Indexation to stems and words*

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Abstract

This paper presents a modest extension of indexed constraints, namely that indexed constraints can apply not only to individual morphemes, but also to potentially complex constituents such as the *stem*. This modification allows us to capture a class of long-distance *morphologically derived environment effects* (MDEEs) that have been previously unexplained. MDEEs typically involve an exceptional phonological pattern that is lost under affixation. Formally, this pattern is predicted when complex constituents such as stems are treated as lexically exceptional only when every morpheme contained within them is independently exceptional. This approach further predicts an asymmetry between bare roots and affixed words, between roots and affixes, as well as between inflected and derived words. All other things being equal, the first of each pair is more likely to be expectational or exceptional in more contexts.

1 Introduction

Sound patterns are often affected by the morphological structure of words, not only in the obvious sense that affixation creates new contexts in which phonological processes can apply, but also in more complex cases, with some phonological processes applying only at morpheme boundaries (i.e. not morpheme-internally), or to only a subset of morphemes (e.g. to loanwords, or to affixes but not roots).

This paper focuses on a subset of such morphologically derived environment effects (MDEEs) that present particular challenges for existing accounts of morphophonological interaction because they involve long-distance interactions between affixation and root-internal segments. In Dutch, for example, some speakers produce [ɹ] in recent English loanwords, but produce the native segment [ʀ] in derived words.

(1) Dutch affixation: ɹ → ʀ (Jurgec 2011:§3.4.2; 2014)

Op[ɹ]ah	'Oprah'	Op[ʀ]ah-tje	*Op[ɹ]ah-tje	'DIMINUTIVE'
Ba[ɹ]ack	'Barack'	Ba[ʀ]ack-se	*Ba[ɹ]ack-se	'ADJECTIVE'

Unlike most previously described MDEEs, in this pattern the alternating segment can be at any distance from the triggering affix. Because of this, and because the alternation does not depend on the segmental content of that affix, non-local MDEEs cannot be accounted for by system of constraint indexation like the one proposed in Pater (2007, 2009), which requires that the locus of violation involve an exponent of the indexed morpheme (in this case the affix).

A commonly-expressed intuition about patterns like (1) is that a non-exceptional suffix somehow overrides or conceals the exceptional status of the root. In this paper we implement this intuition with a modest extension of indexed constraints, allowing indexation not only to individual morphemes but also to potentially complex constituents such as the stem or word. This extension derives the regularization patterns typical of long-distance MDEEs. The core of our proposal is that complex constituents are treated by phonology as lexically exceptional only when every morpheme within them is independently exceptional. We show

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that this system can model variation both within and across languages in terms of which classes of affixes (e.g. prefixes vs. suffixes, inflection vs. derivation) trigger root-internal alternations. We also argue that the resulting system has conceptual advantages over a recent account of similar data from Russian by Gouskova & Linzen (2015), which directly encodes regularization factors for individual morphemes. Other accounts of local MDEEs, such as cophonologies (Yu 2000; Inkelas & Zoll 2007) or stratal accounts (Kiparsky 2000; Burzio 2000) also cannot be easily extended to long-distance MDEEs reported in this paper.

We begin in §2 with an introduction to the theory of lexical constraint indexation, and to our minimal extension of allowing constraints to be indexed not only to individual morphemes but also to larger constituents. In §3 we illustrate how this extension accounts for a simple pattern of loanword nativization in Tagalog. In §4–6 we extend the model, illustrating the range of phenomena that can be accounted for by indexed faithfulness constraints. §7 addresses the factorial typology predicted by a system that allows only faithfulness constraints to be indexed, as has been argued for example by Itô & Mester (1995, 2001), Inkelas et al. (1997), and Inkelas & Zoll (2007).

In §8 we turn to the question of whether other constraint types can be similarly indexed. We show that lexically triggered vowel alternations in Russian discussed by Gouskova & Linzen (2015) can be expressed in our lexical indexation model, but only if indexed markedness constraints are possible. We also sketch an index-based analysis of trisyllabic shortening in English, and word-minimality effects in Turkish, neither of which can be captured by indexed faithfulness.

Finally, in §9 we review a number of other accounts that have been offered for similar data, and argue that none matches the empirical coverage of the lexical indexation account we propose.

2 Lexical indexation

Phonology is frequently sensitive to properties of the morphemes to which an operation or constraint applies. In Optimality Theory (OT), one way to account for this is by allowing constraints to be *indexed* to certain classes of words, e.g. to roots (McCarthy & Prince 1993), loanwords (Itô & Mester 1995, 2001), nouns (Smith 2001), specific lexical items (Pater 2000; Becker et al. 2011; Gouskova 2012), or exceptional suffixes (Pater 2007, 2009).

An important observation of work on constraint indexation has been that morphologically sensitive constraint evaluation is *local*: the presence of an exceptional affix in a word does not cause all other affixes to behave as though they were also exceptional. To account for this, Pater (2007, 2009) explicitly limits the reach of indexed constraints with the metaconstraint in (2), so that the locus of violation of an indexed constraint must be part of the morpheme with that index.

(2) $*X_L$ (Pater 2007, 2009)
Assign a violation mark to any instance of X that contains a phonological exponent of a morpheme specified as L.

To illustrate, consider the following example from Colloquial Helsinki Finnish (henceforth Finnish; Anttila 2009). In Finnish, hiatus of a high vowel followed by a low vowel is possible in non-derived words, but not in derived words, where the vowels coalesce into a long high vowel:

(3) Colloquial Helsinki Finnish (Anttila 2009)

NON-DERIVED		DERIVED	
miniæ	'daughter-in-law'	mini-æ → mini-i	'mini-PART'
rasiɑ	'box'	lasi-ɑ → lasi-i	'glass-PART'
saippua	'soap'	hattu-a → hattu-u	'hat-PART'
pøytyæ	'(place name)'	løyly-æ → løyly-y	'steam-PART'

Finnish constitutes a case of a derived environment effect (DEE) applying at morpheme boundaries. To illustrate the mechanism of lexical constraint indexation, here we adapt Anttila's (2009) account of these facts in terms of privileged root faithfulness. We capture this with an indexed constraint $\text{FAITH}_{\text{Root}}$, which is violated by any change to a segment that belongs to a root morpheme. It outranks *IA, the constraint that is violated by hiatus between a high vowel and a following low vowel, which in turn outranks the unindexed Faith.

To see how these constraints interact in Finnish, first consider cases where hiatus is root-internal: (4-a) shows that the indexed constraint $\text{Faith}_{\text{Root}}$ prevents any change to either of the two vowels of the root. In affixed words, this constraint cannot apply to vowels in affixes. *IA is thus able to rule out the fully faithful candidate, forcing the affix vowel to match the preceding root vowel in all features (thus coalescing into a single long vowel).

(4) Lexical indexation in Finnish

a. Hiatus allowed within roots

/miniæ/	$\text{Faith}_{\text{Root}}$	*IA	Faith
i. ☞ miniæ		*	
ii. minii	*!		*

b. No hiatus at the morpheme boundary

/mini-æ/	$\text{Faith}_{\text{Root}}$	*IA	Faith
i. mini-æ		*!	
ii. ☞ mini-i			*
iii. minæ-æ	*!		*

This approach can be easily extended to most other DEEs where a particular process only applies at or close to the morpheme boundary. Yet though the locality requirement expressed in (2) successfully accounts for patterns of the Finnish type, it is challenged by the existence of clearly non-local MDEEs, where an exceptional property of a root is suppressed in certain morphological contexts. Recall the Dutch pattern from (1), for example, in which the segment [ɹ] is possible in certain loanwords when they appear in underived forms (e.g. *Op[ɹ]ah* 'Oprah'), but replaced by [ʀ] in derived words (*Op[ʀ]ah-tje* 'Oprah-DIM'). Such alternations appear to require non-local interactions between affixes and root-internal segments.

We propose that this type of apparently non-local effect can be captured in terms of local constraint evaluation only if constraints can be indexed not only to individual morphemes, but also to complex morphological constituents such as stems and words. This is a natural extension of ideas already present in the literature. We share with many others the view that indexed constraints can be sensitive to both morpheme type (e.g. root, affix) and to arbitrary lexical specification.[1] What we add is the idea that indexed constraints must be further specified for the morphophonological *domain* in which they apply. Maximally local constraint evaluation of the type proposed by Pater (2007, 2009) reflects indexed constraints applying in the domain of single morphemes, but we argue that indexed constraints can also apply to larger constituents of a root plus zero or more affixes (i.e. stems or words). In each case, the indexed constraint will identify both a property (e.g. lexical category, status as a root, belonging to an exceptional class, etc.) and a domain (morpheme, stem, or word).

If *properties* belong to individual morphemes, though, we must ask when indexed constraints will apply to complex domains. We propose that morphosyntactic notions of headedness are not visible within the phonological component, and further assume that complex constituents are not themselves "lexicalized" (i.e. represented in the lexicon without any internal morphological structure, and treated as morphologically simplex by the grammar). Because constituents are not lexicalized, their properties must be calculated on the basis of their component parts; but because morphosyntactic hierarchy is not preserved in the phonology, this calculation cannot distinguish head from non-head elements.[2] We thus propose that phonology resorts to an all-or-nothing calculation of the properties of complex constituents: if a constraint indexed to stems

[1]See for example, McCarthy & Prince (1993); Itô & Mester (1995, 2001); Beckman (1998); Pater (2000); Flack (2007); Gouskova (2007); Jurgec (2010).

[2]This departs from work where morphosyntactic headedness does play a phonological role, e.g. Revithiadou (1999), van Oostendorp (2002), Pensalfini (2002). Note though that the division between derivational and inflectional morphology, central to these proposals, is not maintained in current morphosyntactic theory. Bjorkman & Dunbar (2016) argue on different grounds

or words is further restricted to some class S, the constraint will apply only if all morphemes in the stem or word are equally specified as S.

(5) $*X_{S,M}$
Assign a violation mark for every instance of X that is part of the phonological exponent of an M specified as S. (A constituent M is treated as specified for some class S iff all morphemes within that constituent are specified as S.)

This predicts patterns where marked structures are preserved in stems or words that contain a single morpheme (i.e. a root belonging to an indexed class), but not in stems or words that are complex (i.e. contain at least one non-exceptional affix). The exception will be cases where the root and all affixes are specified for the same lexically exceptional property, as we will see for English trisyllabic shortening in §8.2.

If any of the morphemes in a complex stem or word is not specified for an indexed property, then that stem or word will be treated as not specified for that property, and a general/non-indexed version of a constraint will apply instead. In §3 we briefly show how this extension of indexation accounts for MDEEs in Tagalog loanwords, and in §4–6 how it accounts more broadly for MDEEs across a variety of languages, focusing on MDEE effects in Dutch and Slovenian.

Before moving on, a final remark is in order regarding our assumptions about the morphology-phonology interface, specifically the status of zero affixes. Throughout this paper it will frequently be crucial that forms without any overt affix are treated as having no affix at all, rather than as containing a null affix. Our framework predicts a phonological contrast between an affix that happens to be phonologically null and one that is entirely absent: only the former should ever prevent a lexically indexed constraint from applying to complex constituents. We show that this prediction is borne out by contrasts in zero derivation in §4, and in zero inflection in §6.1.

3 Illustration: Tagalog

This section illustrates our proposed extension of lexical indexation, with reference to non-local MDEEs in Tagalog loanword adaptation.

Consider the Tagalog labial alternations in (6). As first observed by Bloomfield (1917:137), Tagalog allows [f] in bare loanword roots from Spanish, but not in prefixed or suffixed words, where [p] surfaces instead. Note that the segmental content of the triggering affix does not matter.

(6) Tagalog MDEE: f → p (Zuraw 2006, p.c.; Jurgec 2014)

BARE ROOT [f]		PREFIXED [p]		SUFFIXED [p]	
filipino	'Filipino'	pam-pilipino	'INSTR-'	pilipino-ŋ	'-DEF'
fiesta	'feast'	pam-pista	'INSTR-'	pista-han	'festival'

As outlined in §2, we propose that constraint indexation should be divided into two components: the lexical property to which constraints are sensitive (e.g. loanwords), and the morphophonological domain that is potentially specified for that property (e.g. morpheme, stem, word). Each index is thus a pair of a property and a domain. If no domain is specified, we adopt the convention that the constraint applies at the level of individual morphemes. This will yield the type of locality discussed by Pater (2009), which can apply to both roots and affixes. For constraints indexed to larger constituents, there will be an inherent asymmetry between roots and affixes. While it is possible for a root to be the sole morpheme in a stem or a word (allowing the stem or word to "inherit" any lexical properties for which the root is specified), the same is not true of affixes. Any stem or word that contains an affix will always contain at least one other morpheme—a root—and so affixes will only be able to pass on lexical properties that are also shared by the root with which they combine.

