Phonological asymmetries between roots and affixes

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Abstract

This review surveys the phonological asymmetries between roots and non-roots (affixes, clitics). It starts with an extraphonological, structural definition of roots, and considers those non-phonological properties that are phonologically relevant: they are easily borrowed, and they are most deeply embedded. The empirical portion of the review concentrates on templaticism and size restrictions, asymmetries in segmental contrast/inventories, the properties of multi-root words (compounds), and accentual characteristics that differ between roots and affixes. The theoretical section surveys theories that account for these properties: Prosodic Morphology, Positional Faithfulness, the cycle and its analogs, and Anti-Faithfulness. I then critically review several recent and not-so-recent proposals that blur the line between affixes and roots, using the 'root' designation diacritically or recasting diacritic distinctions as structural distinctions. The concluding section discusses the role of roots in phonological learnability.

1 Introduction

Trubetzkoy (1939:306) laments how little interest his contemporaries take in the phonological properties of different kinds of morphemes. In the ensuing 80 years, the situation has definitely improved: we understand a lot more about the phonology of morpheme classes, including roots and affixes. My goal in this review is to summarize our current understanding of the differences between roots and affixes, and why they exist.

The phonological properties of roots started coming into sharper focus around the 1980's and 90's, which saw the development of the theories of Prosodic Morphology and eventually Optimality Theory (McCarthy and Prince 1986, Prince and Smolensky 1993/2004). Prosodic Morphology seeks to explain generalizations such as "roots must be at least two syllables". Optimality Theory studies recurrent but non-absolute cross-linguistic tendencies, such as restricting certain segmental contrasts to roots—true of some but not all languages. At the same time, developments in morphological theory, especially Distributed Morphology (Halle and Marantz 1993), have resulted in a more sophisticated understanding of what roots are, and we have a clearer sense of the properties of non-roots—affixes and clitics (Selkirk 1995).

Despite this gained knowledge, phonological and morphological theories do not always listen to each other. For example, phonologists will sometimes dub an affix a 'root' just because it exhibits the phonological properties that are normally reserved for roots in the language—without solid morphological arguments. Conversely, some morphological proposals do away with the root-affix distinction altogether, neglecting the phonological consequences of such a move. Towards the end of this review, I take a critical look at these proposals.

In the rest of the paper, I start by defining roots in an extraphonological way, and survey briefly those non-phonological properties that have phonological consequences: their being most deeply embedded, and belonging to an open class (§2). Section §3 is empirical, focusing on asymmetries in templaticism/size,

segmental inventories, and the special status of multi-root words (compounds), and accentual differences between roots and affixes. Theories of these phenomena are discussed in §4: Prosodic Morphology, Positional Faithfulness, the cycle, and Anti-Faithfulness. Section 5 looks at proposals, both new and old, that blur the distinction between roots and affixes (Lowenstamm 2015, Creemers et al. 2018, Urbanczyk 2006, inter alia). I conclude the paper (§6) with some recent evidence from phonological learnability modeling that underscores the importance of roots.

2   Defining roots and affixes

Any analysis root-affix asymmetries must establish an extra-phonological definition of these categories, which turns out to be far from straightforward. Many discussions presuppose the root-affix distinction without defining it in overt terms that cover all the edge cases and work for a variety of languages. Textbook definitions of roots and affixes are often circular: an affix is a bound morpheme that attaches to a stem (which includes a root), and a root is something that an affix attaches to, and perhaps the morpheme that contributes the most semantic content to the word. I think the most straightforward definition of a root is structural, so I next explain what this means.

2.1   Roots defined structurally

We can define a root as a morpheme that occupies the syntactic position $\sqrt{}$. Non-roots are other morphemes: the category heads *n*(oun), *v*(erb), and a(djective/adverb), plus various functional heads (number, aspect, tense, etc.) This view of roots is associated with syntactic theories of morphology: Nanosyntax, Distributed Morphology, Exoskeletal morphology (Halle and Marantz 1993, Harley and Noyer 1999, Borer 2005, Caha et al. 2018). Such theories usually assume that roots lack syntactic categories, which, along with other grammatical properties, are contributed by functional structure.

   The idea that roots lack categories extends the logic of zero derivation. Early morphological theories assumed that roots had basic syntactic categories, even if they were obscured by zero derivation (e.g., *a feud/to feud*). Thus, Allen (1978:ch.4) uses the selectional restrictions of suffixes such as *-al* and *-ive* to determine the basic categories of roots as follows:

(1)   Zero derivation in Allen (1978), assuming roots have basic syntactic categories

   a.   feud$_N$ feud-al$_A$ *-al* selects for nouns (*music-al*), therefore *feud* is a noun
        feud$_V$ *feud-ive$_A$ [[feud$_N$]Ø$_V$]
   b.   respect$_V$ respect-ive$_A$ *-ive* selects for verbs (*collect-ive*), therefore *respect* is a verb
        respect$_N$ *respect-al$_A$ [[respect$_V$]Ø$_N$]

Of course, *-al* and *-ive* select for neither nouns nor verbs. They attach to a variety of constituents, including bound roots (*vest-al, abysm-al, fer-al, develop-ment-al, pejorat-ive, dat-ive*). The idea that roots lack categories can reconcile these facts. If neither *feud* nor *respect* are fundamentally verbal or nominal, they get their categories in context, from *-al, -ive*, or the null morphemes[1] they combine with. This alternative offers a formally consistent analysis of roots:

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[1]This style of theory has been criticized for the amount of null structure it needs to assume. Lieber (1980), for example, argues against zero derivation because it requires at least three distinct zero morphemes (-Ø$_n$, -Ø$_a$, -Ø$_v$). It also requires a lot of specification of selectional requirements. The proliferation of zeroes raises both philosophical and learnability issues, but these problems are not usually seen as fatal in modern syntax theories. I will likewise supend disbelief for the duration of this review.

(2)   Roots as structural positions, combining with syntactic categories
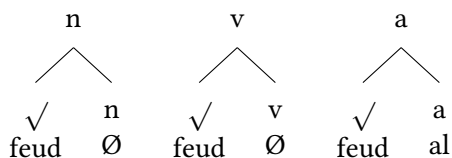
In addition to being formally consistent, this view works for many languages. In Semitic, roots are bound in a rather different way from *fer-* in *feral*. The invariant part of a Semitic root is its consonants, with the vowels and other properties such as consonant length co-varying with morphological contexts. Thus, the Arabic root for writing is √*ktb*: [kataba] 'he wrote', [kutiba] 'it was written', [kattaba] 'he caused to write', [kitaabun] 'book (nom)', [kuttaabun] 'Koran school (nom)', [maktabun] 'office (nom)', [makaatibu] 'offices (nom)' McCarthy 1979:116). Many analyses of Semitic morphology assume that roots obligatorily combine with a *pattern* that expresses the grammatical meaning; the pattern is the affix. Kastner (2019), for example, analyzes the vowels in Hebrew verbs as affixes, so [katav] 'he wrote' is underlyingly /√ktb/ plus a null verbalizing head and /a a/, spelling out active voice in the past tense. In this view, roots are morphologically bound both in English and Semitic. The only difference is that English roots are bound to morphemes that are sometimes phonologically null.

What, then, is an affix? An affix is any morpheme that is not a root—i.e., that expresses functional structure—and is contained in a phonological word with a root. This leaves clitics: function morphemes that lack roots but that also may be phonologically more independent than affixes. Just like affixes, clitics are normally phonologically dependent, but their morphosyntactic distribution is different (Klavans 1985, Marantz 1988, Selkirk 1995, inter alia). For example, the English possessive *'s* is phonologically identical to the 3rd person singular -*s* (and similar to the plural -*s*), but the possessive attaches to the rightmost word of a DP, rather than a smaller constituent. This view of roots, affixes, and clitics essentially divides the world of morphemes into roots vs. everything else. Whether this is the right cut is an open question; it would require that phonologists zoom out beyond affixes in their study of the phonology of roots. I discuss a few relevant cases below (Navajo, Lakhota).

2.2   Other extraphonological differences between roots and affixes

2.2.1   Syntactic properties

Roots have been the focus of intense study in syntactic approaches to morphology (Marantz 1996, Borer 2005, Alexiadou et al. 2014, Haugen and Siddiqi 2013, Harley 2014, inter alia). I will not review all the properties of roots here, especially since most are controversial. The key contrast for our present purposes is that morphosyntactically, roots are poor, but phonologically, they are rich.

Morphosyntactic treatments often strip roots of various properties and shift them into functional structure. We already saw above that roots are thought to lack categories. Roots are moreover argued to lack morphosyntactic features such as gender and number; whenever the root of a noun appears to be inherently feminine (e.g., *mare*) or plural (*alms*), this is contributed by its null nominalizing head *n*, which bears the relevant features (Acquaviva 2008, Kramer 2015). Similarly, roots of verbs are thought to lack argument structure; they do not take complements (Arad 2003 and many others). Another thing roots lack is the ability to project: while just about every functional projection is a phrase, most syntactic treatments do not assume a root phrase (Harley 2014 is a prominent dissenting opinion). De Belder and Craenenbroeck (2015) suggest that various properties of roots follow from being introduced early in the derivation—they are most deeply embedded. Embeddedness might be responsible for several of their phonological properties, as well, as I explain below. For example, if a root is combined with a minimal amount of functional

structure, which may be null, it will have to be prosodified by itself. This requires that it be prosodically big enough, and in turn might be part of an explanation for minimal word effects (§3.1).

2.2.2   Semantic differences: function vs. content morphemes

The root-affix distinction is sometimes seen as analogous to the distinction between content and function morphemes (see, for example, Harley and Noyer 1999 on l-morphemes and f-morphemes). Content morphemes encode real-world meanings, whereas function morphemes encode grammatical meanings from a universal pool of features (definiteness, plurality, modality, and so on). While this works for most roots and affixes, it is not difficult to think of counterexamples. Thus, most linguists would likely put prepositions such as *to* in the function class (e.g., Selkirk 1995 treats them as function words). The class of prepositions is not in an obvious way an open one. But, prepositions can be built from demonstrably category-flexible roots (English *behind*, cf. *hind legs, behinds*). Russian has a sizeable category of *root prepositions*, as shown in (3), which can appear in verbs, nouns, adjectives, and so on.[2] We can make sense of such examples if roots can combine with P as a category head; sometimes this head is phonologically null, just as *n* and *v* can be null in English. If this is the right analysis, then [skvós^j] 'through' in (3) is not a "function word" nor a "content word" but a complex constituent composed of both kinds of morphemes.

(3)   Root prepositions in Russian (Gouskova 2019, and references therein)

UR	Preposition		Verb	
/√skvoz^j/	√skvós^j	'through'	√skvaz-ít^j	'to be draughty'
/√pered/	√périt	'before'	a-√pirid-ít^j	'to come ahead'
	Noun		Adj/Adv	
	√skvaz-n^{j}ák	'draught'	√skvaz-íst-ij	'draughty'
	√piréd-nik	'apron'	na-√skvós^j	'to the core (adv)'
	√pir^{j}ód	'front'	√piréd-n-ij	'front (adj)'

Just as some function elements have roots, some content elements are affixes. Salish languages have "lexical affixes" with meanings like 'dishes', 'foot', 'building'. Wiltschko (2009), working within DM assumptions, analyzes these affixes as bound/incorporated roots (contra traditional analyses that treat them as nouns). The so-called disjunct suffixes of Navajo have been analyzed as lexical, as well; see §3.2.2. English, too, has several affixes that are root-like. The suffix *-itis* (*burs-itis, laryng-itis, tenure-itis*), with its meaning "a disease of X", seems like a poor candidate for a function morpheme expressing plausibly universal features. Again, allowing roots to be abstract allows us to make sense of this. One possibility is that words derived with *-itis* are compounds that include a cranberry root. Alternatively, affixes like *-itis* might be complex constituents composed of a nominalizing category head and a root. As I show in §5, this second view comes with phonological predictions, which at least for morphemes like *-itis* appear to be correct.

