of the μ suffix, $(n)en'i$, and a short form, $(n)ey'$.

3.1 The basic facts

In the following subparadigm, either zero or one overt suffix follows the μ suffix.³ The long forms of μ appear when the material following is smaller than CV. (Glide formation occurs here in the regular way.)

(24) Long form: $(n)en'i / (n)en'y$

Form	Suffixes following μ (in order)
'aw-'yáâ-nan'i- \emptyset	Imperative singular
'aw-'yáâ-nan'i-tx	Imperative plural
'aw-'yáâ-nan'i-s- \emptyset	P aspect, present
'iyáâ-nan'i-t	Nominalizer
'aw-'yáâ-nan'y-u'	Prospective aspect
'aw-'yáâ-nan'y- \emptyset -a	P aspect, remote past

The short form appears when μ is followed by a suffix which is CV or longer.

(25) Short form: $(n)ey'$

Form	Suffixes following μ (in order)
'aw-'yáâ-nay'-sa- \emptyset	Imperfective singular, present
'aw-'yáâ-nay'-six- \emptyset	Imperfective plural, present
'aw-'yáâ-nay'-t'aaâ	Modal
'aw-'yáâ-nay'-tato- \emptyset	Habitual singular, present
'aw-'yáâ-nay'-ta- \emptyset	'Go to', singular imperative

The generalization is thus:

(26) μ is $/ey'/$ (short form) when the following material is CV+.
 Otherwise μ is $/e'ni/$ (long form).

This alternation is outward-looking. Nominalization, aspect, mood and "light verbs" all attach outside of μ .

³ The parsing conventions followed here are proposed and justified in Deal (2010, ch 2).

3.2 Phonological conditioning and morpheme-specificity

At this juncture, two preliminary points are in order.

First, there is evidence in this data set that the forms of μ are indeed conditioned by phonological features, rather than grammatical ones. Neither the suffixes triggering the long form nor those triggering the short form constitute a grammatically unified class. Both the nominalizer *-t* and a range of inflectional affixes condition the long form; the short form appears before both sub-inflection affix *te* ‘go away to’ and a range of CV inflections. Suffixes which are in complementary distribution with one another, and thus plausibly instantiate the same morphosyntactic category, fall on different sides of the paradigm. Aspectual markers, for instance, are split between *s* (P aspect) and *u’* (Future/prospective) on the long form side, and *se* (Imperfective) and *tetu* (Habitual) on the short form side.

Second, there is evidence that the choice between short and long forms of μ is ultimately morpheme-specific; it is not indicative of more general phonological processes. Suppose, for instance, the short form appeared with only a following /s/, in the present P aspect. The resulting form, *’aw-’yáx-nay’-s, is ungrammatical, but in other cases the language freely allows *e/ay’-s*-final words:

(27) paay’s
maybe

(28) kiceey’-s
be.ashamed-ADJ

This suggests that the long form is not derived from the short form via phonological processes that result from an independent phonological requirement.

The same argument can also be made in the opposite direction. Consider the long form appearing prior to a CV suffix, e.g. the imperfective singular *se*. The resulting form, *’aw-’yáx-nan’i-sa violates no known constraints on Nez Perce phonology. Forms ending in similar ways include

(29) pe-wye-sepn’i-se-0
3/3-as.one.goes-ask-IMPERF-PRES
He is asking him as he goes.

(30) ’e-tmiipn’i-se-0
3OBJ-remember-IMPERF-PRES
I am remembering it.

These data suggest that the short form is not derived from the long form due to independent phonological constraints.

We might finally consider whether the short and long forms could be derived from an alternative common UR, perhaps *en’y*, by generalized phonological processes. In this case glide vocalization would be required for long-form words like ’aw-’yáx-nan’i-s; /n/-deletion would be required for short-form words like ’aw-’yáx-nay’-sa. Such processes would have to apply only in a highly limited phonological environment – perhaps strictly nGC – as we find no evidence of them in the more general case. To pursue this analysis, we would need to identify a constraint or constraints that could properly adjudicate between the two repairs. Crucially, the constraints required must favor vocalization (and thus *-nan’i-s* over *’-nay’-s) when nGC falls in word final position, but favor n-deletion when a vowel immediately follows nGC (in which case *’-nan’i-sa loses to *-nay’-sa*). We are not aware of independently motivated constraints that would give us this effect while remaining consistent with the data in (27)-(30).

These considerations force us to conclude that the choice between the short and long forms of μ is unlikely to be the result of independent phonological processes in Nez Perce. It is a case of item-specific morphological alternation, a.k.a. allomorphy. The allomorphic distribution is phonologically-conditioned, and looks ‘out’.

3.3 Locality effects

Let us now consider cases where the μ suffix is followed by two or more overt suffixes. As we might expect, when the additional material is added after the CV suffixes conditioning the short form, the short form persists. It also persists when the first suffix following is greater than CV, as in the case of ‘low future’ suffix *tet’ee*.