In Tagalog, it appears that what is relevant is whether a *word* consists only of morphemes specified as

that giving phonology access to true morphosyntactic hierarchy makes pathological typological predictions about phonological interactions between prefixes and suffixes.

belonging to the class of *loanwords* (L)—i.e. whether the word consists of a single loan root. The relevant IDENT constraint is defined in (7).

(7) $\text{IDENT}_{\text{L,Word}}$
No change in any segment that is part of the phonological exponent of a *Word* specified as *L(oanword)*.

Following the conventions discussed in §2, the constraint in (7) will not apply in words where a non-native root occurs with any native affix, as illustrated in (8-a), because the word-level domain contains non-L-marked morphemes (assuming that no prefixes or suffixes are L-marked in Tagalog). The constraint $\text{IDENT}_{\text{L,Word}}$ does apply, by contrast, in non-affixed words where the word contains only the L-marked root, as illustrated in (8-b). As a result, [f] surfaces in bare roots, but not in prefixed or suffixed words.

(8) Tagalog labial MDEE

a. *Root* ≠ *Word*: $\text{IDENT}_{\text{L,Word}}$ does not apply

/filipino$_\text{L}$-ŋ/	$\text{IDENT}_{\text{L,Word}}$	*f	IDENT_L
i. filipino$_\text{L}$-ŋ	d.n.a.	*!	
ii. ☞ pilipino$_\text{L}$-ŋ	d.n.a.		*

b. *Root* = *Word*: $\text{IDENT}_{\text{L,Word}}$ applies

/filipino$_\text{L}$/	$\text{IDENT}_{\text{L,Word}}$	*f	IDENT_L
i. ☞ filipino$_\text{L}$		*	
ii. pilipino$_\text{L}$	*!		*

This rather simple analysis captures the intuition that it is the status of some roots as loanwords that allows non-native segments to be preserved, together with the idea that the addition of morphology somehow "conceals" the loanword status of the root. This intuition has previously been implemented in different terms, particularly in Inkelas & Zoll's (2007) proposal invoking cophonologies, to which we return in §9.2. We show in the next few sections is that accounting for other MDEEs requires the greater flexibility of indexing constraints not only to individual morphemes or to words but also to intermediate morphological constituents such as the stem.

4 Extension to stems: Dutch

In this section, we detail our analysis of the Dutch rhotic nativization data seen in (1). Dutch resembles Tagalog in that nativization is required only in affixed words, but differs in that only *derivational* affixes trigger nativization. As we will see, this type of pattern is predicted by the system of indexation proposed in this paper.

Recall that Dutch exhibits an alternation between [ɹ], which occurs in some bare roots borrowed from English, and [ʀ].While in (1) it appeared that [ɹ] was incompatible with all suffixes, closer examination reveals that it can occur in some suffixed words, as long as the suffix is inflectional.

(9) Dutch ɹ → ʀ: derivation only (Jurgec 2011:§3.42, 2014)

BARE ROOT [ɹ]		INFLECTED [ɹ]		DERIVED [ʀ]	
Ba[ɹ]ack	'Barack'	Ba[ɹ]ack[s]	'PL'	Ba[ʀ]ack-se	'ADJ'
Op[ɹ]ah	'Oprah'	Op[ɹ]ah[s]	'PL'	Op[ʀ]ah-tje	'DIMIN'
Flo[ɹ]ida	'Florida'	Flo[ɹ]ida[s]	'PL'	Flo[ʀ]ida-tje	'DIMIN'
[ɹ]ex	'Rex'	[ɹ]ex-en	'PL'	[ʀ]ex-en	'V.INF'

We see in (9) that English [ɹ] is retained not only in bare roots in Dutch, but also in words with inflectional affixes only, represented here by plurals. When a loan root undergoes derivational affixation, by contrast, English [ɹ] must be replaced by [ʀ].

This resembles Tagalog in that morphological complexity affects the phonological exceptionality of loans. In Tagalog, we accounted for this by indexing the relevant faithfulness constraints to the domain of *words*: these constraints applied only to words that contained only borrowed morphemes (i.e. to words consisting solely of a borrowed root). In Dutch, we suggest that the constraint refers instead to a smaller domain: the *stem*, a morphological constituent that contains the root and all derivational affixes, but excludes inflectional affixes. The relevant constraint is defined in (10), identical to the one seen in (7) except in the domain over which indexation is evaluated.

(10) $\text{IDENT}_{L,Stem}$
No change of any feature in any segment that is part of the phonological exponent of a *Stem* specified as *L(oanword)*.

Just as with words, a stem will be treated as having a property P if and only if every morpheme within the stem is specified as P. In words where the stem consists only of a root specified as P, this will be trivially satisfied regardless of whether the word as a whole contains any other morphemes (i.e. inflectional morphemes affixed to the stem). But in words that contain at least one derivational affix, it will not be, assuming again that only roots are specified for the relevant property.

The constraint $\text{IDENT}_{L,Stem}$ does not apply in words with derivational suffixes, as illustrated in (11) (abbreviated *d.n.a*), where the constraint *ɹ thus rules out the faithful candidate in (11-a-i). In words with only an inflectional suffix, by contrast, high ranked $\text{IDENT}_{L,Stem}$ prefers the faithful candidate.

(11) Dutch

a. ɹ not possible with derivational suffixes

[flɔɹida$_L$-t^{j}ə]$_{Stem}$	IDENT$_{L,Stem}$	*ɹ	IDENT
i. [flɔɹida$_L$-t^{j}ə]$_{Stem}$	d.n.a.	*!	
ii. ☞ [flɔʀida$_L$-t^{j}ə]$_{Stem}$	d.n.a.		*

b. ɹ possible with inflectional suffixes

[flɔɹida$_L$]$_{Stem}$-s	IDENT$_{L,Stem}$	*ɹ	IDENT
i. ☞ [flɔɹida$_L$]$_{Stem}$-s		*	
ii. [flɔʀida$_L$]$_{Stem}$-s	*!		*

So far we have focused on segmentally realized affixes, and have set aside the issue of possible zero affixes. As pointed out by a reviewer, our analysis predicts that zero affixes should pattern with segmentally overt affixes for the purposes of evaluating constraints indexed to stems or words. As it turns out, data from Dutch shed light on this issue.

First person singular verbs and uninflected nouns in Dutch can be segmentally identical, as in [tekən] 'sign' and [tekən] '(I) draw'. Despite their segmental identity, they interact differently with a phonological process of final n-deletion. Most Dutch words ending on [n] show optional deletion, as in [tekən] ∼ [tekə] 'sign'. First person singular forms are not subject to n-deletion: [tekən], but never *[tekə] '(I) draw'. Zonneveld (1982) attributes this exception to the morphological structure of the verbal forms, which have a zero derivational affix, called the 'theme vowel', while uninflected nouns contain no suffix at all.

This same zero derivational affix can account for the data in (12); the derived first person singular verbs in the second column exhibit obligatory nativization of [ɹ], despite lacking any segmentally overt suffix.

(12) Dutch zero derivation: ɹ → ʀ

BARE ROOT [ɹ]		ZERO DERIVED [ʀ]		
Ba[ɹ]ack	'Barack'	Ba[ʀ]ack-∅	*Ba[ɹ]ack-∅	'act like Barack-1SG'
Op[ɹ]ah	'Oprah'	Op[ʀ]ah-∅	*Op[ɹ]ah-∅	'act like Oprah-1SG'
Flo[ɹ]ida	'Florida'	Flo[ʀ]ida-∅	*Flo[ɹ]ida-∅	'live like in Florida-1SG'
[ɹ]ex	'Rex'	[ɹ]ex-∅	*[ɹ]ex-∅	'act like Rex-1SG'

The prediction of the indexed approach is thus correct: zero derivational affixes pattern with segmentally overt counterparts. We show the same for zero inflectional affixes in §6.1.

The analysis of Dutch is thus a straightforward extension of Tagalog, the principal difference having to do with the domain of the indexed faithfulness constraint. The comparison between the two languages highlights the fact that non-local MDEEs behave differently across languages, even when we restrict our attention to loanword nativization, but that this variation can be captured in terms of the domain to which an indexed constraint applies.

In what follows, we make two further extensions to demonstrate the effectiveness of indexation to stems and words. The first is a cross-linguistic study of loanword nativization patterns (§5), while the second is a case study of several MDEEs in a single language (§6).

5 Loanword nativization crosslinguistically

The two examples of non-local MDEEs we have discussed so far both involve loanword nativization. We have seen variation in whether nativization is triggered by all affixes, or only by derivational affixes. What we have not seen is a language where nativization is triggered by inflectional affixes only. Indeed, our proposed model of constraint indexation predicts that such a pattern is impossible: if derivational morphology is structurally closer to roots than inflectional morphology is, no complex constituent could include inflection but exclude derivation.

This prediction is borne out by a preliminary survey of loanword MDEEs, summarized in Table 1. We have found languages where all suffixes trigger nativization, and others where only derivation does so. Furthermore, some languages show multiple, differing loanword MDEEs[3] All of these patterns can be captured within the framework developed here.For MDEEs triggered only by derivational morphology, indexation will be to the stem; for those triggered by all affixation, indexation will be to the word.

LANGUAGE	STRUCTURE	TRIGGER	EXAMPLE			
Basque	#r	Any suffix	rugbi	‘rugby’	erugbia	‘ABS.DEF.SG’
Catalan	θ	Derivational	θərəˈɣoθə	‘Zaragoza’	sərəɣuˈsa	‘ADJ’
	Unstressed mid V	Derivational	ˈboston	‘Boston’	bustunˈja	‘demonym’
English (Can.)	ʀ	Any suffix	kʀetjɛ̃	‘Chretién’	kɹeɪʧjɛnz	‘POSS’
French	Hiatus (h-aspiré)	Derivational	lə eʁo	‘the hero’	l eʁoin	‘the heroine’
Hungarian	ɹ	Any suffix	ɹɛdfoɹd	‘Redford’	rɛdfordok	‘PL’
	l̴	Any suffix	guːgl̴	‘Google’	guːgølhøz	‘ALLATIVE’
Polish	æ	Any suffix	ʤæs	‘jazz’	ʤazovy	‘ADJ’
Serbo-Croatian	ɹ	Any suffix	p^{h}ætɹik	‘Patrick’	petrikom	‘INSTR’
Spanish	#sC	Any suffix	skajp	‘Skype’	eskajps	‘PL’
Ukrainian	w	Any suffix	woker	‘Walker’	vokeru	‘DAT.SG’

Table 1: Cross-linguistic survey of MDEEs in loanwords

To be clear, not all of the examples in Table 1 necessarily represent synchronic alternations. While the pattern of nativization seen for Dutch in §4 applies productively to recent loans such as *Barack*, other cases may instead result from historical variation in the extent of nativization. We nonetheless include this table to illustrate the point that loanword nativization is quite often sensitive to different classes of morphology (derivational vs. inflectional), beyond the cases we have space to discuss in detail in this paper. This yields a profile that can be accommodated within the system of constraint indexation we propose, though further investigation is necessary in any individual case to determine whether a particular alternation is best analyzed as an MDEE, or arises for independent historical reasons.

[3] These data are based primarily on native speaker elicitations and grammaticality judgments. The following languages have been discussed in the literature: Catalan (Mascaró 1978, 2003), English (McCarthy 2003; Wolf 2008), French (Kiparsky 1973), Serbo-Croatian (Simonović 2015), and Ukrainian (Jurgec 2014).

Table 1 is also limited to loanword nativization, though MDEEs potentially also arise in other areas of the grammar. In §6 we turn to the interaction of several MDEEs in Slovenian, some of which involve loanword phonology, but one of which (schwa fronting) also occurs in the native vocabulary. This demonstrates that a single language can have MDEEs sensitive to different domains, as predicted by the indexation approach.

6 Multiple interactions: Slovenian

Standard Ljubljana Slovenian (henceforth Slovenian) exhibits several different MDEEs. We first look at a pattern that involves loanword nativization under affixation (§6.1). We then turn to a pattern of schwa fronting that occurs only in words with derivational affixes, not those with inflectional affixes, and which we argue requires constraint indexation to the morphological stem (§6.2). Finally, we look at words that exhibit both types of MDEEs, demonstrating that this interaction is predicted by our approach (§6.3).