While roots are supposed to be content morphemes, some have very little content indeed (see, e.g., Harley 2014). Roots can display contextual allosemy (Marantz 2013), and some roots are so flexible as to mean very little (e.g., con-*ceive*, de-*ceive*, per-*ceive* in English, and similar examples from Semitic). These edge cases are not problematic if roots are defined structurally, rather than semantically.

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[2]The examples are transcribed in IPA and show unstressed vowel reduction and word-final devoicing; these rules demarcate prosodic words in Russian.

2.2.3 Open/closed distinction: a possible source of phonological root/affix asymmetries

Another phonologically relevant feature of roots is that they are an open class. An open class can be expanded through borrowing or coinage, whereas a closed class is supposedly finite, because languages do not often borrow (presumably universal) functional structure. While it is true that languages tend to borrow roots more readily than functional morphology, there are well-known exceptions (e.g., *them* in English is borrowed from Scandinavian). Still, borrowing is a plausible source of some phonological asymmetries between roots and affixes discussed in §3.2: if a language often borrows roots without modifying their segmental content, then roots have sounds that affixes lack.

An example of borrowing non-native segments along with roots comes from Quechua (Muysken 2012). Quechua borrows Spanish roots and embeds them in words with Quechua suffixes. An example from Media Lengua, a Spanish-Quechua interlanguage, is in (4). The Quechua suffixes are italicized. The phonologically interesting part of this example is that Quechua does not have voiced stops in its native contrastive inventory, but they appear in Spanish loans. If roots are more commonly borrowed than affixes, then over time this might lead to an asymmetry: voiced stops only occur in roots. As I show in §3.2, Quechua already has a similar asymmetry in the distribution of native laryngeal contrasts.

(4) *pero* *el*-ka $\sqrt{}$*akorda*-ri-ʃpa-wan $\sqrt{}$*anda*-xu-ʃka   *Quechua*
     but   3-TOP $\sqrt{}$reflect-REF-SUB.SS-COM $\sqrt{}$walk-PRG-NPAS
     'But thinking by himself he walked along'

By contrast, affixes can definitely be borrowed, but this happens less frequently, and it is especially rare with affixes that carry certain grammatical meanings. Thus, English has many non-native suffixes that confer nominal, adjectival, and verbal categories (conform-*ity*, custom-*ary*, custom-*ize*, etc.). Quechua has borrowed suffixes from Spanish, such as diminutives (see §3.2.2), but only one loan suffix is uncontroversially a function morpheme: the Spanish plural *-s* (Quechua's native plural is *-kuna*).

Borrowing is of course not the only pathway to root-affix differences: some phonological rules are sensitive to usage factors such as frequency or information load. Even in a language with a complex morphological system, affixes are going to be a smaller set than roots. Moreover, productive affixes are bound to be more frequent in speech than most roots. In some contexts, affixes are also highly predictable, while roots are not; this makes affixes (as well as high-frequency roots) vulnerable to lenition and other structure-reducing phonological rules (Seyfarth 2014, Hall et al. 2018, Cohen Priva and Jaeger 2018).

To summarize, defining roots in structural terms allows us to have a formal but non-circular characterization of them. Ideally, various properties of roots should follow from their structural characteristics. Now that we have a non-phonological definition of roots, we can sensibly ask what their phonological properties are.

3   A tour of phonological root-affix asymmetries

I start with generalizations about phonological size, and then go on to segmental asymmetries, asymmetries in the directionality of rule application, and accentual differences between roots and affixes. Compounds present a special case; in just about any language where roots have some special phonological property, compounds will be an exception compared to single-root words.

3.1 Templaticism and size

3.1.1 Size generalizations about roots

Languages often require roots to be a minimal size, or a certain shape—that is, to follow a template. But before showing you what such languages look like, I want to show you a language that doesn't care about

root size: Russian. In Russian, roots can be so small that they are easily missed (see (5)). In the following paradigms, the verb 'drink' at least some of the time appears as just a single consonant [p-], or a consonant followed by a glide, [pj-]. In the usual analysis of this paradigm, affixes consist of one segment each, that is, 2.sg.[pj-o-ş] '√drink-ᴛʜᴇᴍᴇ-2.sɢ'. This is not an isolated example; cf. [bitʲ] 'to beat', [nitʲ] 'to whine' (vs [noj] 'whine-imper'), [şitʲ] 'to sew' (vs. [şof] 'seam'). Russian requires all phonological words to have at least one vowel, but there are nouns whose roots are vowelless: [mgl-a] 'dusk', [tlʲ-a] 'aphid', [xn-a] 'henna' (see (5c)).

(5)   Russian: no minimal size for roots

a.	pitʲ 'to drink'		b. skristí 'to scrape'	
	Sɢ	Pʟ	Sɢ	Pʟ
1	pjú	pjóm	skribú	skribʲóm
2	pjóş	pjóti	skribʲóş	skribʲóti
3	pjót	pjút	skribʲót	skribút
ᴘᴀsᴛ:	píl (ᴍ), pilá (ꜰ), pílə (ɴ)	píli	skrʲób, skriblá, skribló	skriblí
ɪᴍᴘᴇʀ:	péj	péjti	skribí	skribíti

c. 'henna'	sɢ	ᴘʟ
Noᴍ	xn-a	xn-ɨ
Gᴇɴ	xn-ɨ	(paradigm gap)
Dᴀᴛ	xn-e	xn-am
Aᴄᴄ	xn-u	xn-ɨ
Iɴsᴛ	xn-oj	xn-ámi
Loᴄ	xn-e	xn-ax

As these examples suggest, Russian roots may be smaller than a syllable. Whatever theory one concocts for languages that do have minimal size requirements must admit languages such as Russian, which do not.

For languages that do have minimality requirements, we can formulate a generalization: if minimality requirements apply to any morphemes, they hold of roots. Affixes are *said to* be subject to maximality requirements, but good examples hard to find. I suspect that more often than not, affixes are just harder to generalize over.

Let's look at some languages with minimality requirements on roots. English roots contain at least one heavy syllable: _cat, police, flee, cert-ify, atroc-ious_ (Golston 1991, McCarthy and Prince 1994b). The generalization holds equally of bound and free roots, but not of affixes. Suffixes and prefixes can also be several syllables long (e.g., *meta-*, *pre-*, *-ify*, *-able*) or nonsyllabic (e.g., *-z*, *-θ*, *-d*). Monosyllables may be light or heavy (*-less*, *-ness*, *-y*). English prefixes cannot consist of a single consonant, but otherwise affixes are not constrained in size.

In other languages, too, it is not difficult to find examples of root templaticism—but the same cannot be said of affix templaticism. Roots are reported to be maximally monosyllabic in Mbe verbs (Walker 2000:95) and Chinese (Lin 1993). Roots are minimally disyllabic in Fijian (Dixon 1988:26) and Quechua (Gouskova and Gallagher 2020). Some generalizations concern C/V shape rather than syllable count. Trubetzkoy (1939) notes that Russian roots end in consonants, and that roots in Arabic and Hebrew tend to have three consonants in them.

In most of these cases, there are exceptions, however. For example, in Russian, there is a sizable class of indeclinable roots such as *bizé* 'meringue', *lédi* 'lady', *menʲú* 'menu', which end in vowels. Fijian roots are mostly disyllabic, but there are some that are shorter than two syllables, e.g., √*ðaa-* 'bad', √*dree-* 'pull'. Arabic has some roots that have two or four consonants, rather than three (see McCarthy 1979, McCarthy

and Prince 1990), and Hebrew nouns (especially the borrowed ones) are far less templatic than verbs (Bat-El 1989, 1994). Here is a quantitative picture of roots in Quechua, based on a list of 2,479 roots (Laime Ajacopa 2007, digital version from Gouskova and Gallagher 2020). There is a clear generalization: most roots are CV(C)CV, and they end in a vowel. But there are exceptions, too.

(6)   Root shapes in Quechua: majority are disyllabic and end in a vowel

CVCCV	1,074	VCVCV	19	CVC	8
CVCV	1,024	CVCCVCV	18	CV	6
VCCV	120	CVCVCCV	16	VCVCVCV	5
CVCVCV	59	CVCVCVCV	10	other (12 shapes)	23

By contrast, Quechua suffixes are atemplatic: the only generalization is that most start in a consonant. Out of 76 suffixes that occur in Gouskova and Gallagher's (2020) morphologically parsed corpus, only the diminutives borrowed from Spanish are vowel-initial (*-ito, -ita*), and even they have consonant-initial allomorphs (*-sito, -situ, -sita, -witu,* etc). In terms of size, Quechua suffixes range from a single consonant (*-j* 'INF', *-n* '3.SUBJ') to several syllables (*-kuna* 'PL', *-puni* 'certainly'). It is also common for suffixes to start in a CC cluster *(-rqa* 'PAST', *-ŋki* '2G.SUBJ'), while roots never do—Quechua syllables are CV(C), and roots in this exclusively suffixing language cannot begin with CC without violating its phonotactics.

Quechua shows a plausible mechanism for how restrictions on root shapes come about, and how they are connected to restrictions on word shapes. In Quechua, nouns may be unaffixed (see (7a)). Quechua verbs, on the other hand, always have overt suffixes (see (7b)). But in some common forms of verbs (infinitive, 3P.SG), the suffixes are -C, and all the syllables are contributed by the root. If the root had fewer than two syllables, so would the word. Quechua has penultimate stress, so the disyllabicity requirement on roots in effect ensures that most words are long enough to have a stress on the penult, rather than the ultima (see §4.1, §4.3.1 for theories that could derive the connection).

(7)   Quechua nouns and verbs: word minimality ≈ root minimality (examples from Hoggarth 2004)

a.	wármi	'woman'	b.	játʃa-j	'learn-INF'
	tʃáki	'foot'		púri-n	'walk-3P.SG'
	wási	'house'		ʎáŋk'a-j	'work-INF'
	álqo	'dog'		mikʰú-ni	'eat-1P.SG'

3.1.2   Are affixes ever restricted?

Do languages restrict affixes in size? The claim is made often (McCarthy and Prince 1994b, Walker 2000, Downing 2006, Urbanczyk 2006), but it is surprisingly hard to find solid examples of such restrictions.[3] Some size restrictions hold trivially: Mandarin restricts affixes to at most a syllable (*-er, -zi*; Lin 1993). But Mandarin has only two productive suffixes, and most of its roots and words are also limited to a syllable. It is also fairly common to see affix size restrictions asserted in OT work on reduplication, but in the examples given, it is reduplicants that are restricted in size, not affixes in general (e.g., Spaelti 1997, Walker 2000, Urbanczyk 2006). In Generalized Template Theory approaches to reduplication, restrictions that hold of reduplicative affixes but not of other affixes are seen as a feature, not a bug, because they support the claim that constraints are violable (McCarthy and Prince 1994a; see §5.2.3). Beyond such examples, I have not found any solid cases where non-reduplicative affixes are subject to a size maximum,. If they exist, they do not appear to be as common as claimed in the literature.

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[3]Urbanczyk (2011) does not even mention this restriction.

While true size maxima on affixes are either unattested or very rare, it is common enough for functional morphemes to be treated as phonological affixes vs. words based on morphosyntactic and phonological properties. First, affixes may be phonologized differently depending on manner of attachment and compositionality. English Class II prefixes are minimally heavy syllables (*pro-integration, re-target, de-segregation*), but they have light syllable counterparts when analyzed as Class I, i.e., when attaching to bound roots: *produce, reduce, deduce* (example from McCarthy and Prince 1994b:A9). Second, morphemes might be treated as affixes (internal to the phonological word) if they are small, but as phonological words of their own if they are large. This is the case in Fijian: *monomoraic* functional morphemes are parsed as affixes, but longer functional morphemes are phonological words (Dixon 1988). The diagnostic for the parse here is stress: it moves to the penultimate mora in the transitives in (8a), but the forms in (8b) have two equally strong stresses. Dixon notes that pronominal/possessive suffixes do not form separate phonological words, however, and marks the roots as having secondary stresses regardless of the length of the suffix.