(31) Short form

Form	Suffixes following μ
’aw-’yáx-nay’-sa-qa	Imperfective singular, recent past
’aw-’yáx-nay’-sii-ne	Imperfective plural, remote past
’aw-’yáx-nay’-qa-qa	Habitual, recent past
’aw-’yáx-nay’-ta-ca- \emptyset	‘Go to’, singular imperfective, present
’aw-’yáx-nay’-tat’aa-sa- \emptyset	Low future, imperfective singular, present

What is more striking is that the long form environments behave in a parallel way. The realization of μ is sensitive outwards only to its immediately local environment.

Forms involving the prospective aspect suffix *u’* provide a first example of this. The fact that CV+ suffixes *kom* (cislocative) and/or *qa* (recent past) appear to the right of μ in the same word is insufficient to trigger the short form; prospective *u’* is in the way.

(32) Long form

Form	Suffixes following μ
’aw-’yáx-nan’y-o’-qa	Prospective aspect, recent past
’aw-’yáx-nan’y-o’-kom	Prospective aspect, cislocative
’aw-’yáx-nan’y-o’-kom-qa	Prospective aspect, cislocative, recent past

Even though quite a substantial amount of phonological material separates μ from the end of the word, the realization of μ remains sensitive only to whether the *first suffix to its right* does or does not begin with CV. This is an instance of opacity in allomorph selection: the long allomorph is chosen even though its conditioning environment is not met in the surface form.

A second example of this type of opacity involves the P aspect, an aspectual morpheme common to constructions translated with the English perfect or perfective. The realization of the P aspect is null in the examples below. Material attached outside of P aspect, *even if CV in form*, does not condition the short form of μ :

(33) Long form

Form	Suffixes following μ
’aw-’yáx-nan’i- \emptyset -m-a	P aspect, cislocative, past
’aw-’yáx-nan’i- \emptyset -ki- \emptyset	P aspect, translocative, present

The challenge for theories of allomorphic conditioning is to account for both the existence of outward-sensitivity of this type and its sensitivity to this locality constraint.

4 Outward-looking phonologically-conditioned allomorphy of \sqrt{GO}

We now present a second case study of outward-looking phonologically-conditioned allomorphy in Nez Perce. This example features not an affix, but the verb root meaning ‘go’ (and also ‘do’).

It is not uncommon for roots to show phonologically-conditioned allomorphy; conditioned allomorphy of a root will always, by definition, be outward-looking. What we want to show with this particular example of root allomorphy is that outward-looking phonological sensitivity is once again restricted to a limited domain. Crucially, the limited domain of relevance is the same for root allomorphy as for allomorphy of μ .

The two forms of root $\sqrt{\text{GO}}$ are shown in (34): *kuu* in (34a), and *ki* in (34b).

- | | | |
|------|---|---|
| (34) | a. <i>kuu-se-0</i>
<i>kuu-se-0</i>
go-IMPERF-PRES
I am going | b. <i>ki-yu'</i>
<i>ki-u'</i>
go-PROSP
I will go |
|------|---|---|

On the surface, the *kuu* and *ki* forms occupy very similar phonological environments. Each is followed by a consonant, but the status of these two consonants is importantly different. The glide in (34b) is not present underlyingly. It is inserted to resolve hiatus between the verb and the prospective aspect suffix *u'*. We propose that *kuu* is inserted before a consonant, and *ki* before a vowel. Glide insertion renders the choice of allomorphs derivationally opaque. Where glides are inserted or harmony applies, we give the surface forms in parentheses in the tables below.

(35) *kuu* form

Form	Suffixes following $\sqrt{\text{GO}}$ (in order)
<i>kuu-se-0</i>	Imperfective singular, present
<i>kuu-tetu-0</i>	Habitual singular, present
<i>kuu-t'ipeec</i>	Frequentative
<i>kuu-qa-qa</i> (kooqaqa)	Habitual, recent past
<i>kuu-s-0</i>	P aspect, present
<i>kuu-t</i>	Nominalizer

(36) *ki* form

Form	Suffixes following $\sqrt{\text{GO}}$ (in order)
<i>ki-u'</i> (kiyu')	Prospective aspect
<i>ki-uu-se-0</i> (kiyuuse)	Goal applicative, imperfective, present
<i>ki-ey'-se-0</i> (kiyey'se)	μ , imperfective, present
<i>ki-aatk-sa-0</i> (kiyaatksa)	'Take away', imperfective, present

Just as for μ , the choice between allomorphs of $\sqrt{\text{GO}}$ is clearly phonologically conditioned. Once again, the alternation at stake is not one that can be explained by reference to general properties of Nez Perce phonology. There is no general /uu/ ~/i/ alternation. The goal applicative, for instance, has form *uu* regardless of whether a vowel follows. In (37), $\sqrt{\text{GO}}$ adjusts its form to reflect the vowel following it, but the goal applicative does not. Glides are inserted to resolve two hiatuses:

- (37) *ki-yuu-yu'*
ki-uu-u'
 go-APPL:GOAL-PROSP

This is thus a case of outward-looking phonologically conditioned allomorphy.

This allomorphy shows a locality effect precisely parallel to what we see for μ in (33). $\sqrt{\text{GO}}$, like μ , is sometimes followed by the P aspect with no overt realization. This means that $\sqrt{\text{GO}}$

is sometimes realized phonologically adjacent to a vowel which is not in its local domain – for instance, a vowel that realizes Tense. In this case, $\sqrt{\text{GO}}$ takes the form *kuu*.