6.1 Loanword nativization

The pattern observed in Slovenian loanwords very closely resembles the Tagalog and Dutch patterns analyzed above: bare roots allow onset [ɹ] and [w] in words borrowed from English, as shown in (13-a) and (13-b), but these segments are replaced by the corresponding native sounds, [ɾ] and [ʋ], in suffixed words. Similarly, front round vowels, such as [y], are possible in loanwords from German, French, and other varieties of Slovenian, but are replaced by the corresponding unrounded vowels in words containing a suffix, as seen in (13-c).[4]

(13) Slovenian suffixation

a. ɹ → ɾ

BARE ROOT [ɹ]		SUFFIXED [ɾ]		
ɹɔk	'rock'	ˈɾok-oma	*ˈɹɔk-oma	'INSTR.DU'
ˈɹɛgan	'Reagan'	ˈɾegan-i	*ˈɹɛgan-i	'NOM.PL'
maɹk	'Marc'	ˈmaɾk-ts-a	*ˈmaɹk-ts-a	'DIM-GEN.SG'

b. w → ʋ

ˈwɔʃiŋktən	'Washington'	ˈʋaʃiŋkton-a	*ˈwɔʃiŋkt(ə)n-a	'GEN.SG'
wajlt	'Wilde'	ˈʋajld-oʋ-a	*ˈwajld-oʋ-a	'POSS-F.NOM.SG'
twist	'twist'	ˈtʋist-om	*ˈtwist-om	'INSTR.SG'

c. y → i

ˈmynxən	'Munich'	ˈmiŋxen-sk-i	*ˈmyŋxən-sk-i	'ADJ-M.NOM.SG'
tyɾk	'Türk'	ˈtiɾk-om	*ˈtyɾk-om	'INSTR.SG'
ˈnyɾəmbeɾk	'Nuremberg'	ˈniɾəmbeɾg-a	*ˈnyɾəmbeɾg-a	'GEN.SG'

Parallel to Tagalog and Dutch, Slovenian data illustrate a long-distance interaction between the presence of a suffix and the segmental properties of the root. The same interaction can be seen in (14), but triggered by the presence of a prefix rather than a suffix.

(14) Slovenian prefixation (secondary stress not marked)

a. ɹ → ɾ

BARE ROOT [ɹ]		PREFIXED [ɾ]		
ɹɔk	'rock'	anti-ˈɾɔk	*anti-ˈɹɔk	'anti-'
ˈɹɛgan	'Reagan'	nʌd-ˈɾɛgan	*nʌd-ˈɹɛgan	'uber-'

b. w → ʋ

ˈwɔʃiŋktən	'Washington'	nɛ-ˈʋaʃiŋkton	*nɛ-ˈwɔʃiŋktən	'non-'
wajlt	'Wilde'	supeɾ-ˈʋajlt	*supeɾ-ˈwajlt	'super-'

The constraint proposed to account for nativization in Tagalog, $\text{IDENT}_{\text{L,Word}}$, also accounts for the Slovenian data. As before, this constraint applies to words that contain only a loanword root, but fails to apply to

[4] Mid vowels also show alternations in line with the generalizations above, but because the distribution of mid vowels in Slovenian is subject to several other restrictions, the analysis would be more complex than for other cases. These patterns are entirely consistent with the current analysis (for details, see Toporišič 1976/2000:131–132; Jurgec 2007, 2010).

words that contain any non-loanword morpheme. This is illustrated for nativization of [ɹ] in (15-a), and its preservation in (15-b).

(15) Slovenian loanword nativization

a. ɹ not possible with prefixes (and suffixes)

/anti-ɹɔk$_{\text{L}}$/	Ident$_{\text{L,Word}}$	*ɹ	Ident$_{\text{L}}$
i. anti-ɹɔk$_{\text{L}}$	d.n.a.	*!	
ii. ☞ anti-ɾɔk$_{\text{L}}$	d.n.a.		*

b. ɹ possible in bare roots

/ɹɔk$_{\text{L}}$/	Ident$_{\text{L,Word}}$	*ɹ	Ident$_{\text{L}}$
i. ☞ ɹɔk$_{\text{L}}$		*	
ii. ɾok$_{\text{L}}$	*!		*

Indexing constraints to words, as opposed to any other constituent, makes the prediction that all affixes should behave the same. We have seen already that nativization of [ɹ] and [w] is triggered by both prefixes and suffixes, but have not yet considered the distinction between derivation and inflection. For the alternations we have considered so far, it turns out that this distinction plays no role. The English rhotic is replaced by the native flap in both inflected and derived words, as shown in (16). The same holds for both $w \sim \upsilon$ and $y \sim i$, though for reasons of space we do not include data for those alternations.

(16) Slovenian affixation: ɹ → ɾ

bare root [ɹ]		inflected [ɾ]		derived [ɾ]	
ˈɹ̲ɛgan	‘Reagan’	ˈɾ̲egan-i	‘nom.pl’	ˈɾ̲egan-tʃək	‘dimin’
ˈbaɹ̲ak	‘Barack’	ˈbaɾ̲ak-a	‘nom.du’	ˈbaɾ̲ak-əts	‘dimin’
maɹ̲k	‘Marc’	ˈmaɾ̲k-ix	‘loc.pl’	ˈmaɾ̲k-əts	‘dimin’

Before moving on to another MDEE in Slovenian, which does exhibit a contrast between derivational and inflectional morphology, let us briefly address the morphological structure of the Slovenian nominative singular. Our analysis crucially relies on the assumption that the nominative singular involves a bare root, rather then a root followed plus a zero nominative case affix. Traditionally, though, the nominative singular in the main masculine and neuter paradigm is represented as a zero suffix, as is the genitive plural/dual in the neuter only (Toporišič 1976/2000). However, for the analysis advocated in this paper to work, the nominative must differ from all other cases, because long-distance MDEEs do not apply in the nominative, but do apply in all other cases, including the neuter genitive plural/dual.

There are strong syntactic reasons to consider the nominative different from other cases, corresponding to that *absence* of case morphology. Caha (2009) argues on a variety of grounds for the view that nominative corresponds to the absence of structure associated with other case forms. This sets apart the nominative from all other structural cases. There are equally strong phonological reasons that single out the nominative singular from other cases. These come from stress shift and segmental patterns parallel to the Dutch zero derivation discussed in §4. A detailed analysis of these data is beyond the scope of this paper, but see Jurgec (2007).

We now move on to a different MDEE in Slovenian, which involves the occurrence of schwa; it differs from the above cases of loanword adaptation in (i) being triggered only by derivational affixes, and (ii) occurring in both loans and native words.

6.2 Schwa fronting

Slovenian allows schwa in bare roots, but though this schwa is retained in inflected words it is fronted to [e] in the presence of a derivational affix, as shown in (17); note that this alternation can occur at any distance from the derivational affix, and that it occurs in both open and closed syllables.

(17) Slovenian derivation: ə → e

BARE ROOT [ə]		INFLECTED [ə]		DERIVED [e]	
ˈtɛnəsi	'Tennessee'	ˈtenəsi-jem	'LOC.SG'	ˈtenesi-ski	'ADJ'
ˈwiskɔnsən	'Wisconsin'	ˈʋiskonsən-a	'GEN.SG'	ˈʋiskonsen-tʃan	'demonym'
dəˈtɹɔjt	'Detroit'	dəˈtrojt-u	'DAT.SG'	deˈtrojt-əts	'demonym'
ˈɛndʒələs	'(Los) Angeles'	ˈendʒələs-om	'INSTR.SG'	ˈendʒeles-ək	'DIMIN'

The examples in (17) involve loanwords, which often preserve schwa from the source language. The same effect can be seen in a small number of native roots, illustrated in (18).

(18) Slovenian derivation: ə → e

BARE ROOT [ə]		INFLECTED [ə]		DERIVED [e]	
dəʃ	'rain'	dəʒ-ˈjɛm	'INSTR.SG'	deʒ-ˈnik	'umbrella'
bət	'stem'	bəˈt-a	'GEN.SG'	beˈt-its	'head'
məˈnix	'monk'	məˈnix-a	'GEN.SG'	meˈnix-aɾ	'PEJOR'
kəs	'regret'	kəˈs-a	'GEN.SG'	keˈs-a	's/he regrets'
təʃtʃ	'fast.ADJ'	ˈtəʃtʃ-ega	'GEN.SG'	ˈteʃtʃ-ost	'fasting'

Importantly, the alternation between [ə] and [e] cannot be attributed to some other vowel-related process. The examples in (19) show that fronting applies across intervening front and back vowels, and in words containing front and back suffix vowels. Even more strikingly, some inflectional and derivational suffixes are identical (e.g. *-a*, which is both genitive singular and verbalizer), yet only the latter trigger fronting.

(19)

INFLECTED [ə]		DERIVED [e]	
tʃəˈbel-a	'bee-NOM.SG'	tʃebel-ˈnjak	'beehive'
tʃəˈbul-i	'onion-NOM.PL'	tʃeˈbul-ni	'ADJ'
		tʃeˈbul-aɾ	'producer'
kəˈs-a	'regret-GEN.SG'	keˈs-a	's/he regrets'

Before showing that an analysis of Slovenian schwa follows straightforwardly from our approach to indexing, we give more background on the wider distribution of schwa in Slovenian. First, note that the distribution of schwa in native Slovenian roots is fully predictable, as illustrated in (20), determined by phonotactics of root consonants. In other words, it is never the case that two roots have the same three consonants, but differ in the position of schwa. For instance, while *bəzək* 'elderberry' is an attested word, the following words are unattested **bzk*, **bzək*, **bəsk*, **əbəsk*, **əbzək*, **əbəzək*. Standard Slovenian does not allow syllabic consonants (Toporišič 1976/2000) and restricts combinations of consonants (Srebot Rejec 1975; Chen 2017). The predictable distribution of schwa supports the view that schwa is epenthetic at least in native words.

(20) Distribution of schwa is predictable in bare native roots[5]

NO. OF Cs	IMPOSSIBLE ROOTS	POSSIBLE ROOTS	EXAMPLES	
2	CC	CəC	sən	'dream'
	ɾC	əɾC	əɾt	'peninsula'
3	SCC, CSC, CCS	CəCəC	pəkəl	'hell'
	OOO	OəOO	təʃtʃ	'fasted'
		OOəO	stəs	'path-GEN.PL'
		OəOəO	bəzək	'elderberry'
	CɾO	CəɾO	pəɾt	'tablecloth'
	CCɾ	CəCɾ	tʃəbəɾ	'bucket'

If schwa is epenthetic in native roots, this means that fronting of schwa to [e] cannot be viewed as a violation of IDENT—indeed, this means that "schwa fronting" is not strictly accurate as a label, though we continue to use it in keeping with prior literature. We view schwa as the minimal epenthetic repair, a vowel with no

[5] Abbreviations: C = consonant other than ɾ, S = sonorant consonant other than ɾ, O = obstruent

other features. Fronting of [ə] to [e] requires epenthesis of a further feature, namely [front], and so is less faithful to the input. We thus adopt DEP(front) as the constraint militating against [e].

This single constraint, appropriately indexed as in (21), is sufficient to account for the distribution of schwa in (17)–(19). This constraint prohibits the insertion of a feature [front] in constituents specified for the morphological property of being roots, but it is indexed to the morphological *stem* rather than to either single morphemes or to the word as a whole, parallel to the analysis developed for Dutch in §4. It applies to stem constituents that contain a root and no other morphemes (we return below to the different distribution of schwa in final suffixes).

(21) DEP(front)$_{\text{Root,Stem}}$
Output [front] must have an input correspondent when part of the phonological exponent of a *Stem* specified as a *Root*.

We assume that phonological constituents are never discontinuous, so that vowels epenthesized within the root must be treated as part of the stem, thus potentially subject to this constraint. We capture the markedness of schwa by invoking a markedness constraint *ə (van Oostendorp 1995), and the complex phonotactic restrictions resulting in the distribution of schwa in (20) with an undominated cover constraint PHONOTACTICS. The application of the indexed constraint DEP(front)$_{\text{Root,Stem}}$ is illustrated in (22-a), where epenthesis of schwa is possible in an inflected word—i.e. in a word where the stem contains only a root morpheme. (22-b), meanwhile, illustrates that this constraint fails to apply to a derived stem, resulting in fronting to [e].