(8)   Fijian: functional morphemes $>\mu$ form free phonological words (Dixon 1988:ch.3)

	a.	monomoraic suffixes	b.		longer morphemes	
		rámbe	'kick'		réʔi # táʔi	'rejoice at-PASS'
		rambé-ta	'kick-TR'		tàlanóa # taʔína	'relate-TR'
		luá-ða	'vomit on-TR'			
	c.	possessive suffixes are all word-internal				
		liŋá-ŋgu	'my arm'	liŋà-nratóu	'3PA arm'	
		liŋá-mu	'2SG arm'	liŋà-munráu	'2DU arm'	
		liŋá-nra	'3PL arm'	liŋà-munúu	'2PL arm'	

Similar cases of differential treatment based on size include Yidiɲ (Dixon 1977), Serbian prepositions (Zec 2005), and several cases in Kager (1994). In all these examples, though, the languages have functional morphemes of various sizes; they are just prosodified differently depending on size. In my opinion, the question of how commonly affixes are size-restricted is still open.

3.1.3   Some prosodic asymmetries that go both ways

In the same vein of accepted wisdom that does not seem to be supported by robust typological evidence is the purported asymmetry in syllable structure: roots are supposed to allow a more marked set of possibilities than affixes. Thus, Urbanczyk (2011) cites Sanskrit and Tibetan as allowing complex onset clusters in roots but not in affixes.[4] But such asymmetries can go in the other direction: in languages such as Lakhota, non-roots (affixes and clitics) may have codas, and roots are not allowed to (Albright 2004). Albright shows that phonological words may have codas, but they are invariably of the function class. A sliver of the intricate pattern is shown in (9):

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[4]The claim about Sanskrit is attributed to Steriade (1988), but Whitney (1889, §1077) lists several prefixes that start with consonant clusters: *prá-* 'forward', *práti-* 'in reversed direction', *prádus-* 'forth to view'; there are also suffixes in his list that start with consonant clusters or contain ones that might be syllabified as onsets (*-mna, -tni, -iṣṭha, -utra*; see Whitney's Sanskrit Appendix for more).

(9)   Lakhota: function words with codas, vs. roots without (Albright 2004)

a. Function words:				b. Unaffixed nouns:	
tak	'what'	eniʃ, 'niʃ, naʔĩʃ	'or'	√pte	'cow'
ma'hel	'on'	he'nɔs	'they two'	√xtætu	'evening'
tu'ktel	'somewhere'	le'han	'now'	√blo	'potato'
c. Derived codas in affixes:			d. Reduplicants:		
/√juha-pi/	juhap	'have-PL'	sap-√sape	'black'	
/√lowã-pi/	lowãm	'sing-PL'	sak-√sake	'hard'	*sak-sak (cf. tak, juha-k)
/√juha-ki/	juhak	'have-DEF'	pus-√puze	'dry'	

The point of interest about this case is that there is an asymmetry, but it goes in the opposite direction from the "roots have more stuff" pattern. Still, perhaps it is notable that roots pattern apart from everything else here, and it suggests a direction for analysis: roots are singled out, which means that the grammar should be able to refer to them (see §4). Indeed, this is Albright's argument, and his analysis uses a NoCoda constraint indexed to roots.

3.2   Inventory differences

3.2.1   The basics

Just as with size restrictions, it helps to start with an example of a language that does not have any segmental differences between roots and non-roots when it comes to size. English is a reasonably good example of this, if we cast the net to encompass Class I and II affixes and do not attempt to draw the shaky line between inflectional and derivational morphemes. Among English consonants, [p t k b d g m n ŋ f s θ ʃ h v ð z ʒ tʃ dʒ l ɹ w j], the ones missing from affixes are [ð] and possibly [dʒ]. If *-logy* is considered an affix, as it is in CELEX, then only *ð* is unattested in affixes. The voiced interdental is ubiquitous in function words, of course, and it is positionally restricted for historical reasons (being an allophone of [θ]). Thus, in English, there are no segmental asymmetries between roots and non-roots.

But in other languages, roots may contain a superset of segments compared to affixes. Many examples of such inventory differences can be found in Beckman (1998:ch.4). For example, South African languages that allow clicks usually restrict them to roots, and lack affixes or functional morphemes with clicks. The following examples are from Xhosa (Southern Bantu):

(10)   Xhosa clicks in roots only (Beckman 1998:188)

úku-√|ʰóla	'to pick up'	
ukú-√‖ʰoɓa	'to arm oneself'	
ukú-√ŋ!ola	'to climb up'	
ukú-√ŋǁiɓa	'to put on clothes'	
ukú-√ŋǁóŋǁa	'to lie on back knees up'	

3.2.2   Are the gaps systematic or accidental?

One of the challenges in evaluating such segmental inventory differences lies in distinguishing accidental from principled gaps. If a language has few affixes, are certain sounds absent from the affixes because they are disallowed there, or is it chance? Above, I characterized English as not showing any segmental inventory asymmetries between roots and non-roots. But English is sometimes said to restrict its *inflectional*

	labial	alveolar	(alv-)palatal	velar	uvular	glottal
stops	**p** pʰ p'	**t** tʰ t'	**tʃ** tʃʰ tʃ'	**k** kʰ k'	**q** qʰ q'	
fricatives		**s**	**ʃ**	**x**		h
nasals	**m**	**n**	**ɲ**			
approximants	**w**	**r l**	**ʎ j**			

Table 1: Quechua consonant inventory: black ones occur in roots and affixes, gray ones in roots only

suffixes to mostly coronals (plural/3p.sg/possessive *-s*, past *-d*, participial *-en*, comparative/superlative *-er/est*, with the progressive *-ing* being an exception—and even that can be pronounced as [-ɪn]). The problem with this generalization is that it rests on a shaky quantitative foundation. There are very few suffixes in the set, and coronals are quite frequent in English across the board (Paradis and Prunet 1991)—so is this the result of a grammatical prohibition or an accidental generalization over a small sample? Is it even right to focus on inflectional affixes, as opposed to all affixes? There are no good criteria that distinguish the affixes in this set from other English affixes.

Rather than squint at the numbers and query our intuitions, let's look at a language with more affixes, where the asymmetries might be more principled. In several varieties of Quechua, ejectives and aspirates occur in roots but not suffixes. The inventory asymmetries are summarized in Table 1: Quechua suffixes may have any sonorant, fricative, or plain stop, but not ejectives, aspirates, or [h] (Parker and Weber 1996, MacEachern 1997, Gallagher 2013, Gouskova and Gallagher 2020; see (7) for examples of roots with plain, aspirated, and ejective stops). The segments excluded from affixes arguably form a phonological natural class (Gallagher 2011 proposes a single feature, [longVOT] for these laryngeals, in part because they cannot co-occur with each other in a root).

Are the asymmetries in Quechua systematic or accidental? How likely is a set of morphemes to lack certain segments? We can find out by examining the list of 2,479 Quechua roots described in §3.1, along with the 76 suffixes that occur in the morphologically parsed corpus of ~10,000 words, tokenized (Gouskova and Gallagher 2020).[5] First, we can check whether the distributions of various natural classes of segments differ between roots and affixes in a statistically significant way, using a Fisher's Exact Test. This test assesses whether pairs of values are drawn from similar distributions: for example, if 726 roots have uvulars out of 2,479, how different is this distribution from 20 affixes out of 76? As shown in Table 2, the distributions of uvulars, affricates, and nasals (as well as other natural classes such as liquids and labials, not shown) are similar in roots and in affixes. By contrast, the lack of aspirates, ejectives, and [h] in affixes is surprising, given their distribution in roots.

Another way to assess these asymmetries is via Monte Carlo simulations.[6] Here, we pool all the roots and affixes together (2,555 morphemes), and then randomly draw 76 morphemes. We can repeat this random draw many times—say, a million. When drawing randomly, we expect the proportion of morphemes that contain some segments from a particular natural class to mirror the lexical distribution. This method

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[5]Homophonous suffixes were collapsed, and I abstracted away from allophonic alternations so that each suffix was represented as much as possible with just one allomorph (e.g., /-n/ shows place assimilation: [-n, -m, -ŋ, -ɲ, -ɴ] but was represented in the list just once as /-n/). Allomorphs that are unlikely to be phonologically conditioned were not taken out, however (e.g., *-ito/-ita/-sito/-sita* 'diminutive' were all kept in).

[6]Martin (2011) has a very clear explanation of Monte Carlo simulations. They are especially useful where probabilities of occurrence are daunting to calculate from first principles, as in a case where they are subject to positional and co-occurrence restrictions (in Quechua, certain consonants occur only in onsets, others cannot follow certain other consonants at any distance, etc.).

	Actual lexical distributions			Monte Carlo draws	
	roots (N=2,479)	affixes (N=76)	Fisher's Test	some X	no X
uvulars [q q' qʰ ɴ]	726 (29%)	20 (26%)	0.86, p=0.61	1,000,000	0
affricates [tʃ tʃ' tʃʰ]	501 (20.2%)	14 (18%)	0.89, p=0.77	999,998	2
nasals [m n ɲ ŋ ɴ]	818 (32.9%)	29 (38%)	1.25, p=0.39	1,000,000	0
glottal fricative [h]	144 (5.9%)	0 (0%)	0.0, p=0.02	988,089	11,911
aspirates+ejectives [pʰ tʰ tʃʰ kʰ qʰ p' t' tʃ' k' q']	1,169 (47%)	0 (0%)	0.0, p<0.000	1,000,000	0
all laryngeals (aspirates, ejectives, and [h])	1,255 (50.6%)	0 (0%)	0.0, p<0.000	1,000,000	0

Table 2: Quantifying Quechua root-affix asymmetries: are lexical differences between roots and affixes statistically significant? And how likely is a set of randomly drawn 76 morphemes to lack segments of a particular natural class, out of a million draws?

allows us also to see how likely each 76-item draw is to contain no morphemes with segments from a given class. The results of these draws are shown on the right side of Table 2. The chance of drawing a list of 76 Quechua morphemes that have no affricates is very low but not zero—about 2 in a million. The chance of drawing no [h]-containing morphemes is much higher: this happened almost 12 thousand times. This is unsurprising, because [h] is comparatively rare in Quechua roots (6%). But for affixes to lack aspirates and ejectives is more surprising. What we learn from this exercise is that (a) the distribution of various consonants in the morphemes of Quechua is sufficiently balanced between affixes and roots in general, and (b) there are enough affixes that when an entire natural class is missing from affixes, it is not something that is likely to happen by chance. This is a robust phonological asymmetry and requires an analysis (see §4).