(38)	Form	Suffixes following $\sqrt{\text{GO}}$ (in order)
	kuu-0-e (kuuye)	P aspect, remote past

Despite the fact that $\sqrt{\text{GO}}$ appears immediately prior to a vowel-initial suffix, the form *ki* is not chosen. This makes for an important difference between (38) and the forms in (36). In both cases, $\sqrt{\text{GO}}$ occurs on the surface with a following glide and vowel. What seems to matter is that in one case, but not the other, this vowel falls within the local domain of $\sqrt{\text{GO}}$.

In the next two sections, we consider how the two case studies we have now seen can be analyzed within a revised version of Distributed Morphology (§5) and within Stratal OT (§6).

5 Realization by cyclic domains: Distributed Morphology with insertion by phase

In this section we outline a slightly revised version of Distributed Morphology (Halle and Marantz 1993, Harley and Noyer 1999, Embick 2010), and show how it allows us to capture the Nez Perce facts we’ve just reviewed. The key DM tool for handling allomorphic distributions is the process of Vocabulary Insertion. Following Bobaljik (2000), Adger, Bejar, and Harbour (2003), and Embick (2010), we propose that Vocabulary Insertion operates in a cyclic manner. Where we depart from prior work is in the size of the cyclic domains in which Insertion applies. We propose that Insertion takes place in cycles that may be non-trivial – they need not consist of just a single node. This innovation allows a natural account of limited outward-sensitivity to phonological material.

5.1 DM with Insertion by Phase: the framework

We adopt three particular constraints on Vocabulary Insertion.

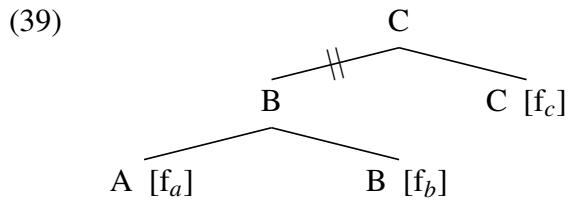
The first and most crucial constraint is *cyclicity*: Insertion proceeds inside-out, cycle by cycle. This, we propose, is the only hard-wired constraint on order of insertion. Within a cycle, items can in principle be inserted in any order. The order of insertion may be constrained only by phonological conditioning requirements of particular VIs: if VIs competing for insertion at α reference the phonology of cycle-mate β , β will need to be inserted before α . In principle, the cycles we require could be particular to the morphological component of grammar, but they could also reflect cyclic domains which have independent motivation in other areas. We pursue the latter approach here. With Svenonius (2012), we hypothesize that cyclic domains for Vocabulary Insertion correspond to phases, the cyclic domains of syntactic computation.

The second constraint is *monotonicity*: Insertion strictly adds information. We thus assume that after Insertion, both morpho-syntactic and phonological features are present. This constraint is prefigured by the work of Adger et al. (2003) and Harizanov and Gribanova (this volume).

The final constraint is *linearity*: the conditioning environment for allomorphy of α must be linearly adjacent to α . This constraint figures centrally in the argumentation of Embick (2010). We understand it in what we take to be the simplest way, assuming in particular that zeros are ignored for purposes of linearity calculation.

With these pieces in place, let us consider the possibilities for allomorphy in a toy example consisting of two phases. The lower phase consists of two nodes, A and B; the higher phase consists

of just one node, C. Each node bears various syntactic features; the phase boundary is marked with a double dash.



Vocabulary Insertion begins with the lower phase. A and B are inserted in any order which makes it possible to resolve conflicts between VIs. Given cyclicity and linearity, allomorphy of A may be conditioned *only* by features of B. Allomorphy of A may look to phonological features of B (in which case B will have to be inserted before A); it may also look to morphosyntactic features of B (regardless of the order of insertion, given monotonicity). Allomorphy of B likewise may look to phonological features of A (if A is inserted first), or to A's morphosyntactic features; but it may also be sensitive to morphosyntactic features of C. Since C belongs to the higher phase, it cannot be inserted before B is. Therefore it is not possible for B to show allomorphy conditioned *phonologically* by C. The only type of outward dependence possible between B and C is morphosyntactic.