(22) Schwa fronting in roots

a. ə preferred in roots without derivational affixes

	[bzg]$_{\text{Stem}}$-a	PHONOTACTICS	DEP(front)$_{\text{Root,Stem}}$	*ə
i.	[bzg]$_{\text{Stem}}$-a	bz!		
ii.	[bəzəg]$_{\text{Stem}}$-a			**!
iii. ☞	[bəzg]$_{\text{Stem}}$-a			*
iv.	[bezg]$_{\text{Stem}}$-a		*!	

b. ə not possible with derivation

	[bzg-oʊ]$_{\text{Stem}}$-a	PHONOTACTICS	DEP(front)$_{\text{Root,Stem}}$	*ə
i.	[bzg-oʊ]$_{\text{Stem}}$-a	bz!	d.n.a.	
ii.	[bəzg-oʊ]$_{\text{Stem}}$-a		d.n.a.	*
iii. ☞	[bezg-oʊ]$_{\text{Stem}}$-a		d.n.a.	

So far, this analysis predicts that schwa should occur in underived words, but also only within the root. Yet schwa does occur in some suffixes, as we have already seen in (16) and (17) with the diminutive suffixes *-tʃək*, *-əts*, and *-ək*. As in roots, the distribution of schwa in affixes is predictable, though it is subject to different generalizations. In support of viewing affixal schwa as epenthetic, we see by comparing the last two data columns in (23) that schwa alternates with zero in all suffixes in which it occurs, whenever that suffix is followed by another vowel-initial suffix.

(23) Schwa in suffixes: ə → ∅ with further suffixation

ˈgɔr-ə̠k	'hot'	ˈgɔr-k-a	'-F.NOM.SG'
ˈtan-ək	'thin'	ˈtaŋ-k-a	'-F.NOM.SG'
maˈrin-əts	'marine'	maˈrin-ts-a	'-GEN.SG'
ˈsɛj-əm	'fair'	ˈsej̩-m-i	'-NOM.PL'
ˈbaj-ən	'marvellous'	ˈbaj-n-i	'-M.NOM.SG.DEF'

Comparing the data in (23) with that in (24), we see that schwa occurs in affixes so to prevent complex codas that are licit in bare roots: ɾk#, ŋk#, nts#, jm#, and jn#. In other words, Slovenian permits certain clusters root-internally, but epenthesizes schwa to prevent affixation from creating new instances of such clusters.

(24) Same final clusters licit root-internally (no alternation)

baɾk	'sailboat'	ˈbaɾk-a	'-GEN.SG'
taŋk	'tank'	ˈtaŋk-a	'-GEN.SG'
pɾints	'prince'	ˈpɾints-a	'-GEN.SG'
se̹jm	'Polish parliament'	ˈse̹jm-i	'-NOM.PL'
komˈbajn	'harvester'	komˈbajn-i	'-NOM.PL'

This is a classic example of a *local* derived environment effect, of the type discussed above for Finnish, and can be captured by classic locally-indexed constraints. In this case, an indexed constraint preventing epenthesis within the root DEP(V)$_{Root}$ would outrank the markedness constraints that penalize the above complex codas (a subset of the constraints that fall under our general PHONOTACTICS constraint), but these markedness constraints would in turn outrank the unindexed version of DEP(V).

Complicating matters further, we find in Slovenian that schwa in affixes alternates not only with zero, but also with [e]. Descriptively, fronting in suffixes is subject to different generalizations in affixes than in roots: while in roots fronting is triggered by derivational affixes, in affixes fronting is triggered by the addition of any further affix, whether inflectional or derivational.[6]

(25) Schwa fronting in affixes

FINAL AFFIX [ə]		PLUS ANY AFFIX [e]	
ˈjazb-ə̲ts	'badger'	ˈjazb-e̲ts-a	'-GEN.SG'
		ˈjazb-e̲tʃ-aɾ	'dachhund'
ˈtseplj-ə̲n	'vaccinated'	ˈtseplj-e̲n-a	'-FEM'
		ˈtseplj-e̲n-ost	'vaccination rate'
ˈkuɾj-ə̲n	'burned'	ˈkuɾj-e̲n-a	'-FEM'
		ˈkuɾj-e̲n-je	'burning'
ˈlol-ə̲k	'idiot'	ˈlol-e̲k-u	'-DAT.SG'
		ˈlol-e̲k-ow-sk-emu	'-POSS-ADJ-DAT.SG'

While this might appear to be a morphological condition, we suggest here that it instead illustrates a *positional* licensing effect: schwa is possible only in prominent positions, including not only roots (as seen above) but also in final syllables. While initial syllables are typically associated with prominence (Beckman 1997, 1998), word-final positions have also been independently argued to be associated with enhanced faithfulness (Barnes 2006; Jurgec 2011). There is independent evidence for this in Slovenian: the contrast between the two low tense vowels [ʌ] and [a] is limited to word-final closed syllables. The relevant constraint is DEP-σ#(front), defined in (26).

(26) DEP-σ#(front)
A [front] feature in the word-final syllable in the output must have an input correspondent.

The interaction of this constraint with other proposed constraints is illustrated in (28-a). When affixation creates an illicit consonant cluster, highly ranked markedness (PHONOTACTICS) requires epenthesis. In general, the language would prefer to epenthesize [e], due to the markedness constraint dispreferring schwa (*ə). Epenthesis of [e] violates DEP(front), but also its positionally-restricted variant DEP-σ#(front), which outranks *ə and so preserves schwa as the epenthetic vowel in final syllables. When the word is further affixed, the epenthetic vowel no longer occurs in the final syllable, and so surfaces as [e], as shown in (27-b).

(27) Schwa fronting in affixes

[6] In contrast to (23), the epenthetic vowels in (25) are preserved under further affixation due to the complex codas of the preceding roots.

a. ə possible in final syllables

[jazb-ts]$_{Stem}$	Phonotactics	Dep-σ#(front)	Dep(front)$_{Root,Stem}$	*ə
i. [jazb-ts]$_{Stem}$	bts!		d.n.a.	
ii. ☞ [jazb-əts]$_{Stem}$			d.n.a.	*
iii. [jazb-ets]$_{Stem}$		*!	d.n.a.	

b. ... but not otherwise

[jazb-ts]$_{Stem}$-a	Phonotactics	Dep-σ#(front)	Dep(front)$_{Root,Stem}$	*ə
i. [jazb-ts]$_{Stem}$-a	bts!		d.n.a.	
ii. [jazb-əts]$_{Stem}$-a			d.n.a.	*!
iii. ☞ [jazb-ets]$_{Stem}$-a			d.n.a.	

To summarize, schwa in Slovenian occurs in both loans and in native morphemes. In the native lexicon, its distribution is fully predictable as a means of preventing illicit consonant clusters (with a local derived environment effect making the set of illicit clusters broader for affixes than for roots). At the same time, schwa is generally dispreferred in Slovenian, and so is preserved only in contexts of enhanced faithfulness. There are two such contexts: final syllables (a positional faithfulness effect), and stems that have the property of also being roots. It is the latter that gives rise the MDEE of central interest to this paper.

6.3 Interaction

Slovenian MDEEs involve several interacting alternations, subject to different classes of affixation. This is illustrated by inflected words such as *də'trojt-u* ('Detroit-DAT.SG'), where schwa is preserved while [ɹ] undergoes nativization to [ɾ]. Despite the complexity of the system, the system of constraint indexation proposed in this paper can account for the interaction without any further constraints or mechanisms: the divergence between schwa fronting and the nativization of other segments is captured by different domains of application for different indexed constraints. Because the constraint preserving schwa is indexed to the stem as opposed to the word, it applies in contexts where the more general constraint requiring total identity in loanwords does not, as illustrated in (28).

(28) Interaction of ə and ɹ

[dəˈtɹojt$_{P,L}$]$_{Stem}$-u	Ident$_{L,Word}$	Dep(front)$_{Root,Stem}$	*ə	*ɹ	Ident
i. [dəˈtɹojt$_{P,L}$]$_{Stem}$-u	d.n.a.		*	*!	
ii. ☞ [dəˈtɾojt$_{P,L}$]$_{Stem}$-u	d.n.a.		*		*
iii. [deˈtɹojt$_{P,L}$]$_{Stem}$-u	d.n.a.	*!		*	*
iv. [deˈtɾojt$_{P,L}$]$_{Stem}$-u	d.n.a.	*!			**

The interaction of MDEEs in Slovenian cannot be accounted for in other systems of constraint indexation (e.g. Itô & Mester 1995, 2001; Pater 2000, 2009; Flack 2007; Gouskova 2007; Jurgec 2010). Such approaches could take two routes. First, some faithfulness constraint would need to be indexed to bare roots, making them exempt from the effects of a low-ranking markedness constraint. Yet this would predict no nativization in affixed words, since affixes could not erase the root index. Second, it could be that affixes could be indexed for markedness constraints driving nativization, but in this case, it is unclear how indexed constraints would apply over roots in suffixed words. In any case, while locality of evaluation in these approaches could perhaps be relaxed sufficiently to account for the long-distance nativization of [ɹ], [w], and [y]—as well as for the alternation between [f] and [p] in Tagalog—this could not account for the contrast between derivational and inflectional affixes for the purposes of schwa fronting.

7 Indexed Faithfulness: A factorial typology

So far we have focused on long-distance DEEs that can be accounted for by faithfulness constraints indexed to different morphological constituents. We have given detailed accounts of MDEEs in Tagalog, Dutch, and Slovenian, as well as mentioning a variety of loanword nativization effects that appear to fit a similar profile.

Our analysis accounts for non-local MDEEs by allowing constraints to be indexed not only to the arbitrary properties of individual morphemes, but also larger morphological domains.This is combined with an assumption that for the purposes of constraint evaluation, a complex morphological constituent is treated as being specified for some property P only if each of its subconstituents is individually specified as P. Traditional indexed constraints, which produce only local effects, can be reinterpreted in this framework as having the *morpheme* as their domain of application, but both *stem* and *word* are also possible domains.

An indexed faithfulness constraint will lead to a phonological effect only if it outranks some markedness constraint that in turn outranks the unindexed version of the faithfulness constraint. This is shown schematically in (29), with the additional consequences determined by the domain to which the indexation is relativized.

(29) Faithfulness$_{Property,Domain}$ ≫Markedness ≫Faithfulness

a. *Domain* = morpheme
Marked structures are permitted morpheme-internally, but are disallowed at morpheme boundaries. (Local MDEEs)

b. *Domain* = stem
Marked structures or segments are preserved with inflectional affixes, but lost with derivational affixes. (Non-local MDEEs: Slovenian schwa, Dutch loans)

c. *Domain* = word
Marked structures or segments are preserved in bare roots, but lost under affixation. (Non-local MDEEs: Slovenian loans, Tagalog loans)

The second point of variation is the lexical property to which indexation can be sensitive. Following much other work on constraint indexation, we assume that morphosyntactic properties of morphemes can be indexed (i.e. lexical category, root vs. affix), as well as classes of exceptional morphemes, of which loanwords are a prototypical example. This is in line with the large literature on constraint indexation (McCarthy & Prince 1993, 1995, 1999; Itô & Mester 1995; Smith 2001; Beckman 1998; Pater 2000, 2007, 2009; Flack 2007; Gouskova 2007).

Let us consider (29-b) in more detail. The table in (30) shows potential combinations of roots and affixes with an indexed property P. Under a ranking such as (29-b), with an indexed constraint that is indexed to a *stem* constituent, roots can preserve exceptionality as long as no derivational affixes are present (30-a), while inflectional affixes have no effect (e). By contrast, any non-P derivational affix will be stem-internal and will trigger regularization (c). The remaining two combinations both involve derivational affixes that bear the indexed property P: when such affixes co-occur with indexed roots, exceptionality of the whole stem is preserved (b); when affixes co-occur with non-indexed roots, the whole word is regularized (d). While (d) is generally unproblematic since it would be difficult to distinguish from a non-indexed affix, (b) presents a potential challenge to our proposal, because we predict the possibility of indexed affixes that exceptionally fail to trigger regularization.