A more complicated example of inventory asymmetries along the same lines is Navajo (Athabaskan, Sapir and Hoijer 1967, Young and Morgan 1987, McDonough 2003, Alderete 2003, Gallagher 2020, a.o.). Navajo verbs have prefixal morphology, with roots occurring at the end.[7] The prefixes are grouped into two categories, based on phonological and morphosyntactic criteria. The first group (traditionally known as "disjunct stem") are sometimes characterized as clitic-like (McDonough 2003:23 & 26). Disjunct prefixes can bear tone and have more diverse syllable structure. These prefixes also resist alternations such as anteriority harmony (Berkson 2013, Gallagher 2020). Analysts such as McDonough do not even consider them to be prefixes. The second group ("conjunct stem") is less controversial as to affixal status. It is for this group that inventory asymmetries have been reported. (My characterization is based on McDonough 2003 and Alderete 2003; whenever they disagree, I go by Alderete's supplementary materials, which include an explicit list). Navajo roots may contain any of the consonants in Table 3. Some of the missing consonants form natural classes, just like in Quechua. The lack of ejectives and aspirates is exactly parallel, but Navajo also lacks velars, lateral affricates, and voiced fricatives in its conjunct prefixes. There are some almost-generalizations here, as well: labial sonorants do not occur in prefixes, but [p] occurs in one. As for vowels, Navajo conjunct prefixes tend to have only [i], which is almost always oral; roots and disjunct prefixes contrast vowels for nasality, length, and four qualities, [i e o a]. Conjunct prefixes tend to not bear high

[7]What I call 'roots' is usually called 'stems' by Athabaskanists. As McDonough (2003:11) explains, a stem is a root inflected for aspect: e.g., [-tsid] 'pound:imp', [-tsiʔ] 'pound:rep', [-tseed] 'pound:perf', [-tsiɬ] 'pound:fut' (McDonough p. 28). See Rice 2006 for a thorough treatment of Athabaskan morphology, and Harley 2010 for an analysis of the mirror principle violations.

	labial	alveolar	(alv-)pal	velar	glottal
plosives	**p**	**t** tʰ t'		k kʰ k'	ʔ
fricatives		**s** z ɬ	**ʃ** ʒ	x ɣ	**h**
strid. affricates		**ts** tsʰ ts'	**tʃ** tʃʰ tʃ'		
lateral affricates		tɬ tɬʰ tɬ'			
nasals	m	**n**			
glides/approximants	w	l	**j**		

Table 3: Navajo consonants. Grayed-out ones do not occur in conjunct prefixes

tone, either. So are these gaps systematic or accidental?

Alderete (2003) compiles a list of affixes based on Young and Morgan (1987) and does a careful statistical analysis. On the basis of statistics, he argues that the gaps are systematic at least for laryngeal contrasts, the lack of velars, and vowel length, quality, nasality, and tone. What makes this case more difficult than Quechua is that the asymmetries are tendencies rather than all-or-nothing asymmetries. The other source of complexity is in analyzing the source of differences between conjunct and disjunct prefixes. Alderete argues that disjunct prefixes are lexical morphemes, and some indeed appear to be incorporated roots (e.g., [ʔaɬtá-] 'grazing', [tʃa-] 'darkness'). But this class also includes some morphemes that he acknowledges do not sit easily in the open-class category (e.g., [k'i-] 'on', [ʔa-] 'reflexive'). So, while I think the quantitative arguments are convincing, but some more work could be done on clarifying exactly what an affix is in Navajo.

3.3   Special behavior of compounds

The phonology of single-root words is often different from words with multiple roots: *compounds*.[8] Compounds might have multiple stresses where one-root words have only one (as in Russian; see §5). Compounds are often exempt from vowel harmony or consonant co-occurrence restrictions, as well. In Turkish rounding/backness harmony, the last vowel of the root determines the backness of the vowels that occur in suffixes (see (11a)). But roots may be disharmonic (see (11b)), and compounds do not show harmony (see (11c)).[9]

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[8]Unlike the for other phenomena in §3, I did not start the compound section with an example where compounds are not in any way special compared to single-root words. There may be languages that are like this, but I have not looked, so I cannot claim whether they do or do not exist.

[9]Back vowels are [a, o, u, ɯ]; front vowels are [e, i, ø, y]. Rounding harmony accompanies backness harmony for high vowels only, and some suffixes are exempt from harmony; Kirchner (1993) lists [-ijor/-ujor/-yjor/-ɯjor] and [-edur/-adur], among others.

(11) Turkish harmony in suffixes, but not in roots or compounds (Clements and Sezer 1982, Kornfilt 2013, Kabak and Vogel 2001).

		Unaffixed	Gloss		Acc	Pl
one √:	a.	√gøl	'lake'		√gøl-y	√gøl-ler
		√bylbyl	'nightingale'		√bylbyl-y	√bylbyl-ler
		√karpuz	'watermelon'		√karpuz-u	√karpuz-lar
	b.	√dekor	'stage design'	*dekør	√dekor-u	√dekor-lar
		√buket	'bouquet'	*bukot, bukat	√buket-i	√buket-ler
		√otobys	'bus'	*otobus	√otobys-y	√otobys-ler
compounds:	c.	√altɯn-√jyzyk	'golden ring'	*altɯn-juzuk		
		√demir-√kapɯ	'iron door'	*demir-kepi		
		√kará-√deniz	'Black Sea'	*kara-danuz		

Another example of the same sort is Navajo strident/anteriority harmony, shown in (12). In Navajo roots, stridents must be alveolar or alveolo-palatal, and prefixes (in the conjunct domain, see §3.2) assimilate to root stridents. But in compounds, there is no assimilation. Gallagher (2020) notes that disjunct prefixes are also exempt from anteriority harmony; if Alderete (2003) is right, then they are exempt because they are lexical morphemes (=roots), i.e., words with disjunct prefixes are not too different from compounds.

(12) Navajo sibilant harmony in roots, one-root words, but not compounds (Martin 2011:753)

a. Roots harmonize

√tʃʼoʒ   'worm'   /ji-s-léézʒ/

√tsʼózí   'slender'   /ji-s-tiz/

*√soʒ, *√tʃíz

b. Prefixes agree with roots

ji-ʃ-√léézʒ 'it was painted'

ji-s-√tiz   'it was spun'

c. Compounds exempt

√tʃéí-√tsʼiin 'rib cage' (heart+bone)'   *√tséí-√tsʼiin

√tsʰé-√tʃééʔ 'amber' (stone+resin)'

The explanation sometimes offered for the special behavior of compounds is that they consist of several phonological words, and that the relevant rules or constraints apply inside but not across words (Kabak and Vogel 2001, Martin 2011). For example, in English, [ʃ] and [s] cannot be adjacent inside a root or across a suffix boundary: "fishes" is [fɪʃəz], *[fɪʃs]. But compounds such as *fish sauce* are allowed; [fɪʃsɑs] not *[fɪʃəsɑs]. English phonology provides some evidence of prosodic word boundaries within compounds, from stress (see §5) to various juncture rules that do not apply or do so variably (Allen 1978). But this is only part of the explanation, because there needs to be a theory of how phonological word boundaries are decided, and surely roots play a role in it somehow.

3.4 Accentual asymmetries between roots and affixes

Just as not all languages show root-affix asymmetries in segmental inventories, languages do not all have accentual asymmetries between roots and affixes. Plenty of languages discussed in the voluminous body of work on metrical stress theory are described as assigning stress to phonological words on the basis of their segmental content and prosodic shape, without any regard for morphology (Hayes 1995, Gordon 2002, and many others). In Polish, for example, stress is on the penult no matter how many affixes are added (e.g., *repórter, reportér-a, reporter-ámi* 'reporter (NOM.SG, GEN.SG, INST.PL)'; see Newlin-Łukowicz

2012 and references therein). On the other hand, in some languages, morphological structure does matter for stress assignment, and whether the morphemes in question are roots or affixes is paramount.

3.4.1   Roots must be stressed

One type of stress asymmetry is found in languages where stress is confined to the root, no matter how many affixes are added. A version of this pattern operates in words with English Class II suffixes: *bóttom*, *bóttom-less*, *bóttom-less-ness;* stress stays in the same position as if the affixes were not there. English does not enforce this pattern language-wide (stress can move around in words derived with Class I suffixes, see §5). But stress is required to be on the root in languages such as Chuckchee, Tahltan, Nancowry, and Nisgha (Alderete 1999:56). Thus, the asymmetry is that roots must be stressed while affixes either cannot or do not have to be. An intuitive account of this type of system is the theoretical device of the cycle, and its analogs such as Output-Output Faithfulness (see §4.3.1).

3.4.2   Dominance effects

Yet another phonological asymmetry between roots and affixes is in the analytic domain of lexical accent, such as those of Greek, Russian, and Japanese. I call these *lexical accent* systems following Alderete (1999): word-level prominences are governed by similar grammatical principles in these languages, even though the prominences have different phonetic correlates (in Russian, stress is vowel length, intensity, and quality, and in Japanese, pitch change). Unlike languages with predictable demarcative stress, lexical accent languages contrast the position of stress as well as its presence. Thus, morphemes can be either accented or unaccented. Pertinent to the subject of this article, morphemes can differ in another property: affixes but not roots can be dominant, meaning they impose their stress will onto the word. Roots arguably cannot do this.[10]

To illustrate, let's look at Russian. As shown in (13), stress can fall on any syllable in a monomorphemic word (these examples are chosen for vowel quality, since high vowels do not reduce in unstressed syllables).

(13)   Contrastive lexical stress in Russian (NOM.SG and GEN.PL suffixes are both -Ø)

kizíl	' NOM.SG'	kukurúz	'corn GEN.PL'	sífilis	'syphilis NOM.SG'
fílin	'owl NOM.SG'	furúnkul	'boil, zit NOM.SG'	dʲúzʲin	'dozen GEN.PL'
irís	'toffee NOM.SG'	íris	'iris flower NOM.SG'	birʲúk	'lone wolf NOM.SG'

In affixed words, stress position depends, among other things, on whether the morphemes in play are accented, and whether the affixes are dominant. Since in Russian, all single-root phonological words must have exactly one stress, the main way that a root shows that it is unaccented is in combination with a non-dominant (recessive) accented affix. This is best illustrated with examples. As shown in (14), when a stressed root such as /irís/ combines with a recessive suffix, the stress is **fixed** on the root. When an unstressed root such as /golos/ combines with a suffix, its stress is on the first syllable of the root when the suffix is unstressed, and on the suffix if the suffix is stressed—i.e., stress is **mobile**. The third type of roots shows a consistent post-stem stress pattern, with stress falling on the last syllable of the stem if there are no overt suffixes, and on the first syllable of the suffix otherwise; this is **final** stress.[11]

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[10]Zaliznjak (1985:53) disagrees: he characterizes stems such as /na-ród-/ 'people' as being dominant. All the examples he gives have recessive suffixes attached to the stem, though. On p. 54 he formulates a rule whereby dominant stems cannot combine with dominant affixes, which effectively renders this analysis untestable.

[11]The characterization of the patterns varies with the analysis. In particular, there is disagreement about what the default is (initial or post-stem). There are relatively few roots that are analyzed as unaccented, but they tend to be high-frequency. Over 90% of the roots are analyzed as underlyingly stressed by Zaliznjak 1977). For more, see Halle 1973, Zaliznjak 1985, Melvold 1989, Alderete 1999, Revithiadou 1999, Alderete 2001, Gouskova 2010, and citations therein.

(14)   Three root stress types in Russian, in combination with different suffixes (all recessive)

Suffix type	UR	stressed/**fixed** root /irís/ 'toffee'	unstr./**mobile** root /golos/ 'voice'	**final**-type root /sapog*/ 'boot'
null	/-Ø/ NOM.SG	iris	góləs	sapók
unstr. recess.	/-a/ GEN.SG	irísə	góləs-ə	səpag-á
stressed recess.	/-ámi/ INST.PL	irísəmi	gəlas-ámi	səpag-ámi

Unlike recessive affixes, dominant ones override the root's stress type. In words with dominant suffixes, stress falls in the location of the affix's choosing. This can be on the suffix itself, on the preceding syllable, or on the following syllable—i.e., the suffix imposes the post-stem stress pattern (just like /sapog*/. Thus, any word derived with /-ízm$_D$/'-ism' has stress on that suffix. A native Russian example is in (15): the suffix /-úlʲ$_D$/ imposes its stress not only on words derived from mobile/unstressed roots such as [sɨn] 'son', but also fixed/stressed roots ([déd] 'grandfather', [ernést] 'Ernest'). Not only do dominant suffixes rob roots of their stress—they also prevent recessive accented suffixes such as [-ámi] from being stressed. Thus, /déd-úlʲ$_D$-ámi/ is [didúlʲəmi] and not [didulʲámi]. It is not the case that the leftmost stress wins, or the outermost one. Rather, the dominant suffix wins. When more than one dominant affix appears in the same word, the outermost wins; Zaliznjak gives the example /bánd-ít$_D$-ízm$_D$/ 'banditism' (cf. /bánd-a/ [bánd-ə] 'band, gang (FEM.NOM.SG)' and [band-ít] 'bandit').