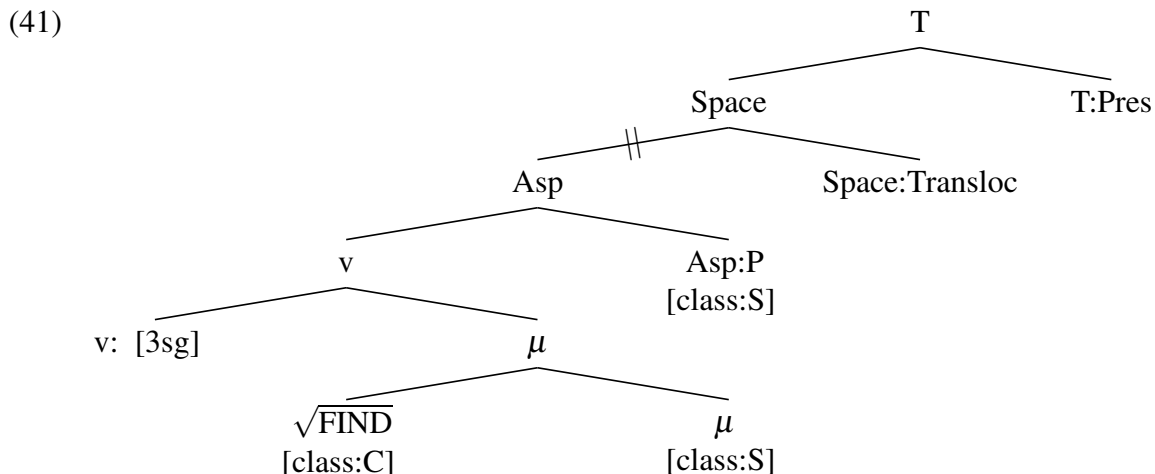
5.2 Handling the realization of μ

We are now ready to apply the proposal to a real example. Particularly illustrative will be the derivation of an example like (40). Here, μ appears in a long form even though it is followed by a CV suffix, translocative *-ki*.

- (40) 'aw-'ya \hat{x} -nan'i-0-ki-0
 3OBJ-find- μ -P.ASP-TRANSLOC-PRES

This suffix will be unavailable to condition allomorphy on μ in virtue of the cyclic nature of Vocabulary Insertion.

The structure of word (40) is shown in (41). Note the presence of a phase boundary between Aspect and Space marking. (For simplicity, we have suppressed morphosyntactic features of material in the higher phase.)



The order of insertion in the lower phase is constrained only by the particular VIs available. Consider, to begin, the case of v . Bearing the features [3sg], the v head has two potential realizations: /'ew/ before a glottal stop, and otherwise /'e/. This means there is competition between two VIs for insertion here.

- (42) a. $v \leftrightarrow \text{'ew} / \text{___} \text{'}^{\wedge}$
 b. $v \leftrightarrow \text{'e}$

In order to resolve this competition, the material linearly right-adjacent to v will need to be present before v is inserted. This means that the root must be inserted before v . Fortunately, the root in this example is quite simple. It shows no allomorphy. This means that there is only one VI available to realize the root's syntactic features.

- (43) $\sqrt{\text{FIND}} \leftrightarrow \text{'yaq}$

Insertion in the lower phase can in principle begin with the root, given that there is no phonologically-driven competition for insertion here. What is crucial, though, is not the *absolute* timing in the derivation of insertion at the root. The theory requires only a *relative* ordering between insertion at the root and insertion at v . The former must precede the latter in order for the competition in (42) to be resolved.

Insertion at μ imposes additional ordering constraints. As we've seen, allomorphy here depends inward on morphosyntax and outward on phonology. Four VIs compete for insertion:⁴

- (44) a. $\mu \leftrightarrow \text{ney}' / [\text{Class:C}] \text{'}^{\wedge} \text{___} \text{'}^{\wedge} \sigma(\text{'}$
 b. $\mu \leftrightarrow \text{ey}' / \text{___} \text{'}^{\wedge} \sigma(\text{'}$
 c. $\mu \leftrightarrow \text{ne'ni} / [\text{Class:C}] \text{'}^{\wedge} \text{___}$
 d. $\mu \leftrightarrow \text{e'ni}$

Resolution of this competition will depend on the phonology of material to the right. This results in another relative ordering imposed on insertion. Insertion at Aspect (to the immediate right of μ) must precede insertion at μ .

As the highest node in the phase, Aspect is subject to a hard-wired constraint: it may not depend phonologically on material outside the phase. It may, however, depend on such material morphosyntactically, given that morphosyntactic features are available throughout the derivation. Indeed, insertion at Aspect in this example depends both inward and outward on morphosyntactic features. It depends inward on class-features, as μ does: outside C-class items, P aspect is always /n/. Outside an S class item, it is /s/ if present tense follows; otherwise it has no realization. We posit two VIs, then:

- (45) a. $\text{Asp:P} \leftrightarrow \text{s} / [\text{Class:S}] \text{'}^{\wedge} \text{___} \text{'}^{\wedge} [\text{T:Pres}]$
 b. $\text{Asp:P} \leftrightarrow \text{n} / [\text{Class:C}] \text{'}^{\wedge} \text{___}$