(30) Faithfulness$_{\text{P,Stem}}$ ≫Markedness ≫Faithfulness

	Word structure	Faith$_{\text{P,Stem}}$ applies?	Pattern
(a)	$[\text{Root}_{\text{P}}]_{\text{Stem}}$	Yes	Exceptional bare root
(b)	$[\text{Root}_{\text{P}}\text{-Affix}_{\text{P}}]_{\text{Stem}}$	Yes	Exceptional derived words
(c)	$[\text{Root}_{\text{P}}\text{-Affix}]_{\text{Stem}}$	No	Regularized derived words
(d)	$[\text{Root-Affix}_{\text{P}}]_{\text{Stem}}$	No	Affixes cannot be exceptional alone
(e)	$[\text{Root}_{\text{P}}]_{\text{Stem}}\text{-Affix}_{\text{(P)}}$	Yes, within stem	Inflection cannot be exceptional and cannot regularize

As it turns out, languages contrasting (30-b) and (d) are attested. In Tagalog, the overall trend is clear: affixed words prefer roots with *p* rather than *f* (6). A few affixes do not have a nativizing effect, for instance the prefix *mag-*: *mag-filipino* 'F. language' is a much more common than the the expected *mag-pilipino* (Zuraw 2006). This may be surprising, but it is actually predicted by the present approach, which allows for affixes to be indexed, and thus have no effect on regularization. At the same time, no affix can contain [f], exactly as predicted by the typology in (30).

In the following sections we examine two further potential examples. In the case of English trisyllabic shortening, Latinate roots preserve their exceptionality with Latinate derivational affixes, but not with non-Latinate affixes (§8.2). This account of trisyllabic shortening requires that indexation be available to markedness constraints as well as faithfulness constraints. A similar parallel exists in Russian vowel alternations, where only some affixes trigger regularization (§8.1).

The comparative rarity of interactions involving indexed affixes can be explained if we consider the sources from which they would arise. For the contrast between (30-b) and (d) to arise in a language, there must be a phonologically exceptional class of morphemes that includes both roots and affixes. Some morpheme classes (such as the class of morphemes that are *roots*) definitionally exclude affixes. Others exclude affixes incidentally: as we have seen, one of the most frequent phonologically exceptional classes is the class of *loanword* morphemes, but because it is already comparatively uncommon for languages to borrow affixes, it is unsurprising that only a few cases involving roots and affixes belonging to the same exceptional class have been reported in the literature.

This system of indexation does exclude a number of patterns—patterns that are, as far as we know, unattested. Some of these are due to morphological constituency: any pattern in which marked structures or segments are preserved under derivation but lost under inflection is impossible to capture in the present system, precisely because there is no constituent that includes both a root and all inflectional affixes, but excludes derivational affixes.

Also excluded is any pattern in which marked structures or segments are preserved only in complex words or stems, but lost in bare roots. In contrast to preservation under derivation but not inflection, such patterns are not impossible within the system we propose, but would be predicted by indexed markedness constraints, alongside the indexed faithfulness constraints we have considered so far. In §8 we suggest that indexed markedness constraints may explain some non-local MDEEs that cannot be explained in terms of indexed faithfulness. This requires some explanation for the absence of indexed markedness effects in classic patterns of loanword nativization—in §8.4 we suggest that this may be due to historical and learnability factors.

8 Extending the account: Indexing other constraint types

As mentioned in the introduction, Itô & Mester (1995, 2001), Inkelas et al. (1997), and Inkelas & Zoll (2007) have argued that morphological indexation is limited to faithfulness constraints, which predicts that indexed morphemes can contain structures illicit in non-indexed morphemes, but not the reverse.

As further noted in §7, including indexed markedness constraints in the system we have proposed in this paper would predict that there should be languages where morphologically complex words are permitted to contain marked structures that are banned in their simplex counterparts.

While this prediction might be pathological in the domain of loanword nativization, there are nonetheless phenomena that appear to have the formal profile of MDEEs, but that cannot be explained by indexed faithfulness. Here we discuss two such cases: lexically conditioned vowel alternations in Russian prepositions (Gouskova & Linzen, 2015), and trisyllabic shortening in English. We also discuss morphologically-sensitive word minimality effects in Turkish, which can be accounted for by indexing a constraint such as MParse, often viewed as neither a faithfulness nor a markedness constraint.

We discuss the predictions made by including indexed markedness constraints in more detail in §8.4. Their inclusion does add considerably to the generative power of phonological theory—for this reason, this section is intended to be exploratory, showing how certain classes of phenomena can be accounted for if we extend the theory in this way, rather than as a definitive argument in favour of indexed markedness constraints.

8.1 Russian vowel alternations

Our first potential case of indexed markedness constraints is drawn from Gouskova & Linzen (2015), who discuss a pattern of lexically triggered vowel deletion in Russian prepositions: while with most roots and prepositions the preservation of a vowel is phonologically predictable (to avoid certain consonant clusters), when some prepositions (e.g. *so* 'with, from'; *ko* 'towards'; *vo* 'in, into') occur with specific roots, the vowel is exceptionally preserved. Of further interest is that exceptionally vowel-preserving roots lose their exceptionality when they occur with (some) derivational suffixes (e.g. the diminutive suffix *(n)ik* is not regularizing). This basic pattern is illustrated in (31).

(31) Exceptional vowel-preservation in Russian prepositions (Gouskova & Linzen 2015)

sə dvaˈrom	'with the yard'	(exceptional root blocks deletion)
ˈz dverʲu	'with the door'	(phonologically similar root exhibits regular deletion)
z dvaˈ**rov**ɨm	'with the yard-ADJ'	(root exceptionality lost with suffix *-ov*)
**sə dvaˈrovɨm*		

This is very much the type of pattern we have been considering throughout this paper: certain roots exhibit phonological behavior that is otherwise blocked in the language, but this exceptionality is lost with the addition of further morphology. Russian resembles Dutch and Slovenian in that only derivational morphology triggers loss of exceptionality, and again this can be captured by the indexation of constraints to the morphophonological stem, rather than to the word.

At the same time, the vowel alternation in (31) cannot be straightforwardly captured as an instance of indexed faithfulness, if indexed constraints must be evaluated locally. The reason for this is that though the pattern in (31) involves the exceptional retention of the prepositional vowel, that vowel is not associated with the morpheme that triggers the exceptionality (the following root), but instead with the preposition itself.

Constraint indexation would nonetheless be able to account for these data if indexed markedness constraints are possible alongside indexed faithfulness constraints. Here we outline such an account, using the same constraints proposed by Gouskova & Linzen (2015), whose analysis is framed within a Maximum Entropy model.

The crucial constraint is *#CCC, which is violated by word-initial clusters of three consonants. Following Gouskova and Linzen, we assume that the locus of violation of this constraint is the medial consonant rather than the entire string; as Russian lacks CC prepositions, this will always be a root consonant. To account for the data in (31), we index this constraint to stems specified as lexically exceptional, notated here as E. The other relevant constraint is *V, which favours vowel deletion; this is a locally indexed constraint applying to morphemes that bear a prepositional categorial feature, notated here as P (parallel to *PrepV in Gouskova & Linzen 2015).*V_P outranks the general constraint *#CCC, but is outranked by the more specific constraint *#$CCC_{E,Stem}$.

(32) Exceptional vowel preservation in Russian prepositions

a. Root *dvor* exhibits exceptional vowel preservation

/$sə_P$ $[dvor_E]_{Stem}$-om/	*#$CCC_{E,Stem}$	*V_P	*#CCC
i. ☞ $sə_P$ $[dvar_E]_{Stem}$-om		*	
ii. z_P $[dvar_E]_{Stem}$-om	*!		*

b. Addition of suffix *-ov* overrides root exceptionality

/$sə_P$ $[dvor_E\text{-}ov]_{Stem}$-ɨm/	*#$CCC_{E,Stem}$	*V_P	*#CCC
i. $sə_P$ $[dvar_E\text{-}ov]_{Stem}$-ɨm	d.n.a.	*!	
ii. ☞ z_P $[dvar_E\text{-}ov]_{Stem}$-ɨm	d.n.a.		*

These vowel alternations closely resemble previously-discussed patterns of loanword nativization, and the Slovenian alternations involving schwa, in that the addition of derivational morphology prevents a root from asserting otherwise-exceptional phonological behaviour. They differ only in that they cannot be explained in terms of locally-evaluated faithfulness constraints, because the locus of the faithfulness violation (the vowel of the preposition) is distinct from the locus of exceptionality (the nominal root), and there is no domain containing the preposition and the following stem but excluding inflectional suffixes. Accounting for this pattern with the indexed markedness constraint *#CCC shifts the locus of violation into the root itself, where lexical exceptionality also resides.

In §9.1 we return to these data, arguing that the account in terms of indexed faithfulness is also preferable to the Maximum Entropy analysis proposed by Gouskova & Linzen (2015), in part by providing a fully principled explanation for the fact that only derivational affixes (and not inflectional affixes) trigger loss of exceptionality.

8.2 Trisyllabic shortening in English

Trisyllabic shortening is one of several morphologically conditioned alternations between tense and lax vowels in Modern English, and has been discussed in the generative literature since at least Chomsky & Halle (1968). It resembles other phenomena discussed in this paper in being restricted to a subset of the vocabulary, but is of particular interest not only because it requires indexation of markedness constraints, but also because it is sensitive to lexical properties of both roots and derivational affixes. Trisyllabic shortening thus supports our prediction that complex morphological constituents should be treated as lexically exceptional when all roots and affixes bear the same indexed property.

Here we are maximally restrictive in the set of phenomena we consider under the umbrella of trisyllabic shortening, focusing on the core phenomenon of quality/length alternations that are independent of any shift in stress. Relevant examples appear in (33): words in the left column have a stressed tense (i.e. long) vowel in penultimate or final position, alternating with a stressed lax (i.e. short) vowel when derivation moves that syllable into antepenultimate position.

(33) English trisyllabic shortening

divine	[dɪ.vájn]	divinity	[dɪ.ví.nɪ.ti]
derive	[də.ɹájv]	derivative	[də.ɹí.və.tɪv]
serene	[sə.ɹí̇n]	serenity	[sə.ɹrɛ́.nɪ.ti]
impede	[ɪm.pí̇d]	impediment	[ɪm.pɛ́.dɪ.mənt]
sane	[sén]	sanity	[sǽ.ni.ti]
profound	[pɹə.fáwnd]	profundity	[pɹə.fʌ́n.dɪ.ti]
school	[skúl]	scholastic	[skɑ́.lr̩.li]
sole	[sól]	solitude	[sɑ́.lɪ.tjud]

Though the canonical examples of this alternation involve vowels in the antepenultimate syllable of the derived word, this alternation is also attested with some monosyllabic suffixes, so that the relevant vowel is penultimate in the derived word, as in *cyclone* ∼ *cyclonic* (and other pairs involving *-ic*), *malign* ∼ *malignant*, and *revise* ∼ *revision*.

Though trisyllabic shortening reflects quality alternations that were once productive (Lahiri & Fikkert 1999), it is now limited to words containing only Latinate roots and affixes, those borrowed directly from Latin or via French—though not all etymologically Latinate morphemes are synchronically treated as members of this exceptional class. The examples in (34), which all exhibit tense antepenultimate stressed vowels, demonstrate that the restriction seen in (33) is not attested elsewhere in English.

(34) No trisyllabic shortening with non-Latinate roots

nightingale	[náj.tɪŋ.gel]
ivory	[áj.və.ri]
carrion	[ké.ri.ən]
boundary	[báwn.də.ri]
hooligan	[hú.lɪ.gn̩]
odious	[ó.di.əs]

More interestingly, the ban on antepenultimate tense vowels does not apply in words containing fully productive derivational suffixes (i.e. with suffixes that can also occur with non-Latinate roots), even for roots that do exhibit the alternation elsewhere, as can be seen in comparing (35) with (33). The suffix *-able* fails to trigger shortening despite being two syllables long—and though *-able* was historically backformed from French loanwords, it is evidently not synchronically treated as belonging to the exceptional class of affixes that trigger trisyllabic shortening. The same can be seen with combinations of affixes such as *-ful-ness* and *-ly-ness*; these affix combinations are not always entirely natural, often having a playful or metalinguistic quality, but to the extent that they are possible they very clearly do not allow trisyllabic shortening.

(35) No trisyllabic shortening with non-Latinate suffixes

divinable	[dɪ.váj.nə.bl̩]	
impedeable	[ɪm.pí.də.bl̩]	
pronouncable	[pɹə.náwn.sə.bl̩]	
evokeable	[ɪ.vó.kə.bl̩]	
saneliness	[sén.li.nəs]	(cf. *kindliness*)
schoolfulness	[skúl.fl̩.nəs]	(cf. *Sleepfulness*, an iOS app)

The standard analysis of trisyllabic shortening links it to a requirement that vowels in antepenultimate stressed position be short—in other words, the proposal that long vowels are only licensed in the Latinate vocabulary when they are both stressed and either final or penultimate (Chomsky & Halle 1968; Kiparsky 1979; Myers 1987; Hammond 1988; Kager 1989, among others).[7] We take trisyllabic shortening to be motivated by prosodic optimization, assuming moraic trochees (Prince 1990). We implement this analysis using the constraints Ft-Bin(μ), which must be indexed to Latinate stems (which we give the index R for "Romance"), and Ident(length).