(15)   Dominant suffix in Russian: /-úlʲ$_D$/ 'affectionate evaluative'

Root UR	Unstr-recess /-a/ GEN.SG	Str-recess /-ámi/ INST.PL	str-dom /-úlʲ$_D$/ EVAL	str-dom+str-recess /-ulʲ$_D$-ámi/	Gloss
/déd$_{fix}$/	déd-ə	déd-əmi	did-úlʲ	did-úlʲ-əmi	'grandfather'
/ernést$_{fix}$/	ernést-ə	ernést-əmi	ernest-úlʲ	ernest-úlʲ-əmi	'Ernest'
/sɨn$_{mob}$/	sɨn-ə	sɨn-ámi	sɨn-úlʲ	sɨn-úlʲ-əmi	'son'

Dominance effects can include not only auto-stressing but also shifting stress to the first syllable (the nominalizing suffix -/enʲ$_D$/ in Russian, see Melvold 1989:75) or assigning stress to the syllable following the suffix (Russian /-atɕ$_D$/, another nominalizer; Melvold 1989:72). In Japanese, dominant suffixes can cause accent deletion on roots without assigning a new accent of their own (see §4.3.2).

As I noted earlier, dominance is a property of affixes but not roots. Several explanations have been proposed for this, which are covered in §4.3. The empirical question is what it would look like for a root to be dominant. Presumably, a dominant root would impose its stress pattern on the rest of the word, no matter what affixes were in play. It is odd that this does not occur, as any theory that has provisions for lexical exceptions has a way of generating the pattern where a root resists all attempts by outer affixes to move its stress.

3.4.3   No roots consisting only of tones/accents

This last asymmetry is similar to the "there are no dominant roots" asymmetry, but does not hinge on alternation patterns: rather, it is about the phonological essence of roots. First, a little background on tone. In languages that have contrastive tone, it is not uncommon for certain morphemes to be purely tonal (see, for example, Yu 2020 for a recent discussion and a list of examples).[12] In (16) is an example

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[12] Affixes can be realized as stress shifts, as well (as in English *convíct* (v)/*cónvict* (n), *invíte* (v)/*ínvite* (n)), although this characterization is somewhat controversial. It aligns with the direction of noun/verb stress asymmetries, so there are accounts that do not rely on *stress shift* per se (Smith 2011).

from Kipsigis (Nilotic), where nominative case is marked with a tonal melody. The tones in the Oblique are unpredictable, and would be analyzed as underlying. The tones in the Nominative are predictable, and attributed to morpheme that underlyingly consists of tones only, /LHL/—with the high tone realizing on sufficiently long words.

(16)   Nominative melody on nouns in Kipsigis (Kouneli and Nie 2021)

segments	Oblique	Nominative	Gloss
pe:k	H	L	'water'
la:kwɛ:t	LH	LL	'child'
ŋo:ktɑ	HH	LL	'dog'
sʊɡarʊ:k	LLH	LHL	'sugar'
magasɛ:t	HHH	LHL	'skin'
soloptʃɑ:t	LHH	LHL	'cockroach'

While this type of example is completely unsurprising when the tonal melody expresses a functional meaning, I do not know of any cases where roots are expressed as tones only. It is not difficult to imagine what this would look like; I constructed an example below, borrowing some lexical items from Russian (recall §3.1). This language takes the Russian pattern slightly further, alleviating the trivial minimal size requirement on morphemes to contain at least one segment.

(17)   A hypothetical example of a tonal root: /√H/

	'dog'		'cat'		'mom'	
Nom.sg	/√pat-a/	pata	/√xn-a/	xn-a	/√H-a/	á
Nom.pl	/√pat-i/	pati	/√xn-i/	xn-i	/√H-i/	í
Inst.pl	/√pat-ami/	patami	/√xn-ami/	xn-ami	/√H-ami/	ámí

It is not difficult to generate this hypothetical language under the assumptions of an item-and-arrangement theory of morphology (in the well-worn terminology of Hockett 1954). Similar examples, equally unattested, could be constructed using featural affixes (Zoll 1996, Wolf 2007). Pushing the idea that morphemes can consist of other non-segmental phonological material, such as prosodic templates (McCarthy and Prince 1986 and others), we could imagine a root that expresses itself through the reduplication of the affixal string it combines with: /σ+a/ →[a-a] 'dad nom.sg', [i-i] 'dad nom.pl', [am-ami] 'dad inst.pl'. If the theory allows morphemes to lack segmental content, there is no reason why affixes but not roots should be allowed to consist of tones only, or features only, or templates only. And yet, as far as I know, roots always have some segmental content, even in languages that have tonal affixes, featural affixes, and templatic reduplication. One possible explanation for this is the cycle; see §4.3.1.

4   Theoretical treatment of root-affix asymmetries

In approaching phonological asymmetries between roots and affixes, we could ask whether they are worth capturing at all, and if so, whether they are mediated by the phonology as opposed to being properties of the lexicon and the morphological component. On the first question, one could argue that certain asymmetries between roots and affixes are not derived by the grammar—rather, they accumulate through diachronic change, or arise from functional pressures and need not be encoded in the system of phonological rules. This stance could be justified by not taking examples such as Quechua and Navajo seriously. Alternatively, some theorists feel that to let phonology have direct access to morphosyntactic labels gives it too much

power. Correspondingly, some phonological theories assume that phonology is a self-contained system that does not have access to lexical information: there are no morpheme-specific constraints, no lexical strata, no devices that might refer to trans-derivational relationships between words or to paradigm structure (see Inkelas et al. 2004, Green 2006, Inkelas and Zoll 2007, Bye and Svenonius 2012 for articulated views along these lines).

In this section, I focus on those theories that do take root-affix asymmetries as something the phonology should explain. Throughout, I will focus on whether the explanations in these theories require reference to labels such as "root." This is what Revithiadou 2011 calls *direct reference* theories. We will see, however, that it is possible to derive some aspects of root phonology by exploiting their structural properties: they are most deeply embedded, so theories that are given access to morphosyntactic tree structure can get some explanatory action without seeing the root labels. Either way, taking the problem of root-affix asymmetries seriously requires either reference to the root label or access to the structure, and sometimes both.

4.1   Prosodic Morphology

Prosodic Morphology, as the name suggests, is the study of prosodic regularities in morphology (McCarthy and Prince 1986, 1993a, 1994a, 1999). Quite a lot of the work in Prosodic Morphology concerns morpho-phonological operations that involve templates—especially templatic truncation and reduplication. Of these, it is reduplication that is clearly affixal, and expresses functional features such as plurality and aspect.[13] Prosodic Morphology also interrogates the nature of templates in languages like Semitic (McCarthy and Prince 1990), and size requirements of the sort discussed in §3.1.

The theory has gone through a few iterations, but throughout, its main claim has been that generalizations about morpheme and word shapes involve prosodic units: moras, syllables, feet, phonological words (Selkirk 1980). This is in contrast to earlier theories that used consonant and vowel skeleta and timing slots (Marantz 1982, Levin 1985). To make this concrete, let's take the Quechua example: recall that in Quechua, roots are overwhelmingly disyllabic. In Prosodic Morphology, the restriction would be reduced to a syllabic trochaic foot, $[\acute{\sigma}\sigma]$. This happens to be the right type of foot for an account of Quechua stress, which falls on the penult. This is one of the arguments that made Prosodic Morphology so compelling: it is a reductionist theory that uses the minimum amount of theoretical machinery. The structural units that Quechua uses in its stress system are also the units it uses to regulate the shapes of its roots.

Where the multiple iterations of the theory come in is in pinning down the details of how the requirements are stated, and if they are even stated overtly. The basic idea that templates can be reduced to prosodic units can be implemented in different ways. For example, we could say that there is a Morpheme Structure Constraint in the Quechua lexicon that requires the roots to be the size of a foot (on Morpheme Structure Constraints, see Booij 2011). Alternatively, the restriction could be emergent, and not overtly stated: every Quechua root has to surface either unaffixed or with at least a single consonant suffix, so if the language requires its phonological words to be headed by feet, and the feet might be required to be minimally binary at the syllabic level. This is the essence of the Optimality-Theoretic version of Prosodic Morphology (see McCarthy and Prince 1993c on Axininca Campa root/word minimality).

A notable feature of the emergent analysis of root minimality is that it does not need to mention roots at all—it is an indirect reference account (although McCarthy and Prince are certainly not opposed to direct reference in principle). As long as roots are the obligatory part of any lexical word that is phonologized as a prosodic word, and as long as the language imposes its specific minimality requirements on feet, everything else follows from independent principles of prosody (possibly, though not obligatorily combined with devices such as the cycle, or alignment constraints). The violability and language-specific use of a handful

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[13]Bye and Svenonius 2012 suggest that templatic truncation (as in hypocoristics *Susan*→*Sue*) never expresses morphosyntactic features; to them it is on a par with language games.

of universal parameters can also be recruited to accommodate languages like Russian, where there is no root minimality and where word minimality is trivial (at least one syllable).

By comparison, caching this analysis out in terms of Morpheme Structure Contraints (MSCs) would require some sort of reference in the lexicon to the root/affix distinction. This is presumably necessary anyway, since lexical knowledge must include information about syntactic roles that a morphemes can play. As long as the root category is available for the constraints to make reference to, the approach predicts that roots may be required to have a certain shape or be of a certain size. Whether it makes the same prediction for affixes depends on the availability of an 'affix' label (or 'clitic', etc.) for the constraints' reference. If MSCs can refer to both affixes and roots, it is hard to see how any asymmetrical predictions can follow in this approach without a brute-force stipulation that only roots can be subject to size minima. Without such stipulations, one could easily imagine a language that imposes a foot minimality requirement on its affixes but not on its roots.

By the same token, a criticism has been levied against the emergent prosodic morphology analysis: for all its appeal, it relies on a connection between the templatic size restrictions and the stress pattern of the language, which has not held up to typological scrutiny (Downing 2006). Downing identifies many examples where the minimal word is not the same as the minimal stress domain. The force of her criticisms is especially persuasive against the extension of the emergent approach to templates in reduplication and truncation, which is known as Generalized Template Theory (see §5.2.3).

4.2   Positional faithfulness to roots

The idea that roots are subject to separate faithfulness constraints first appears in McCarthy and Prince 1994b, though it also owes a debt to Lisa Selkirk's thinking on the morphosyntax-phonology interface (Selkirk and Shen 1990, Selkirk 1995). Key here is the idea that lexical categories are of central interest to phonology, whereas functional categories are the afterthought. In Selkirk's (1995) approach to clitics, for example, lexical categories (nouns, verbs, adjectives) are subject to various phonological requirements, whereas function words are parsed wherever the violable constraints will tolerate them. This theory embraces a direct reference to lexical categories, while not having a mechanism (nor needing one, arguably) for referring to affixes and function words in any way.