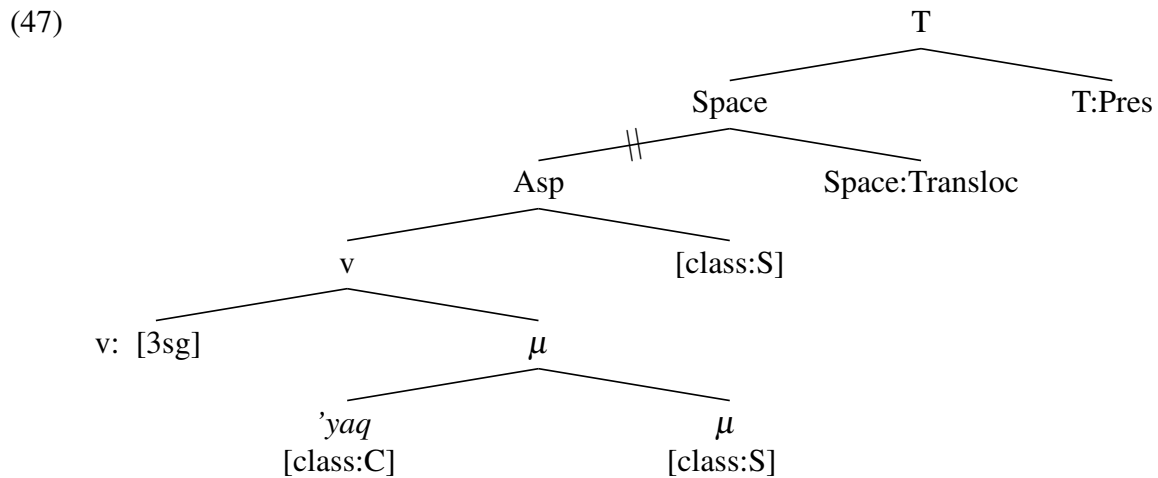
⁴ This list makes it clear that syntactic information to the left and phonological information to the right make independent, non-interacting contributions to the form of μ . While the contribution of phonological material is idiosyncratic, the /n/ triggered by a [Class:C] feature to the left is somewhat regular. In view of this, Peter Svenonius has suggested to us that /n/ might be parsed as an independent morpheme appearing to the right of items bearing a [Class:C] feature. We leave this interesting suggestion to future work, noting only that the appearance of /n/ after Class C items is far from fully automatic. See the examples discussed in Deal (2010, pp 80-82).

If no VI is applicable, insertion simply skips the node; this is our analysis of zero realizations.

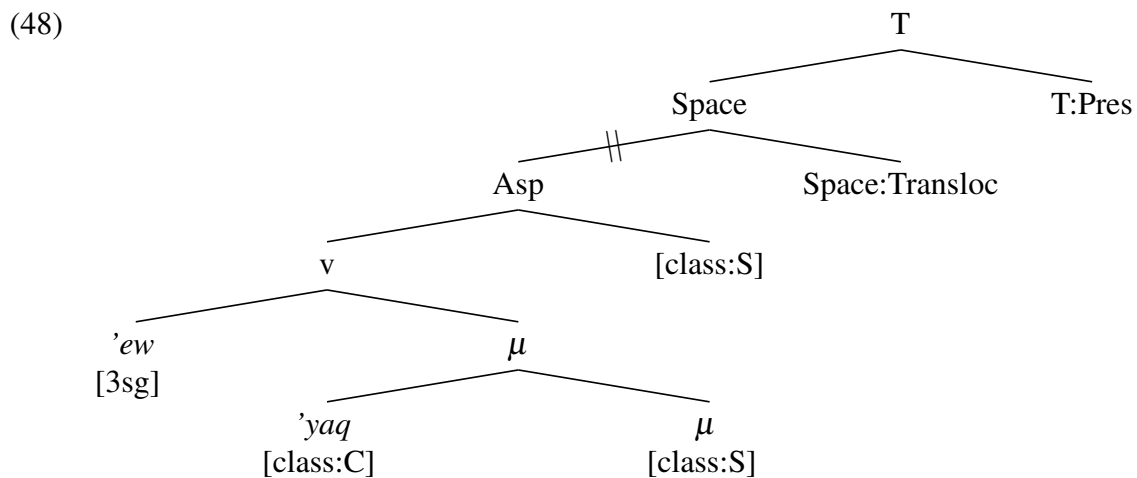
All together, then, the VIs available for the four nodes in the lower phase impose two constraints on insertion. The root must be inserted before v , and Aspect must be inserted before μ . There are thus six admissible orders for insertion in the lower phase:

- (46) i. Root > v > Asp > μ iv. Asp > μ > Root > v
 ii. Root > Asp > v > μ v. Asp > Root > μ > v
 iii. Root > Asp > μ > v vi. Asp > Root > v > μ

Let us exemplify with order (ii). First the root is inserted, and then Aspect. The result is (47).

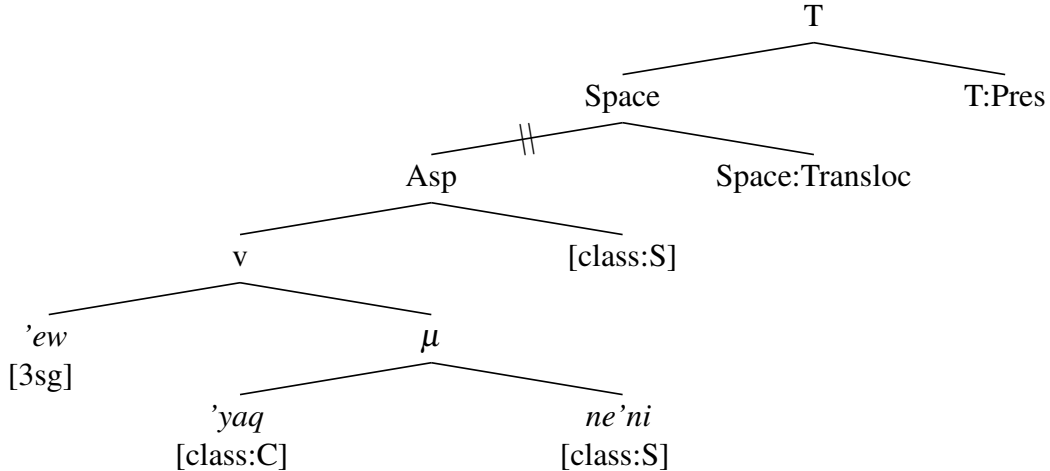


Then v is inserted. The phonology of the root allows the competition among VIs to be resolved in favor of 'ew.