(36) a. Ft-Bin$(\mu)_{R,Stem}$ (McCarthy & Prince 1993; Hewitt 1994)
Feet are binary at the level of moras.

We attribute final syllable extrametricality to a constraint NonFinality, which applies in English to both nouns and to a subset of adjectival suffixes, following Hayes (1982)—we do not show NonFinality in the following tableaux, but this would be an instance of local constraint indexation, applying to the domain of single morphemes. We assume that there are no "superheavy" syllables in English; for the purposes of this constraint, syllables with a long vowel always count as containing two moras, regardless of whether there is a final consonant. NonFinality interacts with a constraint aligning stress at the right edge of words, preventing the main stress foot from retreating more than one (extrametrical) syllable from the right edge, as in Pater (2000).

(37) English interaction of shortening with affixation

a. Non-derived Latinate roots: no shortening

/dɪvajn$_{R}$/	Ft-Bin$(\mu)_{R,Stem}$	Ident(length)
i. ☞ dɪ(vájn$_{\mu\mu}$)$_{R}$		
ii. dɪ(vín$_{\mu}$)$_{R}$	*!	*

[7] Alternatively, trisyllabic "shortening" could reflect lengthening of short vowels in underived forms Burzio (1994); Lahiri & Fikkert (1999). Reframed in terms of indexing, a lengthening approach would not require indexed markedness constraints, but would still illustrate the relevance of lexical indices on affixes as well as on roots.

b. Latinate root + Latinate suffix: shortening

/dɪvajn$_R$-ɪti$_R$/	Ft-Bin(μ)$_{R,Stem}$	Ident(length)
i. dɪ(váj$_{\mu\mu}$n$_R$-ɪ$_\mu$)ti$_R$	*!	
ii. ☞ dɪ(ví$_\mu$n$_R$-ɪ$_\mu$)ti$_R$		*

c. Latinate root + non-Latinate suffix: no shortening

/dɪvajn$_R$-fl̩-nəs/	Ft-Bin(μ)$_{R,Stem}$	Ident(length)
i. ☞ dɪ(váj$_{\mu\mu}$n$_R$-fl̩$_\mu$)-nəs	d.n.a.	
ii. dɪ(ví$_\mu$n$_R$-fl̩$_\mu$)-nəs	d.n.a.	*!

As noted above, what is interesting from the perspective of our analysis is that that the generalization in trisyllabic shortening holds not of words that contain Latinate roots, nor of words with some set of exceptional affixes, but rather of words where both the root and derivational affixes belong to the same exceptional class.

Given that most Latinate derivational suffixes are unproductive we might wonder if the above proposal could be replaced by one with fully local indexation to Latinate affixes alone, rather than to Latinate stems. This would result in an indirect restriction to Latinate roots, as the relevant affixes cooccur only with those roots. This alternative would, however, require non-local evaluation of constraints, as the affected vowels occur root-internally. Also, though Latinate suffixes cannot generally attach to non-Latinate roots, some such forms are attested, and they uniformly fail to trigger shortening in the new forms: *betweenity*, for example, appears in the *Oxford English Dictionary* as a "playful formation [. . .] after words from Latin" (thanks to Daniel Currie Hall for bringing this example to our attention). If shortening were the result of indexation to the affix alone, we would expect it to apply here. Indexed constraints of the type we have proposed, by contrast, will automatically fail to apply to such words, because the root is not specified for the feature *R*. A similar account could be given for well-known exceptions to trisyllabic shortening, such as *ob[í]se* ∼ *ob[í]sity* or *cond[ó]le* ∼ *cond[ó]lence*: we can say that though these roots are etymologically derived from Latin, they are not indexed for the feature *R* by modern speakers, much as the suffix *-able* is not.

Were we to attempt to reframe this analysis in terms of indexed faithfulness, rather than markedness—indexing Ident(length) to words containing only non-Latinate morphemes—it is unclear how the MDEE could be explained. The trisyllabic shortening pattern is crucially sensitive to whether all morphemes in a domain are Latinate, while the hypothetical constraint Ident(length)$_{\neg R,Word}$ would fail to apply whenever any morpheme in a word were Latinate. This would incorrectly predict that words like *betweenity* or *divinable* would exhibit shortening, faithfulness to underlying length being blocked by the presence of a Latinate root or affix. Trisyllabic shortening thus provides additional empirical support for the availability of indexed markedness constraints, in addition to indexed faithfulness constraints, as previously argued by Pater (2000, 2007, 2009), Flack (2007), Gouskova (2007), and Jurgec (2010).

In §8.3 we turn to another interesting case, that of word minimality effects in Turkish, where yet another type of constraint is indexed.

8.3 Turkish

Turkish exhibits an MDEE wherein a word minimality restriction applies only to derived words.This is a prosodic restriction that resembles in some respects the English trisyllabic shortening pattern discussed in §8.2.

As the data in (38) show, bare roots in Turkish can be monosyllabic or longer, while affixed words must be at least disyllabic. The monosyllabic forms that would be predicted by regular inflectional morphology constitute paradigmatic gaps. Unlike the cases above, there is no possible repair for these words, whether via epenthesis or allomorphy, resulting in ineffability for the relevant paradigm cells. (Some speakers do allow repair via lengthening; this pattern is easily captured in the current framework with a top-ranked Ident(length)$_{Root,Word}$.)

(38) Turkish word minimality MDEEs (Inkelas & Orgun 1995)

a. Non-derived words can be monosyllabic

ham	'unripe'
gøk	'sky'
dil	'tongue'
ev	'house'

b. Derived words must be at least disyllabic

*fa-m	'fa (note)-1SG.POSS'	fa-dan	'fa (note)-ABLATIVE'
*de-n	'say-PASS'	de-miʃ	'say-EVID'
*je-n	'eat-PASS'	je-se	'eat-CONE'

Orgun & Sprouse (1999) analyze of the Turkish pattern using standard OT constraints, and conclude that the ranking of these constraints would have to be different for bare roots and affixed words. As a solution, they propose CONTROL, an additional component of the grammar beyond Gen and Eval. Any candidate which wins under Eval is submitted to CONTROL. If the candidate violates a particular CONTROL-imposed constraint, then the output for that particular input is not parsed.

The Turkish pattern in (38) can be captured within our system of lexical indexation, by indexing the parallel constraints proposed by Orgun & Sprouse (1999), thus obviating the need for an additional CONTROL component. The constraint in (39) imposes the disyllabic minimal word seen in Turkish. This constraint must be satisfied by all affixed words in Turkish, but can be violated by bare roots.

(39) LEX≈PR,FTFORM (Prince & Smolensky 1993/2004; Orgun & Sprouse 1999)
Every word must contain a disyllabic foot.

To account for the fact that roots will surface regardless of size, we adopt the constraint MPARSE (Prince & Smolensky 1993/2004; Orgun & Sprouse 1999; Fanselow & Féry 2002; Rice 2007; Raffelsiefen 2004). This constraint is violated whenever a word is realized as a null parse. In Turkish, only bare roots can violate this constraint, while affixed words do not. This suggests that MPARSE must be indexed, as in (40). As before, we treat status as a root as an indexable property to which constraints can be sensitive. $\text{MPARSE}_{\text{Root,Word}}$ is indexed to apply to whole words, and thus applies only when the root is the only morpheme in the word.

(40) $\text{MPARSE}_{\text{Root,Word}}$
The input has a non-zero realization; this constraint is violated by the null parse. (When indexed, the constraint requires that the indexed constituent in the input correspond to a realization in the output.)

In Turkish, $\text{MPARSE}_{\text{Root,Word}}$ outranks the word minimality constraint. As such, monosyllabic bare roots surface, and surface faithfully, as shown in (41-a). In affixed words, the indexed version of the constraint does not apply, and the word minimality constraint rules out the faithful parse, as shown in (41-b). Finally, (41-c) demonstrates that longer affixed words satisfy the minimality constraint.

(41) Turkish word minimality as a MDEE

a. Bare roots can be monosyllabic

/fa/	$\text{MPARSE}_{\text{Root,Word}}$	LEX≈PR,FTFORM	MPARSE
i. ☞ fa		*	
ii. ⊙	*!		*

b. Affixed words cannot be monosyllabic

/fa-n/	$\text{MPARSE}_{\text{Root,Word}}$	LEX≈PR,FTFORM	MPARSE
i. fa-n	d.n.a.	*	
ii. ☞ ⊙	d.n.a.		*

c. Affixed words can be disyllabic (or longer)

/fa-dan/	MPARSE$_{\text{Root,Word}}$	LEX≈PR,FTFORM	MPARSE
i. ☞ fa-dan	d.n.a.		
ii. ⊙	d.n.a.		*!

This implementation of indexed constraints solves the apparent ranking paradox in Turkish without recourse to any additional mechanisms. This illustrates another class of constraints to which lexical indexation can apply: not only faithfulness and markedness, but also a constraint like MPARSE.[8]

8.4 Generalized indexing: The predictions

We have now seen several cases of MDEEs that cannot be captured with indexed faithfulness. In Russian, indexed faithfulness would require reference to a domain that includes prepositions and the root to the exclusion of any suffixes. In English, an indexed faithfulness approach cannot capture the generalization that trisyllabic shortening applies only when all morphemes in a stem are exceptional. Finally, in Turkish, the indexed faithfulness approach cannot capture ineffability (rather than unmarkedness) of derived words.

This section addresses some of the typological predictions indexed markedness constraints make, parallel to the predictions made by indexed faithfulness in §7. Again, indexed markedness constraints can differ in their domain of application, and traditional indexed constraints, which produce only local effects, can be reinterpreted as having the *morpheme* as their domain of application, though both *stem* and *word* are also possible domains. This generates the range of possibilities in (42):

(42) MARKEDNESS$_{Property,Domain}$ ≫FAITHFULNESS ≫MARKEDNESS

a. *Domain* = morpheme
Marked structures are disallowed morpheme-internally and at the morpheme boundaries, but are allowed in non-indexed morphemes. (Local MDEEs)

b. *Domain* = stem
Marked structures are disallowed in bare roots and with inflectional affixes, but become possible with derivational affixes. (Non-local MDEEs: Russian vowel deletion)

c. *Domain* = word
Marked structures are disallowed in bare roots, but become possible with the addition of any affixes. (Non-local MDEEs)

The pattern described in (42-b) is found in the case of Russian vowel deletion discussed in §8.1, as well as in English trisyllabic shortening (though in the English case, affixes as well as roots can be indexed for the exceptional property of being Latinate). We have not discussed any MDEEs following the pattern in (42-c), but Dinnsen & McGarrity (2004) discuss a possible case from child language acquisition, where some segments are acquired first in complex words and only later in bare forms: for example [θup] 'soup' but [supi] 'soupy', reflecting the activity of a markedness constraint against strident segments, indexed to words that are roots (*STRIDENT$_{Root,Word}$).

Let us consider the ranking in (42-b) in more detail. The table in (43) shows the crucial combinations of roots and affixes together with their indexes. Several combinations have been considered in the previous subsections. Roots must be unmarked as long as no derivational affixes are present (43-a), while inflectional affixes have no effect (e). In contrast, marked structures are allowed if a derivational affix is present as long as it is itself not indexed (c). The remaining two combinations both involve indexed derivational affixes:

[8] MPARSE is designed to account for a specific type of phonological ineffability—instances where no phonotactic repair (epenthesis, deletion, assimilation, etc.) appears to be possible for certain structures. Lexical indexation extends MPARSE in a limited way to also account for some types of morphophonological ineffability, but only those with the same profile as Turkish, where ineffability has a clear phonotactic motivation (here word minimality requirements), but the relevant phonotactic constraint fails to apply to bare words, resulting in exceptions to a purely phonological generalization. Instances of morphological ineffability that appear to lack any phonotactic motivation (e.g. the absence for many speakers of a past participle form of the English verb *dive*) cannot be accounted for in terms of lexical indexation of the type adopted here.

when such affixes co-occur with indexed roots, regularization of the whole stem obtains (b), as in English trisyllabic shortening; when such affixes co-occur with non-indexed roots, the whole word is regularized (d).