Beckman's positional faithfulness theory is part of this trend. In this theory, prominent positions such as word beginnings, stressed syllables, and morphological roots are doubly protected: first, by generic non-positional faithfulness, and second, by special constraints that refer to these positions. For example, Beckman analyzes Xhosa (recall §3.2) as follows: the prohibition on clicks, *IngressiveVelaricAirstream (IVA), outranks generic faithfulness to that feature (Ident-IVA), causing clicks to neutralize with regular stops in affixes. But special positional faithfulness constraints preserve clicks in roots:

(18)   Ident-Root(IVA):

Let β be an output segment contained in a root, and α the input correspondent of β. If β is [γIVA], then α must be [γIVA].

"A root segment and its output correspondent must have identical specifications for the feature [IVA]". (Beckman 1998:189)

To get a pattern where roots have stuff that non-roots lack, a markedness constraint must be sandwiched between high-ranking positional faithfulness and generic faithfulness, as in (19). Under the ranking in (20), clicks are prohibited except where positional faithfulness preserves them. It is predicted that no language can have neutralization in roots only. The candidate that preserves the click in the hypothetical prefix but neutralizes it in the root is harmonically bounded: it cannot win under any re-ranking.

(19)   Schema for segmental inventory asymmetries between roots and non-roots:

18

PositionalFaith≫Markedness≫Faith

(20)   Clicks are permitted in Xhosa roots (underlined), prohibited in affixes (Beckman 1998:189-90)

Inputs			Ident-Rt(IVA)	*IVA	Ident(IVA)	comment
/úku-ǀʰóla/	a.	☞ úku-ǀʰóla		*		faithful
	b.	úku-kʰóla	*!W	L	*W	neutralize in root
/úǃu-ǀʰóla/	c.	☞ úku-ǀʰóla		*	*	neutralize in pfx
(hypoth. pfx)	d.	úǃu-ǀʰóla		**!W	L	faithful everywhere
	e.	úku-kʰóla	*!W		**W	neutralize everywhere
	f.	úǃu-kʰóla	*!W	*	*	neutralize in rt only

The input to the tableau has a hypothetical prefix with a click, of a sort that the Xhosa learner would never see or have reason to posit. This is because the account assumes Richness of the Base: there are no constraints on inputs to the phonological component, and any surface generalizations about contrast and neutralization must follow from the grammar rather than from devices such as Morpheme Structure Constraints. The usual argument against Morpheme Structure Constraints in OT is that the neutralization/contrast patterns can be enforced through alternations as well as be static; Morpheme Structure Constraints miss this connection. By contrast, positional faithfulness makes predictions not only about static contrast possibilities but also the direction of neutralization: from the root outward. Several examples of this sort have been noted, primarily for vowel harmony (Zsiga 1997, Beckman 1997, Bakovic 2000). In morphologically determined directionality, harmony will be regressive/right-to-left in prefixing languages, and progressive/left-to-right in suffixing languages. In a suffixing language like Turkish (recall (11)), it is impossible to tell whether harmony is right-to-left or root-controlled. But in languages that have both prefixes and suffixes, root-controlled harmony should be bidirectional. The examples in (21) illustrate this on a minimal pair of roots from Igbo, which trigger assimilation both on prefixes and on suffixes—confirming the prediction.

(21)   Igbo [ATR] harmony (Zsiga 1997:233)

Root	Gloss	Imp	Inf	Agn	Part	3sg.subj.Perf	3sg.Subj.Indic
sị	'tell'	sị-ạ	ị-sị	ọ-sị	ạ-sị	ọ-sị-ạlạ	ạ-sị-rị
si	'cook'	si-e	i-si	o-si	e-si	o-si-ele	e-si-ri

Again, the appeal of this theory is that it is reductionist: it uses the same mechanism to explain static generalizations about roots and to explain alternation directionality. Presumably, phonologists of any theoretical denomination would consider the analysis of directionality to be in the purview of phonological theory, even if statements such as "only roots may have clicks" leave them cold. is not obvious how a theory that does not make reference to roots would capture a pattern such as Igbo root-outward harmony. Positional faithfulness has retained its appeal as a device for capturing both kinds of phonological patterns in the decades since its was originally proposed.

The question is whether the theory can still be described as making predictions about robust asymmetries that always favor roots as the site of contrast. If the only thing that can be indexed to roots is faithfulness constraints, then the prediction certainly follows. If, however, markedness constraints can also be indexed to roots, then we expect a markedness reversal. Proposals for indexing markedness constraints to morphemes have been around for a long time now (Pater 2000, 2006, Flack 2007, Gouskova 2012), and readers still keeping up might recognize that Albright's (2004) proposal is an example of precisely this kind of indexation. The Lakhota case constitutes a markedness reversal: roots are not allowed to have a structure (codas, in this case) that affixes and function words may have, and Albright's account

is NoCoda$_{Root}$.

What do we conclude from this? As with other developments in phonology in the past couple of decades, the explanation for typological asymmetries might lie not in the hard-wired properties of the constraint set but instead in other domains, such as learning or diachrony. Perhaps there is a learning bias that makes positional faithfulness easier to induce than positional markedness—and maybe 'root' is the easiest index available to early learners. This, in my view, is one of the more interesting open questions (see §6): what is the status of roots for learners if one does not assume that all constraints are innate?

4.3   Theories of root-oriented stress and dominance effects

4.3.1   The cycle

The cycle is familiar from the Sound Pattern of English (Chomsky and Halle 1968), the first fully articulated generative theory of the morphology-phonology interface (building on some earlier ideas; see their p. 15, and also Benua 1997, Bermudez-Otero 2011 for overview). The cycle implements the intuition that morphologically complex words are not available to the phonology all at once. Rather, the phonology evaluates the most embedded string, i.e., the root, first, and then expands the evaluation window one morpheme at a time, tracking the morphosyntactic hierarchical structure. Alongside rules that respect cyclic structure are rules that disregard it; the so-called post-cyclic rules are not sensitive to morphological structure or bracketing.

The precise details of how cyclic rules work varies by proposal and is the subject of a huge body of work that I cannot hope to summarize here. But, coupled with some additional ideas, it can be used to derive morphologically sensitive stress patterns such as root-controlled accent (§3.4.1), and it could be part of the explanation for why roots are subject to minimality requirements while affixes do not seem to be (§3.1, 4.1). One useful assumption is that certain rules cannot alter structure that was built on previous cycles (see, e.g., McCarthy and Pruitt 2013 for a recent-ish discussion). Thus, in a hypothetical word *[[√pata]-ka]*, penultimate stress is assigned first to [√*páta*]—as it is most deeply embedded (recall §2.2.1). By the time the larger sub-constituent is evaluated, [*pátaka*], penultimate stress cannot be assigned again because there is already a stress nearby. This offers a ready explanation for languages in which trisyllables have different stress patterns depending on whether they are monomorphemic or morphologically complex.

The cycle might be part of the explanation for the asymmetry I noted in §3.4: while functional features can be realized as reduplication, stress shifts, and feature changes (i.e., as non-segmental affixes), roots always seem to have segmental content. The cyclic explanation is that a root always gets to be phonologized first, and it would be hard to reduplicate, shift stress, or change the features of nothing. Keep in mind, however, that in some languages, roots may be subminimal to a point where they cannot be phonologized as anything pronounceable on the first cycle (recall the Russian *xn-* and *pj-* type roots; these cannot be phonological words in Russian). Thus the cycle is the beginning of an explanation, but not the whoe story.

Other theories have ways to mimic some of the effects of the cycle; notable here is Generalized Alignment (McCarthy and Prince 1993b, Kager 1994) and Transderivational Correspondence Theory (TCT, sometimes known as Output-Output Faithfulness, see Benua 1997). Generalized Alignment relies on the availability of bracketing structure, as well as labels such as "root"; it is very much a direct reference theory of the interface. TCT does not need to make direct reference to the root-affix distinction, as long as words are built root-outward—but it does assume that output-output constraints are associated with specific affixes, requiring in practice that at least lexical information be available for phonological reference (see §5.1 as well as Benua's discussion in 1997:ch.5).

In a nutshell, Output-Output faithfulness constraints require that words that differ in the presence of one affix match with respect to some faithfulness dimension. In Benua's analysis of words such as *[[[bóttom]less]ness]*, there is a basic phonological ranking that establishes right-aligned moraic trochees

with nonfinality in underived words (*bóttom*). Furthermore, the theory establishes transderivational correspondence between pairs of words such as *bóttom* and *bóttomless*, and similarly between *bóttomless* and *bóttomlessness* (but not *bóttom* and *bóttomlessness*). These particular correspondences are mediated by a faithfulness constraint OO-ANCHOR-STRESS, which requires a match in stress position (in English, primarily for Class II affixes). Thus, words derived by such suffixes have stress on roots, even though there is no constraint that requires stress to be on roots—the result follows from the root being most deeply embedded.

4.3.2 Anti-Faithfulness

The theory of Anti-Faithfulness builds on Output-Output faithfulness: it also uses the idea of transderivational correspondence (Alderete 1999, 2001). The innovation is a special class of constraints, available only for this type of correspondence but not for input-output correspondence, which demand that there be at least one specific type of mismatch between the base and the derived form. Some of the most convincing examples in support of this theory come from the domain of affixal dominance in stress and tone. But the theory is designed to be a general approach towards process morphology, where morphosyntactic features normally expressed by affixes are realized as truncation, feature change, and so on (Kurisu 2001, Trommer and Zimmermann 2014, Zimmermann 2017).

Here is a summary of Alderete's analysis of dominant deaccenting affixes in Japanese, a couple of which are illustrated below. Japanese allows words to be accentless. They may surface without an accent if they lack one underlyingly, as in /sake-ga/ [sakega] 'alcohol-NOM'—an accentless root combined with a recessive accentless suffix. But they also may surface as accentless when the root has an accent but combines with a dominant unaccented suffix, shown in (22d–f). The examples in (22a–c) are parallel to Russian stress dominance, (15) in §3.4.2.

(22)   Dominant deaccenting affixes in Japanese

Accented suffix: Unaccented suffix:

a.	/adá-ppó-i/	adappói	'coquettish'	d.	/kéizai-teki/	keizaiteki	'economic'
b.	/kaze-ppó-i/	kazeppói	'sniffly'	e.	/búngaku-teki/	bungakuteki	'literature-like'
c.	/kíza-ppó-i/	kizappói	'snobbish'	f.	/rónri-teki/	ronriteki	'logical'

In Alderete's account, the dominant suffixes *-ppoi* and *-teki* are subject to a transderivational antifaithfulness constraint ¬OO-MAX-ACCENT. This constraint is violated if, in a mapping between [kéizai] and [keizai-teki], there is no violation of MAX-ACCENT. This constraint wants an instance of an accent deletion; other constraints might demand an accent movement (flop) or an insertion (DEP violation). Exactly where the accents end up in the latter two cases depends on the rest of the grammar: if the language has an initial default, that is where stresses will go. Alderete argues, for example, that Russian has a post-stem default, explaining why many of the dominant suffixes are apparently autostressing. He is also quite clear on why this theory derives the generalization I noted earlier: only affixes may be dominant; roots cannot be (see Alderete 2001:221). This is because of the mechanics of how transderivational faithfulness works. A root is present in both the base and the derived word, whereas the affix is present in the derived word only. Therefore, deleting or adding an accent on the affix cannot satisfy a transderivational anti-faithfulness constraint, because the affix is not in correspondence in the transderivational relationship. This is indeed the only account I know of that derives this result.

This theory has generated both excitement and criticism in subsequent years (Horwood 1999, Trommer 2005, Inkelas and Zoll 2007, Gouskova and Linzen 2015, Kouneli and Nie 2021; see Kouneli and Nie's paper for more references). The criticisms are both about the specifics of individual cases and about more conceptual issues: for example, people have pointed out that dominance effects obtain even in cases where

free-standing bases do not exist. There are also alternatives that assume an item-and-arrangement view of morphology (see Wolf 2007 and work by Zimmermann and colleagues), or extend morphological index-ation or cophonologies to explain some of the accentual examples. While these alternatives remove the anti-faithfulness device, they do not, as far as I can tell, have an explanation for why it is roots and not affixes that show dominance. As the recency of some of these citations indicates, the debate is far from concluded.