Finally, μ is inserted. Competition for insertion references syntactic features inward and phonological features outward. Since an attempt has already been made to insert at Aspect, it is possible to choose between a short allomorph of μ , which must be followed by $\sigma($, and a long allomorph. In this example, the long allomorph wins.

(49)



This completes the process of Insertion for the lower phase. Insertion now proceeds to the next higher phase. Once Insertion is complete, the word is subject to a post-cyclic, word-level phonological grammar. Phonological processes of vowel harmony, hiatus resolution, epenthesis and affrication apply at this point. Schematically, then, the overall word is formed as shown in (50).

- (50) a. After insertion on Phase 1
 'ew-'yaq-nen'i-
 3OBJ-find-μ-
- b. After insertion on Phase 2
 'ew-'yaq-nen'i-ki [=phonological UR]
 3OBJ-find-μ-TRANSLOC
- c. After application of post-cyclic phonological rules
 'aw-'yaŋ-nan'i-ki [=surface form]

The system provides a natural account of outward-looking phonological dependence of μ . This unusual property of this affix is recorded in the set of VIs that compete for insertion at the μ node. Because there is such a competition, Insertion must apply at Aspect before it applies at μ . When Aspect begins with CV material, μ appears in the short form; otherwise it appears in the long form. It is clear, furthermore, why the short form of μ cannot be triggered by a CV space marker such as translocative *ki*. In order for μ to depend phonologically on the space marker, the space marker would have to be inserted before μ . But this is impossible here in virtue of the geometry of phases. All material in the lower phase must be inserted before any material in the higher phase. Insertion of μ cannot be postponed until after the space marker is inserted.

5.3 Handling the realization of \sqrt{GO}

A very similar analysis can be provided for examples of \sqrt{GO} allomorphy. Suppose the words in (51) have the (partially simplified) structures below.⁵

⁵ Since there are no object agreement features in these intransitive constructions, v will necessarily be zero; we have omitted it for simplicity. We have also omitted space marking. See Deal (2010) for arguments that space marking has no zero allomorph. When no space marking is overtly present, the syntactic category has not been projected.

- (51) a. kuu-0-ye
go-P-REM.PAST
I went.
- b. ki-yuu-0-ye
go-APPL:GOAL-P-REM.PAST
I went over to him/her.
-

Two allomorphs compete for insertion at $\sqrt{\text{GO}}$. As before, the choice references the phonology of following material.

- (52) a. $\sqrt{\text{GO}} \leftrightarrow ki / _ \sim V$
b. $\sqrt{\text{GO}} \leftrightarrow kuu$

In order for this competition to be resolvable, insertion in (51) cannot begin with the root. In (51b), Insertion may target either Aspect or the applicative first. The goal applicative shows allomorphy for class:

- (53) a. APPL:GOAL \leftrightarrow nuu / [Class:C]__
b. APPL:GOAL \leftrightarrow uu

Because $\sqrt{\text{GO}}$ is S class, the form *uu* will be chosen for the applicative. Insertion can then target $\sqrt{\text{GO}}$. Because the following item begins with a vowel, the form chosen in (51b) is *ki*.

Insertion must target Aspect first in (51a). In this environment, Aspect receives no phonological realization. Insertion at $\sqrt{\text{GO}}$ thus chooses the form *kuu*; the environment for insertion of *ki* is not met. In the second phase, insertion for remote past tense chooses allomorph *e*, placing a vowel immediately after the exponent of $\sqrt{\text{GO}}$. It is too late in the derivation, however, for *ki* to be chosen.

The production of the surface forms in (51) may be schematized as follows.

- (54) a. After insertion on Phase 1
- | | |
|-------|---------------|
| (51a) | (51b) |
| kuu- | ki-uu- |
| go- | go-APPL:GOAL- |
- b. After insertion on Phase 2 [phonological URs]
- | | |
|-------------|-----------------------|
| kuu-e | ki-uu-e |
| go-REM.PAST | go-APPL-GOAL-REM.PAST |
- c. After application of post-cyclic phonological rules [Surface forms]
- | | |
|--------|-----------|
| kuu-ye | ki-yuu-ye |
|--------|-----------|

Note that glide insertion, as part of the post-cyclic phonological grammar, occurs after the choice between *kuu* and *ki* has been made in phase 1. This ordering accounts for the opacity of allomorph selection in the case of $\sqrt{\text{GO}}$.