(43) MARKEDNESS$_{\text{P,Stem}}$ ≫FAITHFULNESS ≫MARKEDNESS

	Word structure	$\text{M}_{\text{P,Stem}}$ applies?	Pattern
(a)	$[\text{Root}_\text{P}]_{\text{Stem}}$	Yes	Regularized bare root
(b)	$[\text{Root}_\text{P}\text{-Affix}_\text{P}]_{\text{Stem}}$	Yes	Regularized derived words
(c)	$[\text{Root}_\text{P}\text{-Affix}]_{\text{Stem}}$	No	Exceptional derived words
(d)	$[\text{Root-Affix}_\text{P}]_{\text{Stem}}$	No	Affixes alone must regularize
(e)	$[\text{Root}_\text{P}]_{\text{Stem}}\text{-Affix}_{(\text{P})}$	Yes, within stem	Inflection can be exceptional, but cannot regularize

The typology of indexed markedness constraints predicts the attested languages. In this paper, we have focused mostly on prosodic markedness constraints, leaving out segmental markedness. We leave the investigation of potential cases of indexed segmental markedness, as well as the broader question of whether these phenomena could be captured in a system with indexed faithfulness only, for future research.

9 Alternatives

We have argued that non-local MDEEs can be accounted for with a modest extension of indexed constraints. Our primary innovation is that indexed constraints apply to potentially complex constituents, and that multi-morpheme constituents are treated as having some property P if and only if every morpheme in the string is independently specified as P. Core to this is the idea that phonology is not sensitive to morphosyntactic headedness, so that lexically indexed properties of a head morpheme (whether a root or affix) do not solely determine the properties of complex constituents.

In this section we discuss a number of alternative proposals that have been made to account for similar data. These include the Maximum Entropy model proposed by Gouskova & Linzen (2015) to account for regularization effects in Russian; accounts of loanword phonology in terms of morphologically indexed cophonologies, as in Yu (2000), Inkelas & Zoll (2007); and the analysis of trisyllabic shortening using Stratal OT and Output-to-Output correspondence developed by Burzio (1994, 2000). In each case we argue that our model of constraint indexation accounts better for attested MDEEs, with less theoretical overhead.

9.1 Maximum Entropy grammar with scaling factors

The first alternative we consider is the analysis of non-local MDEEs developed by Gouskova & Linzen (2015), within a Maximum Entropy (MaxEnt) model, regarding the Russian data discussed above in §8.1. The pattern is repeated in (44):

(44) Exceptional vowel-preservation in Russian prepositions (Gouskova & Linzen 2015)

sə dvaˈrom	'with the yard'	(exceptional root blocks deletion)
ˈz dverʲu	'with the door'	(phonologically similar root exhibits regular deletion)
z dvaˈr**ov**ɨm	'with the yard-ADJ'	(root exceptionality lost with suffix *-ov*)

Gouskova & Linzen's analysis is framed within a MaxEnt grammar that uses weighted constraints to model probabilistic rather than categorical outputs (Wilson 2006; Hayes & Wilson 2008). In addition to the weights associated with constraints in MaxEnt, they propose that individual morphemes can be associated with two types of factors that influence constraint evaluation. The first are constraint-specific *scaling factors*, which can be associated either with roots or with affixes: these have an additive effect on violations of individual constraints, and are evaluated locally, just as indexed constraints are (i.e. they apply only if a constraint is violated in a string that includes the morpheme with which the scaling factor is associated). The second are *regularization factors* associated with some affixes: regularization factors are between zero and 1, and apply multiplicatively not to violations, but to the scaling factors of adjacent morphemes.

To account for the data in (44), for example, Gouskova & Linzen propose that the root *dvor* 'yard' is associated with a scaling factor of 9 for the constraint *#CCC, which causes it to exceptionally preserve the vowel of a preceding preposition. In the absence of any derivational suffix, this scaling factor privileges vowel deletion. The suffix *-ov*, however, is associated with a regularization factor of 0; this multiplies the scaling factor of the adjacent root, cancelling it out.

This proposal resembles our lexical indexation analysis in a number of respects, in particular the idea that exceptionality is the result of morpheme-specific properties that weight violations of a given constraint more heavily (either because an indexed constraint is more highly ranked, or because the morpheme applies a scaling factor to all violations of that constraint). It is significant that scaling factors play the same role in their system as constraint indexation plays in ours, as Gouskova & Linzen (2015) do not assume that scaling factors are limited only to faithfulness constraints—they apply potentially to either faithfulness or markedness constraints.

Beyond that similarity are a number of differences. Some are superficial: the MaxEnt model is not intended to identify a single winning candidate, but to generate a range of probabilities across several candidates. We have not addressed the debate between probabilistic and categorical models of grammar; the choice between them does not bear on our core proposal of lexical indexation to complex constituents, which could be adapted to a probabilistic model such as MaxEnt.

A more significant difference between our analysis and Gouskova & Linzen (2015) lies in the role of their proposed regularization factors. For us, certain morphemes disrupt root exceptionality because they create a complex constituent that does not, as a whole, count as bearing a lexically exceptional property. For Gouskova & Linzen (2015), by contrast, morphemes disrupt exceptionality more directly: regularization factors do not impact the applicability of constraints, but instead the calculation of morpheme-specific scaling factors.

There are both conceptual and empirical issues with this implementation. First, for regularization factors to work as intended, it is crucial that they do not influence the evaluation of the morpheme with which they are associated, but instead the evaluation of adjacent morphemes. This essentially abandons the locality principle proposed by Pater (2007, 2009)—a principle that Gouskova & Linzen (2015) themselves adopt for the application of scaling factors. To the extent that this weakens the overall role of locality in the phonological grammar, this is an issue for their account.

A second conceptual issue with Gouskova & Linzen's model arises from their observation that only category-defining derivational morphemes are ever regularizing. They argue that such morphemes form a natural class, as the set of morphemes that are spelled out on the same *cycle* as the root (following work in Distributed Morphology, particularly Embick 2010), and suggest that only such morphemes can be associated with regularization factors. Within their theory, however, there is no natural connection between the morphosyntactic status of an affix and its ability to be associated with a regularization factor, and so the link between regularization and category-defining morphemes remains a stipulation. Indexing constraints to stems or words, by contrast, builds in sensitivity to morphological constituency: the reason that derivational affixes trigger regularization, while inflectional affixes do not, can be captured by indexing the relevant stem to exceptional stems, rather than to exceptional roots or words. Note also that the appeal to morphosyntactic cycles leaves unexplained those languages where inflectional morphemes do have a regularizing effect, as in the Tagalog and Turkish cases discussed earlier in this paper.

Finally, the MaxEnt approach to non-local MDEEs faces significant empirical limitations. It cannot account for cases of the trisyllabic shortening type, where not only roots but also affixes can be indexed for the same lexically exceptional property, allowing complex constituents to show exceptional behaviour if and only if all morphemes within them are indexed for the relevant property. Similarly, it is not clear how this model could account for the interaction of ə-deletion and ɹ-nativization in Slovenian. We saw in §6 above that though both [ɹ] and [ə] in Slovenian are preserved in bare roots, [ɹ] is lost with the addition of any affix, while [ə] is compatible with inflectional morphology but not derivational morphology. This type of mixed pattern could technically be accommodated by the MaxEnt model, by making regularization factors constraint-specific: one could say that inflectional suffixes have a regularization factor only for Dep, while derivational suffixes have regularization factors for both Dep and the more specific Dep(front) (responsible for schwa preservation). At this point, Gouskova & Linzen's approach is burdened with a duplication of constraint-specific information for each morpheme; the same patterns are captured in our system by general principles of constraint indexation to complex constituents.

To conclude, despite the similarities between our account and the MaxEnt model, there are both conceptual and empirical reasons to prefer the account framed in terms of lexical indexation, as a simpler theory that nonetheless accounts for a wider range of data.

9.2 Cophonologies

Another approach to exceptionality in OT is cophonology theory (Inkelas et al. 1997; Anttila 2002; Inkelas & Zoll 2007). Put simply, the idea is that specific words or morphemes can be associated with distinct constraint rankings, so that multiple rankings coexist within a single language. The choice among these cophonologies depends on the morphemes present in a word: one cophonology applies to regular morphemes, while another applies to exceptional morphemes.

In the case of DEEs, a cophonology applies to a larger domain. That is to say, the exceptional ranking applies to loanword roots, whereas suffixes trigger application of regular cophonology. As such, all suffixed words will have the native phonology. For instance, the loanword Dutch cophonology has the ranking of IDENT $\gg$ *ɹ, thus allowing bare roots like *Op*[ɹ]*ah* 'Oprah'. Once a native suffix is added, the native ranking *ɹ $\gg$ IDENT applies to the whole word, correctly predicting forms like *Op*[ʀ]*ah-tje* 'Oprah-DIM'.

A theory that allows morpheme-specific constraint rankings is very powerful, and should be preferred only if that power is necessary to account for attested phonological patterns. In this section we first argue that some of the difficult cases for which cophonologies have been proposed can also be accounted for in terms of lexical indexation; we then argue that lexical indexation makes stronger predictions about the range of possible MDEE patterns, and so should be preferred on conceptual grounds.

The test case we consider comes from patterns of stress in Tohono O'odham (Yu 2000). This language has a left-to-right trochaic rhythm with a final unparsed syllable in unsuffixed words: $(\acute{\sigma}\sigma)\sigma$, as shown in (45-a). Crucially, suffixed words parse this final syllable into a separate monosyllabic foot: $(\acute{\sigma}\sigma)(\grave{\sigma})$. This is a clear case of a MDEE.

(45) Stress assignment in Tohono O'odham (Yu 2000)

a. Underived words

$\acute{\sigma}\sigma$	píː.ba	'pipe'
	hái.waɲ	'cow'
$\acute{\sigma}\sigma\sigma$	ʔá.su.gal	'sugar'
	sí.min.ʤul	'cemetery'
$\acute{\sigma}\sigma\grave{\sigma}\sigma$	pí.mi.àn.do	'pepper'
	pá.ko.ʔò.la	'Pascola dancer'

b. Derived words (suffixed and reduplicated)

$\acute{\sigma}\sigma$	hím-ad	'will be walking'
	tó-toɲ	'ants'
$\acute{\sigma}\sigma\underline{\grave{\sigma}}$	ʧík.pan-dàm	'worker'
	pí-pi.bà	'pipes'
$\acute{\sigma}\sigma\grave{\sigma}\sigma$	máː.gi.nà-kam	'one with a car'
	pá-pko.ʔò.la	'Pascola dancers'

Yu (2000) attributes the difference between unsuffixed and suffixed words to cophonologies. The root cophonology ranks FT-BIN(σ) above PARSE-σ, predicting unparsed final syllables in odd-syllable words. The affix cophonology applies to all affixed words, and reverses the ranking between these two two constraints, thus preferring the candidate with the final monosyllabic root. To this point, this analysis can be directly restated in terms of constraint indexation, using the constraint FT-BIN$(\sigma)_{\text{Root,Word}}$, indexed to roots and words. This constraint applies only in words without suffixes, as in (46-a), favoring the candidates without monosyllabic feet. In affixed words, PARSE-σ instead favors candidate (46-b-ii), with final secondary stress.

(46) Tohono O'odham and indexation to words

a. Non-derived words have final unparsed syllable

/ʔásugal/	Ft-Bin(σ)$_{Root,Word}$	Parse-σ	All-Ft-L
i. ☞ (ʔá.su)gal		*	
ii. (ʔá.su)(gàl)	*!		**
iii. ʔa(sú.gàl)		*	*!

b. Derived words have final monosyllabic foot

/ʧikpan-dam/	Ft-Bin(σ)$_{Root,Word}$	Parse-σ	All-Ft-L
i. (ʧík.pan)-dam	d.n.a.	*!	
ii. ☞ (ʧík.pan)-(dàm)	d.n.a.		**
iii. ʧik(pán-dam)	d.n.a.	*!	*

These patterns are somewhat complicated by words with an epenthetic [a], as in (47). Some consonant-initial suffixes are preceded by this epenthetic vowel, as in (47-a) where the epenthetic vowel is underlined, whereas other are not, as in (47-b).