5   Are some affixes actually roots?

I now move on to a group of theories that in one way or another erase the root-affix distinction, starting with some of the more recent proposals embedded in Distributed Morphology, and finishing with older work—primarily on reduplication–cast in Optimality Theory.

5.1   Take one: all affixes are roots

Several recent proposals abandon the root-affix distinction, assuming instead that some (or all) affixes are actually roots (Lowenstamm 2015, De Belder 2011, De Belder and Craenenbroeck 2015, Creemers et al. 2018). Lowenstamm's insight is that some affixes in English show as much categorial flexibility as roots (recall §2.1). The suffix *-ian* confers on its stem the category of adjective (*a reptil-ian skeleton*) or noun (*a librar-ian*). Lowenstamm argues that *-ian* is a root, and that the *a* and *n* heads are null.

In Distributed Morphology, category heads *n, v, a* are often assumed to be special: they define phases in spell-out. Phase-based spellout is the counterpart of the cycle in syntax (Chomsky 2001, Marvin 2002, Selkirk and Kratzer 2007, Marantz 2007, Embick 2010, and many others). Being spelled out in the same phase allows morphemes to interact with each other or with something that has already been spelled out, but not with morphemes that have yet to be spelled out. Phases delimit the possibilities for suppletive allomorphy conditioning (Bobaljik 2000, Embick 2010) and idiosyncratic semantic interpretation (Marantz 2013). Phases have also been proposed to be the domains of stress assignment (Marvin 2002, Oltra-Massuet and Arregi 2005, Bachrach and Wagner 2007, cf. Bermudez-Otero 2011). Lowenstamm extends such pro-posals to English affix classes, a classic problem familiar from work in Lexical Phonology and alternatives (Mohanan 1982, Kiparsky 1982, Benua 1997, etc.).

Thus, the claim is that all affixes are roots, and all phase-defining heads are phonologically null. In words with Class I suffixes, roots merge with each other into a root phrase, and a null categorizing head is added last; thus, *atómic* and *atomícity* both constitute one phase each for spellout and stress assigment (shown in (23a–b)). In this account, *atomicity* is not a deadjectival noun. As for Class II affixes, the dif-ference is that they subcategorize for XPs, and so they attach to previously categorized and therefore also prosodified units. After merging with a phrasal constituent [n [$\sqrt{}$P [$\sqrt{}$money]]], the affix *-less* must move and adjoin to its own categorizing head *a*, and gets its own stress.

(23)   An affixes-are-roots treatment of the Class I vs. Class II distinction, after Lowenstamm (2015)

a. atómic (class I)	b. atomícity (class I)	c. móneyless (class II)

While this theory has some appealing features, it also has some problems. First is a specific problem in what it says about English: class II suffix words should be prosodically similar to compounds. Lowenstamm even marks *-less* as having secondary stress, *móneylèss*. But single-root words of this sort are different from compounds, and it is not clear how this theory would derive such differences (see §5.1.1). A second problem has been noted in the literature (§5.2.2): most affixes do not show the sort of categorial flexibility that inspires this approach. Third, it is not clear how this theory would derive some of the root-affix asymmetries listed in §3: in languages like Quechua, which has many suffixes, roots (traditionally construed) are robustly distinguished in shape and segmental content. Removing this distinction takes away the theoretical means of accounting for the differences. Finally, I show in (§5.1.2) that the morphosyntactic differences exploited for essentially diacritic purposes in this account have testable correlates in Russian, but without the phonological asymmetries the account predicts.

5.1.1   Compounds vs. single-root words in English

A closer look at English stress shows that it is far more complex than predicted by this analysis (Peperkamp 1997, Pater 2000, Benua 1997, and many others). As shown in (24), even within Class II affixes, stress patterns are non-uniform: some affixes are systematically unstressed, and when they are stressed, the patterns do not always resemble compounds.[14] Class II suffixes may be weakly stressed (e.g., *-hood*), but most are unstressed (*-ful, -able, -less, -ness, -ist*, etc.).[15] For *-able*, the lack of stress is diagnosed not just by schwas, [-əbəl] but also by flapping (e.g., *pala̲table, rela̲table*). Similarly, Class II prefixes may or may not be stressed (24a–d), but they normally bear weaker stress than the roots that follow—in a pattern that diverges from that of most compounds. The one generalization, which goes back to traditional cyclicity approaches, is that roots tend to receive at least some degree of stress, consistent with theories that assume a root-outward cycle.

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[14]In bimorphemic compounds, stress is usually on the first stem, but there are exceptions; see Plag et al. (2008) and Morrill (2012), among others.

[15]All of my stress transcriptions are according to the Carnegie Mellon Dictionary and the Oxford English Dictionary.

(24)   Affix and compound stress in English are heterogeneous

	Prefixes		Compounds		Class II suffixes	
a.	ùn-concérned	f.	ín-bòund	k.	gírl-hòod	[gˈɚlhˌʊd]
b.	ùnder-résourced	g.	únder-dòg	l.	fánci-ful	[fˈænsɨfəl]
c.	rè-tóld	h.	róund-tàble	m.	pálat-able	[pˈælərəbəl]
d.	be-friénd	i.	bóy-frìend	n.	friénd-less-ness	[frˈɛndləsnəs]
e.	re-rún (v), ré-rùn (n)	j.	àble-bódied	o.	hònor-ée	[ˌɑnərˈi]

This discussion suggests that the all-affixes-are-roots hypothesis is not enough to account for lexical stress patterns in a language like English. There are alternatives (e.g., Fabb 1988, Benua 1997), but they treat the Class I/II distinction as essentially diacritic.

5.1.2   Morphological differences without phonological differences

We can also ask whether, in cases where there is a clear need for a morphosyntactic distinction along the lines exploited by the all-affixes-are-roots theory, the phonological differences necessarily follow. A well-studied class of cases here includes diminutives, which can pattern as either heads or modifiers (Scalise 1988, Wiltschko and Steriopolo 2007, Bachrach and Wagner 2007, Steriopolo 2008). The status can be diagnosed by whether the suffix is transparent to gender, and whether it must attach to previously categorized stems. In German, the diminutive -chen is a head: assigns neuter to all words it derives. In Italian, diminutives have the same gender as the nouns they are derived from. Russian has both kinds of suffixes (as documented by Steriopolo), and Gouskova and Bobaljik (2021) suggest that a single suffix, -onok, can be either a head or a modifier: as a head, it assigns its own masculine gender, and as a modifier, it passes on the gender of the bases, which are previously categorized. This can be translated neatly into structures similar to Lowenstamm's Class I and II affixes: the head is like Class I, and the modifier is like Class II. Again, the prediction is that the modifier should show a compound-like stress pattern, or at the very least be stress-neutral.

The problem is that, regardless of its morphosyntactic patterning, the phonological properties of -onok are the same. It is always stress-dominant, it always causes the same kind of mutation alternations on the last consonant, and so on. This suffix is dominant/autostressing (as shown in (25); the stems are labeled for stress type as fix(ed), mob(ile), and fin(al), and all affixes other than -onok in these examples are recessive—see §3.4.2):

(25)   Russian -onok/-onk suffix is stress-dominant: morphological head attachment pattern

		Adult/unmarked X			Baby X /-ónok/		
		NOM.SG	INST.SG	INST.PL	NOM SG	INST.SG	Gloss
		/-Ø/	/-om/	/-ámi/	/-Ø/	/-om/	
a.	/dʲjávol_fix/	dʲjávol	dʲjávolom	dʲjávolami	dʲjavolʲónok	dʲjavolʲónkom	'devil'
b.	/ʂakál_fix/	ʂakál	ʂakálom	ʂakálami	ʂakalʲónok	ʂakalʲónkom	'jackal'
c.	/volk_mob/	vólk	vólkom	volkámi	volʨónok	volʨónkom	'wolf'
d.	/slon*_fin/	slón	slonóm	slonámi	slonʲónok	slonʲónkom	'elephant'

Superficially, this is similar to compound stress: in compounds, the second/last stem is obligatorily stressed. But unlike single-root words, compounds may have a secondary stress on the first stem (26). Secondary stress is variable but most likely to surface on fixed stress stems.

(26)   Russian compounds have main stress on the last stem and variable secondary stress on first stem

		Nom.sg	Inst.sg /-om/	Inst.pl /-ámi/	Gloss	Compounds	Gloss
a.	/xolod$_{mob}$/	xólod	xólodom	xolod-ámi	'cold'	xòlod-o-stójkostʲ	'cold resistance'
b.	/moróz$_{fix}$/	moróz	morózom	moróz-ami	'frost'	moròz-o-stójkostʲ	'frost resistance'
c.	/ʐar$_{mob}$/	ʐar	ʐárom	ʐar-ámi	'heat'	ʐar-o-stójkostʲ	'heat resistance'
d.	/ogonʲ$_{fin}$/	ogónʲ	ognʲóm	ognʲ-ámi	'fire'	ognʲ-e-stójkostʲ	'fire resistance'

When *-onok* is used as a modifier, it is just as dominant, and there is no secondary stress on its base. It behaves just like any dominant suffix:

(27)   Russian evaluatives with *-onok*, as modifier: same stress properties as baby/head

	Base	Stress type	Evaluative/dismissive	Gender	Gloss	
a.	gazét-a	fixed	gazetʲ-ónk-a	F	'newspaper'	
b.	lóʂadʲ	mobile	loʂadʲ-ónk-a	F	'horse'	*lòʂadʲónka
c.	málʲtɕik	fixed	malʲtɕ-ónk-a	M	'boy'	

If the evaluative *-onok* is structurally farther from the stem's root than baby *-onok* is, as suggested by the morphosyntactic facts, then why is there no evidence of an inner stress cycle in the form of secondary stress? There is a real morphosyntactic asymmetry here, but no phonological differences, and it is not clear how this uniform patterning would follow from the all-affixes-are-roots theory. At the very least, this theory seems to be wrong when combined with phase-based spellout as an account of stress assignment.

5.2   Take two: some affixes are roots

The strong version of this theory seems wrong, but there is a weaker version that has some promise. Perhaps not all affixes are roots, but some are (Creemers et al. 2018). After all, roots can become affixes through grammaticalization: for example, the English suffix *-hood* (*priesthood*, *neighborhood*) comes from Old English root *had*, 'person, condition, rank' (Hopper and Traugott 1993). Allen (1978:117) notes that some of the older, established compounds show vowel reduction to schwa: *fire-m[ə]n, police-m[ə]n, wood-l[ə]nd, straw-b[ə]rry*. This indicates a lack of stress, and possibly some degree of shift towards suffixhood. Allen proffers examples such as "Madam Chairm[ə]n" as evidence that *man* does not have its root meaning in such a compound. Here again we see some blurring of the line between roots and affixes: some roots become more affix-like over time.

5.2.1   Brasilian Portuguese *-mente*

Grammaticalization can fail to cause complete erasure of a former root's phonological heft, even as it loses its morphological rootiness. Gilbert (2021) discusses three suffixes in Brazilian Portuguese that fit the bill. All have special stress properties: they allow the stems to retain their lexical stress as a secondary stress, while regular suffixes merely shift stress rightward (see (28)). Gilbert analyzes the diminutive *-(z)inho* and superlative *-issimo* as syntactic modifiers/adjuncts, attaching to previously categorized stems. The category heads initiate normal phase-based spellout, which explains the extra stress on the stem. But *-mente* is different: it is a root, and it appears as the second half of a compound. There are both morphological and phonological reasons for treating *-mente* as a root. For example, it is unique among Portuguese suffixes in allowing ellipsis in coordination (e.g., *[segura mas lenta]-mente*, [sure but slow]-ADV, 'surely but slowly').