6 Realization by cyclic domains: Stratal OT version

A conceptually similar analysis can be given in Stratal OT (Kiparsky 2000 et seq.). The basic framework of this theory builds on Lexical Phonology and Morphology (LPM; Kiparsky 1982a,b) in dividing the morphology of a language into levels or strata, each associated with a phonological grammar. When a word receives morphology at Level n , it passes through the Level n phonology before moving on to acquire further morphology at Level $n + 1$. In LPM, the phonology of each level is a rule-based grammar; in Stratal OT, it's an OT grammar. Thus processes interact in parallel within a level, but interact serially between different levels.

In implementing a Stratal OT analysis, we adopt the standard assumption that separate morphological and phonological grammars are in force at each level. Class allomorphy is resolved morphologically before the level-internal phonological grammar applies. For the case of μ , this means that the morphology supplies the phonology with either of two sets of disjunctive underlying representations, as appropriate on morphological grounds: {*nen'i*, *ney'*} (after C-class) or {*en'i*, *ey'*} (after S-class). Each candidate in the phonology must pick one or the other alternative UR to be faithful to. In setting the stage for allomorphy in this way, we follow many precedents in the OT allomorphy literature, e.g. Mascaró (1996a,b). (For further references and discussion, see Wolf 2008, §1.2.3.)

6.1 Handling the realization of μ

Let us first consider an example containing only material from a single level. This will include μ and the following aspect suffix; our examples use prospective *u'* and imperfective *se*.


Two constraints are at play in the choice among allomorphs. The first is a morphology-prosody alignment constraint (McCarthy and Prince 1993), which we express below in the categorical constraint schema of McCarthy (2003).

(55) ALIGN(*nen'i*, R, Pwd, R; σ)

Within a prosodic word P, assign a violation-mark if a syllable intervenes between the right edge of the morph /*nen'i*/ and the right edge of P.

For forms where μ is followed by further suffixal material which is smaller than /CV-/ in size, ALIGN is vacuously satisfied by all candidates, and so /-*nen'i*/ will be used on the assumption that this is the default form. (For an overview of various strategies for bringing default preferences among allomorphs into OT models of allomorph selection, see Wolf (To appear b).) This is shown below for μ followed by prospective *u'*. (Prosodic word boundaries are indicated with |...|.)

(56) Selection of long form (prospective aspect)

Input: 'aw-'yáx̣{-{nen'i,ney'}-u'	ALIGN(nen'i,R,Pwd,R, σ)	DEFAULT=nen'i
a.  'aw'.yáx̣.nan'.yo'		
b. 'aw'.yáx̣.nay'.o'		*!

When the following suffix is larger than CV in size, using /-*nen'i*/ will violate the higher-ranked ALIGN constraint, and so /-*ney'*/ will be used instead. This is shown below for μ followed by imperfective *se*.

(57) Selection of short form (imperfective aspect)

Input: 'aw-'yáx̂-{nen'i,ney'}-se	ALIGN(nen'i,R,Pwd,R,σ)	DEFAULT=nen'i
a. 'aw.'yáx̂.na.n'i.sa	*!	
b. 'aw.'yáx̂.nay'.sa		*

As before, we illustrate the crucially cyclic aspect of this analysis with the derivation of (58), where the choice of /-nen'i/ is rendered opaque by subsequent affixation of translocative /-ki/.

(58) 'aw-'yáx̂-nan'i-0-ki-0
 3OBJ-find-μ-P.ASP-TRANSLOC-PRES

Opacity arises here because suffixes are added in two distinct levels. On the first level, only μ and the following aspect marker have been added. Since Aspect has no realization, /-nen'i/ is chosen; there is no full syllable separating it from the right edge of the prosodic word:

(59) Selection of long form at Level 1

Input: 'aw-'yáx̂-{nen'i,ney'}	ALIGN(nen'i,R,Pwd,R,σ)	DEFAULT=nen'i
a. 'aw.'yáx̂.na.n'i		
b. 'aw.'yáx̂.nay'		*!

The chosen form |'aw.'yáx̂.na.n'i| then is passed to the next level, whose morphology adds the further suffix *-ki*. The resultant form |'aw.'yáx̂.na.n'i.ki| now violates ALIGN, since a full syllable [ki] now separates /-nen'i/ from the right edge of the word. However, it's not possible for the phonology of stratum 2 to do anything about that. The alignment violation could be avoided by not syllabifying the segments of the newly-added suffix /-ki/, but we may assume that doing so is barred by highly-ranked Parse-Seg. (Unsyllabified segments are enclosed in <...>.)

(60) Prior selection of long form becomes opaque upon further suffixation at Level 2

Input: 'aw'.yáx̂.na.n'i-<ki>	PARSE-SEG	ALIGN(nen'i,R,Pwd,R,σ)	DEFAULT=nen'i
a. 'aw'.yáx̂.na.n'i.ki		*	
b. 'aw'.yáx̂.na.n'i-<ki>	*!		

(61) PARSE-SEG

One violation-mark for every segment that isn't part of a syllable.


Crucially, there is no candidate *|'aw.'yáx̂.nay'.kil, which would avoid the ALIGN violation – and thereby win – by over-writing the long form selected at Level 1 with the short form. (On the non-existence of 'replacive' morphological operations, see Kiparsky 1996.)

6.2 Handling the realization of \sqrt{GO}

The analysis of \sqrt{GO} is similar, and showcases an important feature of Stratal OT: constraints may be ranked in different ways at different levels.