(47) Distribution of epenthetic <u>a</u> (Yu 2000)

	verb	verb+suffix	
a.	wá.kon	wák.on-<u>a</u>mɨḍ	'go and wash'
	ʧíkpan	ʧíkpan-<u>a</u>dàg	'good at working'
b.	ʧíkpan	ʧíkpan-dàm	'worker'
	ʧíkpan	ʧíkpan-<u>a</u>dàg-dam	'one with a tool'

One way to analyze the distribution of epenthetic [a] is to say that there is a latent segment preceding those suffixes that trigger epenthesis, and is realized when the preceding morpheme is consonant-final (Zoll 1998). While this would be consistent with the indexation approach, indexation also allows us to see these cases as a local DEE, triggered by specific suffixes. We represent such suffixes as having a property *a*. Epenthesis can be captured by the ranking of $*CC_a \gg$ Dep. This is directly parallel to the analysis of Russian latent vowels (yers) with constraint indexation in Gouskova (2012).

A second complication is that epenthetic *a* cannot bear stress in most words. To capture this generalization, Yu (2000) proposes the constraint StressSegment (48).

(48) StressSegment (Yu 2000; henceforth, StressSeg)
The nucleus of a stressed mora must be a full segment. (Only a full segment can bear stress.)

The three constraints can be ranked with respect to the prosodic constraints in (46). The effect of the combined ranking is shown in (49). The winning candidate has an epenthetic [a], which is not stressed, thus violating only high ranked Dep. The remaining candidates fatally violate either the top-ranked $*CC_a$, having no epenthesis (b), StressSeg, having stress on the epenthetic vowel (c), or Dep, having additional epenthesis in the root (d).

(49) a-epenthesis and stress assignment

/ʧikpan-dág$_a$/	$*CC_a$	Dep	StressSeg	Ft-Bin(σ)$_{Root,Word}$	Parse-σ	All-Ft-L
a. ☞ (ʧík.pa)n-<u>a</u>(dàg)$_a$		*		d.n.a.	*	***
b. (ʧík.pan)-(dàg)$_a$	n-d!			d.n.a.		**
c. (ʧík.pa)(n-<u>à</u>dag)$_a$		*	*!	d.n.a.		**
d. (ʧí.k<u>a</u>)(pà.n-<u>a</u>)(dàg)$_a$		**!		d.n.a.		**,****

The final complication is that Tohono O'odham exhibits a morphological pattern of truncation, which overrides the above restriction against stressing epenthetic [a], as shown in (50). Yu (2000) proposes that truncation is associated with another distinct cophonology—but again this can be seen as a further derived environment effect.

(50) Truncated words can have stress on epenthetic [a] (Yu 2000)

a. Stress in truncated words is the same as in derived words

IMPERFECTIVE	PERFECTIVE	
síkon	síko	'hoe object'
wáʧuwì-ʧud	wáʧuwìʧ	'make someone bathe'

b. Epenthetic _a_ can be stressed in truncated words

IMPERFECTIVE	PERFECTIVE	
wákon-_a_mɨɖ'	wákon-_à_m	'go and wash
ʧíkpan-_a_ʧùd	ʧíkpan-_à_ʧ	'make someone work'

Truncation is unlike other kinds of affixation in that its locality is unclear. In some sense, the whole word is the realization of truncation, so that Pater's locality condition in (2) would allow any constraint that is indexed to the truncatative morpheme, to apply locally to the whole word. This underlies the evaluation of the indexed PARSE-σ_{TRUNC} in (51). This constraint applies to the whole word, preferring the winning candidate with a degenerate foot (a).[9]

(51) a-epenthesis in truncations

/wákon-amɨɖ$_a$-TRUNC/	PARSE-σ_{TRUNC}	*CC$_a$	DEP	STRESSSEG	FT-BIN(σ)$_{\text{Root,Word}}$	PARSE-σ	ALL-FT-L
a. ☞ (wá.ko)(n-_à_m)$_a$			*	*	d.n.a.		**
b. (wá.ko)n-_a_m$_a$	*!		*		d.n.a.	*	

This concludes our analysis of of Tohono O'odham, showing that the analysis based on lexical indexation proposed in this paper can successfully account for the kind of complex morphological interactions for which cophonologies have previously been proposed. By contrast, cophonologies cannot capture most local MDEEs. Recall the Finnish hiatus resolution presented in §2: hiatus is possible root-internally, but not at the morpheme boundary, the vowels coalesce into a long high vowel. In a cophonology approach, the root cophonology would have to apply to the whole word—cophonologies do not apply locally—but this would incorrectly predict coalescence not only at the morpheme boundary, but also root-internally. This cannot be easily saved by reference to, for instance, affix-specific markedness constraint (HIATUS$_{\text{Affix}}$), as this constraint cannot distinguish between segments internal to the affix and those that occur across the morpheme boundary. This demonstrates the inability of cophonologies to capture local MDEEs, whereas lexical indexation can capture both local and non-local effects.

Cophonology theory is thus very powerful, but cannot account for all attested derived environment effects, and moreover does not make any explicit predictions about how similar individual cophonologies within a single language can be. In all attested cases, including those discussed in this paper, derived and non-derived environments differ only in a small number of constraint rankings. For instance, the underived and derived cophonologies of Tohono O'odham differ in a single ranking, which is indeed the typical case. But nothing in the approach based on cophonologies would rule out much more radical differences, for example a language exhibiting the overall constraint ranking of English for bare roots, but exhibiting the overall phonology of Tohono O'odham in derived environments. No such cases have been reported.

In short, cophonologies make few predictions about limits on how exceptional an exceptional morpheme can be, while lexical indexation makes very specific predictions. Parsimony thus favors lexical indexation over cophonologies, all other considerations being equal.

[9] An anonymous reviewer notes that the alternative to this analysis would be to treat the affix present in perfective forms as having two exponents: truncation and word-final stress. This alternative is also consistent with indexed constraints.

9.3 Stratal OT

The final alternative we consider is the possibility that at least some cases of long-distance MDEEs could be captured using Stratal OT (Burzio 1994, 2000; Kiparsky 2000; Bermúdez Otero in preparation). The basic idea of Stratal OT is that forms are built up cyclicly by grammars, with (potentially) different rankings on each level. Here we discuss root, stem, and word strata.

The challenge of stratal analyses is that all cycles should apply equally to both derived and non-derived words. To illustrate why this is a problem, let us consider Tagalog data. Recall that in Tagalog, [f] is possible in unaffixed loanwords, but is replaced by [p] in affixed words (6). Stratal OT relies on ranking differences between strata to account for morphophonological interactions In the analysis of Tagalog, reference to two strata (root and word) are needed, so we omit the stem level in the following tableaux. At the root level, Ident would outrank *f, ensuring that [f] can surface in bare roots (52-a). At the word level, the ranking of the two constraints would be reversed so that the long-distance MDEE applies in affixed words (52-b).

(52) Stratal OT analysis of Tagalog: Affixed forms

a. Root level

/filipino-ŋ/	Ident	*f
i. ☞ filipino-ŋ		*
ii. pilipino-ŋ	*!	

b. Word level

/filipino-ŋ/	*f	Ident
i. filipino-ŋ	*!	
ii. ☞ pilipino-ŋ		*

The problem is that this analysis does not work for unaffixed words. The analysis at the root level is directly parallel to affixed words shown in (52-a), resulting in the winning [filipino]. At the word level, the ranking *f ≫ Ident still applies, leading to undesired candidate with [p].

(53) Unaffixed forms: Word level

/filipino/	*f	Ident
i. ☹ filipino		*
ii. ☞ pilipino	*!	

The crux of the problem is that the word level ranking applies equally to affixed and unaffixed words, and so the system cannot distinguish between bare roots and derived words.

To account for MDEEs, Stratal OT must rely on other mechanisms. Stratal OT models local MDEEs using a constraint that refers to a sequence at the morpheme boundary. As such, cases like Finnish hiatus in (3) are unproblematic. However, this analysis is unavailable for long-distance MDEEs, because the constraints involved do not refer to segments at the morpheme boundary. To solve this challenge, Burzio (2000) combines Stratal OT with output-output faithfulness constraints.

In his analysis, bare root forms are subject to input-output faithfulness, which is ranked above some markedness constraint. In Burzio's analysis of English trisyllabic shortening, for example, the bare root forms are subject to a ranking in which IO-faithfulness is higher than *LongVowel, illustrated in (54-a). Crucially, output-output faithfulness does not apply at this stratum. In the derived stratum, the situation is reversed, with IO-faithfulness not applying, because the underlying representation is no longer accessible at this stratum. As such, the next highest ranked constraint *LongVowel favors the shortening candidate (54-b).

(54) English trisyllabic shortening in a stratal approach

a. No shortening in non-derived Latinate roots

/dɪvájn/	Faith-IO	*LongVowel	Faith-OO
i. ☞ dɪvájn		*	d.n.a.
ii. dɪvín	*!		d.n.a.

b. Shortening in derived Latinate roots

/dɪvájn/ /-ɪti/	Faith-IO	*LongVowel	Faith-OO
i. dɪvájn-ɪti	d.n.a.	*!	
ii. ☞ dɪvín-ɪti	d.n.a.		*

This analysis can work only in a stratal approach, where derived strata no longer have access to the original input for the purposes of faithfulness constraints. While this approach could account for most data reported in this paper, it cannot account for all. Recall Slovenian schwa fronting and ɹ-nativization data. Both these long-distance MDEEs apply in derived words, but only ɹ-nativization applies in inflected words. While it is clear that derivation constitutes a separate derivational stratum, inflection may or may not. Thus, when we consider schwa fronting and ɹ-nativization, we are logically left with two possibilities: either inflected words will pattern with bare roots (in which IO-faithfulness would apply), or inflected words will pattern with derived words (in which only OO-faithfulness applies). The problem is that neither solution works for Slovenian, as shown in (55). The general ranking must be the same in Slovenian as in English, with in IO-faithfulness ranked above some markedness constraint, which is in turned ranked above OO-faithfulness. If this general ranking did not apply, no MDEEs would be predicted. To make the argument explicit, we present separate IO-faithfulness constraints and markedness constraints. Whether we consider inflection together with the root stratum (55-a) or with the derivation (55-b), the attested candidate (ii) loses to the unattested faithful candidate (i) or completely nativized candidate (iii).

(55) Interaction of ə and ɹ in Slovenian: Wrong preditions for inflected words

a. Analysis without Faith-IO applying, fails

/dəˈtɹojt/ /-u/	Dep(front)-IO	Ident-ɹ-IO	*ə	*ɹ	Faith-OO
i. dəˈtɹojt-u	d.n.a.	d.n.a.	*!	*!	
ii. ☹ dəˈtrojt-u	d.n.a.	d.n.a.	*!		*
iii. ☞ deˈtrojt-u	d.n.a.	d.n.a.			**

b. Analysis with Faith-IO applying, fails

/dəˈtɹojtu/	Dep(front)-IO	Ident-ɹ-IO	*ə	*ɹ	Faith-OO
i. ☞ dəˈtɹojtu			*	*	d.n.a.
ii. ☹ dəˈtrojtu		*!	*		d.n.a.
iii. deˈtrojtu	*!	*!			d.n.a.

The shortcoming of OO-faithfulness is that it can make only a single distinction, between a first phonological cycle (subject to IO-faithfulness) and all subsequent cycles (subject only to OO-faithfulness). What the case of Slovenian demonstrates is that more granularity is needed, to capture languages that make multiple cuts along a continuum of nativization. OO-faithfulness thus cannot be easily extended to all cases of MDEEs presented in this paper, while the lexical indexation approach we have argued for can. In this circumstance, there is reason to prefer the lexical indexation approach for its wider empirical scope.

We have now seen why Stratal OT is not a viable alternative to account for long-distance MDEEs. The standard approach cannot capture even the most basic patterns. The extended Stratal OT with OO-faithfulness fares better, but cannot account for the full extent of attested patterns.

10 Conclusions

This paper discusses morphologically derived environment effects, which constitute an unusual case of long-distance interactions arising from the interplay of exceptional phonological patterns and the morphological structure of words. These patterns have constituted a serious challenge for theories of locality and exceptionality in phonology.

A simple extension of lexical indexation can successfully account for these effects. Our proposal is that indexed constraints are not only sensitive to lexically determined properties such as "root" or "loanword", but are also specified to apply within particular morphological domains. In maximally local cases, the relevant domain is a single morpheme, but larger constituents such as stems and words are also available for indexation. An indexed constraint applies to such larger constituents only when all the morphemes within them are individually specified for the relevant lexical property. This proposal captures the intuition that the exceptional status of roots can be ignored when a suffix follows; exceptional loanword patterns are lost once a native affix is added.

This model of lexical indexation accounts not only for well-known local morphological effects, but also the non-local effects that are characteristic of loanword adaptation or found in other domains as well. We argue that lexical indexation provides a better account of these data than other proposals, accounting for the attested range of phenomena while also making predictions about patterns that should not be possible.

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