At level 1, a choice must be made between allomorphs *kuu* and *ki*. Allomorph *kuu* is preferred as a default form.

(62) Selection of /kuu/ at Level 1 (imperfective aspect)

Input: {kuu,ki}-se	DEP	*HIATUS	*HIATUS/V:	DEFAULT=kuu
a. ki.se				*!
b.  kuu.se				

Allomorph *ki* is chosen pre-vocalically due to a higher-ranked constraint against hiatus involving long vowels. (No glides are inserted to resolve hiatus in (63) since *HIATUS is outranked by DEP.)


(63) Selection of /ki/ at Level 1 (prospective aspect)

Input: {kuu,ki}-u'	DEP	*HIATUS	*HIATUS/V:	DEFAULT=kuu
a.  ki.u'		*		*
b. kuu.u'		*	*!	
c. ki.yu'	*!			*
d. kuu.yu'	*!			

The constraint *HIATUS/V: is crucial in choosing the non-default allomorph. Independent evidence for such a constraint comes from outward-sensitive allomorphy in Kayardild (Round 2009, §3.14.2, Wolf To appear a, §3.2), where the choice of allomorphs is attributable to a ban on $V_\alpha V_\alpha V_\beta$ —precisely the configuration avoided here by the choice of *ki* over *kuu*. Another line of evidence for the existence of this constraint comes from Turkish, where intervocalic velar deletion is blocked when first vowel is long (Inkelas 2009).

These derivations continue to the second stratum, where *HIATUS is promoted past DEP. This has no effect in the derivation begun in (62), but in the one begun in (63), hiatus is now resolved.

(64) Continuation of (63): Hiatus resolved at Level 2

Input: ki.u'	*HIATUS	DEP	*HIATUS/V:	DEFAULT=kuu
a. ki.u'	*!			*
b.  ki.yu'		*		*

The resolution of hiatus is too late to affect the choice between *kuu* and *ki*, which has been determined in Level 1. The same applies when a vowel-initial suffix is added in Level 2, as in (65).

(65) kuu-Ø-ye
 kuu-Ø-e
 go-P.ASP-REM.PAST

The first level consists of the root and the aspect marker, which has no realization. Default form *kuu* is chosen. At Level 2, this allomorph must be preserved, and the high ranking of *HIATUS ensures that a glide is inserted.

(66) Analysis of (65): Hiatus resolved at Level 2

Input: kuu-<e>	*HIATUS	DEP	*HIATUS/V:	DEFAULT=kuu
a. kuu.e	*!		*	
b.  kuu.ye		*		

Overall, these analyses illustrate how μ and \sqrt{GO} allomorphy in Nez Perce answer an objection to Stratal OT by Embick (2010, e.g. p 171). If phonological outwards-sensitivity did not exist at all, Embick argues, then Stratal OT is under-restrictive: it bars outwards-sensitive/parallel interactions between affixes of different strata, but still allows such interactions within a stratum. Since, as we've argued, the latter type of interaction does exist in Nez Perce, this isn't a problem after all.

7 Conclusion

We have now seen that DM with insertion by phase and Stratal OT both capture the balance between inside-out-serialism and non-inside-out-serialism we find in the allomorphy of μ and \sqrt{GO} . Both approach the facts in essentially the same way. The morphemes μ and \sqrt{GO} belong to an inner cycle, and the order of insertion within the cycle need not be inside-out serial. This allows for allomorphy to be outward-looking for phonological features. All insertion in the inner cycle must precede all insertion in the outer cycle, however, and this imposes a constraint on phonological outward dependence. Such dependence is possible within a single cycle but not across the boundary between two cycles. In view of the Nez Perce allomorphy facts we have introduced, we maintain that any successful theory of allomorph choice will need to make a similar distinction. Theories that forbid all phonological outward dependence are not tenable. Neither are theories that allow global interactions within words without limit.

While they both strike a balanced note on inside-out serialism, the two theories we have presented nevertheless differ in various respects. Perhaps the single biggest difference concerns the question of serialism internal to the cycle. In the DM analysis, insertion within a cycle is serial in a way that need not be inside-out. In the Stratal OT analysis, insertion within a cycle is in parallel; every morpheme is inserted at once. If the Stratal OT analysis is correct, we expect to find cases where allomorphic selection for two adjacent morphemes is resolved in a way that involves mutual phonological dependence. The two morphemes are inserted at the same time, and the grammar chooses the overall best-ranked combination of allomorphs for a particular level. If the DM analysis is correct, this type of situation will never arise. For any morphemes A and B, it is always the case that A is inserted before B or that B is inserted before A. The morpheme that is inserted second may depend phonologically on the morpheme that is inserted first. But two morphemes may not depend on each other phonologically.

We note in closing that the two proposals we have outlined here are not the only frameworks having the architecture required to deal with the Nez Perce facts. An analysis seems within reach, for instance, in the theory of Optimal Interleaving (Wolf 2008 et seq.), versions of which (Wolf 2008, 174-186, Wolf To appear a) already permit outwards sensitivity under certain conditions. The basic approach can be ported over into an Optimal Interleaving grammar by simply replacing the basic operation of 'spell out one morpheme' with 'spell out one phase'.

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