(28)   Special and regular suffixes in Brazilian Portuguese (Gilbert 2021)

base		regular		special		
kaˈʒu	'cashew'	kaʒu-zˈeiɾu	'cashew tree'	kaˌʒu-zˈiɲu	'cashew-DIM'	<zinho>
eduk-ˈada	'well-behaved'	eduka-tʃˈiva	'educational'	eduk-ˌadʒ-ˈisima	'well-behaved-SUP'	<issimo>
				edukˌada-mˈɐ̃tʃi	'well-behaved-ADV'	<mente>

This pattern is parallel to English *-like* or *-wise* (e.g., *snáke-lìke, léngth-wìse*). These morphemes are clearly related to stand-alone roots, but they also assign categories (adjective and adverb respectively)—and have compound-like prosody. If the adverbial category head is a null *a* merged with √*wise,* this cyclic stress pattern follows.

5.2.2   How category-flexible are affixes, anyway?

Creemers et al. (2018) point out that the vast majority of affixes in languages like English and Dutch (80% in De Belder 2011) are not category-flexible. This is especially true of Class II suffixes (*-ness, -hood*, etc.), and Creemers et al. take this lack of categorial flexibility as evidence that *-ness* and its ilk are categorizing heads, not roots inside heads. For Creemers and colleagues, the distinguishing characteristic of a true root in affix clothing is that it is categorially flexible.

But there may be a bigger morphosyntactic generalization that these proposals miss. All of Lowenstamm's examples, and also the Dutch ones in Creemers et al. 2018, are alternations between *n* and *a*, not *v*. Borer (2015) notes that adjective-noun ambiguities of this sort are cross-linguitsically common and suggests that they are plausibly universal. The right analysis of these *a/n* alternations would be beyond the scope of this paper, but if this generaliztaion is right, then categorial flexibility between *a* and *n* cannot be evidence of root status for Class I affixes. If affixes are affixes, then arbitrary differences in phonological properties require diacritic treatment, as in the theories of Melvold (1989), Benua (1997), and Pater (2000).

5.2.3   Some affixes are roots: reduplication in Generalized Template Theory

The claim that some affixes are roots has been used to explain phonological differences well before Lowenstamm (2015): McCarthy and Prince (1994b) and Urbanczyk (1996, 2006) use root status to explain differences in reduplication patterns. In some languages, reduplicants respect the same phonological constraints as phonological words do. For example, in Diyari (Pama-Nyungan), a word must be at least two syllables, have initial stress, and end in a vowel—a classic minimal word restriction (§§3.1, 4.1). Diyari has several reduplicative morphemes (diminutive, degree modification, iterative/progressive aspect), and the reduplicant is two syllables, has initial stress, and ends in a vowel:

(29)   Diyari reduplication (Austin 1981)

kanku	'boy'	kanku-kanku	'little boy'
wiḻapina	'old woman'	wiḻa-wiḻapina	'little old woman'
kuḻkuŋa-	'to jump'	kuḻku-kuḻkuŋa-	'to jump repeatedly'
wakari-	'to break'	waka-wakari-	'to break to pieces'

There are several possible analyses of the reduplicative template (e.g., the reduplicant might be specified as a phonological word; McCarthy and Prince 1994a:18). McCarthy and Prince's (1994b) analysis eschews prosodic stipulations on the reduplicant itself. Instead, they postulate that each reduplicative morpheme is "lexically declared to be a stem" (=root), which makes reduplicatzed words compounds. The disyllabicity and vowel finality follow automatically, because reduplicants are subject to the same requirements as any

other roots in the language. This includes being parsed into phonological words, having a foot at the left edge, and so on.[16] This is **Generalized Template Theory**: there are no templates. All template-like effects arise from phonological requirements on roots and affixes.

Urbanczyk (2006) documents the asymmetries between roots and affixes in Lushootseed (Salishan), which, she argues, are mirrored in its reduplication patterns. Two of the reduplicative morphemes are shown in (30): a plural/aspectual morpheme in (a) and diminutive in (b). Urbanczyk analyzes the plural/aspectual reduplicative prefix as a root, and the diminutive as an affix. The plural/aspectual morpheme has phonological properties that are characteristic of roots in Lushootseed: it may have a stressed schwa and a coda. The diminutive, on the other hand, replaces a schwa with a default [í]. There is no prohibition on codas in Lushootseed affixes: both prefixes and suffixes may be closed syllables. The CV- size is attributed not to a general prohibition on codas in affixes but rather to the emergence of the unmarked: the ranking MAX-IO, MAX-BASE-RED$_{RT}$≫NOCODA≫MAX-BR will allow codas in non-reduplicative affixes and both reduplicative and non-reduplicative roots, while ruling them out in reduplicative morphemes designated as affixes. Similarly, the constraint against stressed schwa is going to be sandwiched between root base-reduplicant faithfulness and general base-reduplicant faithfulness, allowing the marked structure into root morphemes (reduplicants, roots, and lexical affixes) while excluding it from affixes (reduplicative and other).

(30)   Lushootseed reduplication

    a. plural/aspectual ("distributive"): CVC-

        jǎsəd   'foot'   jǎs-jǎsəd   'feet'
        dᶻǎx̌   'move'   dᶻǎx̌-dᶻəx̌   'move household'
        sáqʷ   'fly'   sáqʷ-saqʷ   'fly here and there'

    b. diminutive: CV-

        jǎsəd   'foot'   jí-jəsəd   'little foot'
        tǎdᶻil   'lie in bed'   tí-tədᶻil   'lie down for a little while'
        q'ixʷ   'upstream'   q'í-q'ixʷ   'a little upstream'
        ʔálʔal   'house'   ʔá-ʔalʔal   'hut'

Unlike non-reduplicative affixes, the diminutive may have glottalized consonants (as in [q̲'í-q̲'ixʷ]). This is not a problem for an OT analysis that has distinct faithfulness constraints for reduplicative vs. input-output correspondence: the constraints enforcing base-reduplicant identity for laryngeal features must simply be undominated in this language (see (31)). Urbanczyk notes that Salish languages vary on this point, with Shuswap showing laryngeal neutralization in reduplicants (as in candidate (b), which would win as long as IDENT[cg]-BR is ranked below *CG). The analysis allows fine-grained control over which marked structures get copied, consistent with the general BR-faith approach to reduplication.

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[16]There is a theory-internal reason for preferring this minimalist theory of templates, lacking templatic constraints. In McCarthy and Prince's (1994a) Correspondence Theory approach to reduplication, there are constraints enforcing identity between reduplicants and bases. These identity constraints predict that the base will be truncated to match the size of the reduplicant, /RED-pataka/→[pata-pata], while unreduplicated words can be of any length, /pataka/→pataka, not *pata (a prediction known as the Kager-Hamilton Conundrum). The "reduplicant is a root" approach does not make this prediction. But, while McCarthy and Prince (1999) see templates as the problem, the identity constraints are just as much of a problem for this prediction; see McCarthy et al. (2012).

(31)   Allowing some marked structure into reduplicative affixes

/RED$_{suff}$-√q'ix^w/ 'a little upstream'	IDENT[cg]-BR	IDENT-[cg]-IO-Rt	*CG	IDENT-[cg]-IO
a. ☞q'i-q'ix^w			**	
b. qi-q'ix^w	*!		*	
c. qi-qix^w		*!		*

These analyses of Diyari and Lushootseed seek to derive all the properties of reduplicative morphemes from independent principles, which is appealing. But note that the designation of a reduplicant as a root is arbitrary. In Diyari, the diminutive and aspectual reduplicants are roots. In Lushootseed, the diminutive is an affix, while the plural and aspectual reduplicants are roots. Diminutives are known to vary between languages in systematic ways, with some acting like heads and others like modifiers/adjuncts (Wiltschko and Steriopolo 2007). Wiltschko and Steriopolo in fact discuss the diminutive of Halkomelem (Salish), which is morphosyntactically and phonologically similar to that of Lushootseed, and conclude that it is a modifier rather than a head. The use of the root/affix designation in Generalized Template Theory does not have much to do with this kind of head/modifier analysis, however. Rather, it is diacritic. When realized as reduplicants, functional morphemes such as plural and aspect may be affixes or roots, depending on the language. The way to tell which one the language has, then, is circular: if a reduplicant has the phonological properties of a root, it must be a root, regardless of whether it expresses functional structure.

What would be the alternative? McCarthy et al. (2012) propose to return to the treatment of reduplication in Marantz (1982) and McCarthy and Prince (1986). In these proposals, reduplicative morphemes are underlyingly specified for shape, either in terms of C/V slots or prosodic constituents such as syllables, feet, and phonological words. They take either all or some of their segmental content from the base, through a copying operation. But there is no a priori connection between the morphosyntactic function that a reduplicant has in a language and its phonological shape. This prediction is eminently testable. If it turns out that there is no connection between a reduplicant's function and its size, then templatic theories of reduplication are better motivated than ones that use roots as a diacritic for size.

6   Final thoughts: learnability considerations

As we have seen, distributional asymmetries between roots and affixes can be striking: certain classes of segments may be instantiated only in roots, or mostly in roots. Roots may lack morphosyntactically poor, but they are phonologically rich, and there is no denying that roots are very salient for learners: they come early in acquisition (Massar and Gerken 1998, Tessier 2015:268), and they receive differential treatment in processing and in disorders (Kean 1977, Beckman 1998, Urbanczyk 2011). In a word, roots are special—and additional evidence for their special phonological status has emerged recently in computational work on phonological learnability.

In statistical phonological learning, computational models mimic the theorized learning paths that children take (Zuraw 2000, Albright and Hayes 2003, Hayes and Wilson 2008). The assumption is that children induce generalizations from large and messy learning data, rather than coming to the learning problem equipped with all the constraints (as in Tesar and Smolensky 2000). This research has achieved some success in modeling phonotactic learning, morpho-phonological alternations, non-local phonological interactions, and hidden phonological structure (see Jarosz 2019 for an overview). The results of interest here are those that zero in on roots as the key source of evidence for certain phonological patterns.

Suppose that learners use inductive strategies for figuring out that their languages have nonlocal phonological interactions (such as vowel and consonant harmony/dissimilation, Gouskova and Gallagher 2020, Gallagher 2020). In some languages, consonant dissimilation has the flavor of a Morpheme Struc-

ture Constraint on roots: obeyed inside morphemes, but disobeyed in morphologically complex words, including affixed ones (Rose and Walker 2004). In languages like Quechua, however, laryngeal dissimilation holds statically of both roots and words. This is because suffixes cannot have aspirated or ejective stops at all (§3.2.2). Gouskova and Gallagher's (2020) learner figures out the need for non-local phonological projections/tiers by attending to local co-occurrence statistics, and like other statistical learners, it requires that interacting segments not be rare in their own right. From this standpoint, roots provide the most concentrated evidence for the underattestation of laryngeals in certain configurations, because laryngeals only occur in roots. When the learner is trained on suffixed words, it needs more evidence, and the findings are less reliable. Gallagher (2020) finds an analogous result for Navajo anteriority harmony (recall §3.2.2, 3.3): the inductive projection learner finds harmony when trained on stems, but not when trained on words. As we saw, Navajo does not have many stridents in affixes, compared to its roots—so it is unsurprising that a statistical learner does better on a dataset where stridents are ubiquitous, versus one where they are rare.

Roots turn out to be key for Gouskova and Stanton (to appear). Their learner tackles the problem of how to figure out whether a language has complex segments (affricates, prenasalized stops, etc.) or multi-consonant sequences. The approach is statistical, working from frequencies of co-occurrence in the lexicon. In most cases where multiple types of data are tested, such as Quechua and Navajo, it is roots that supply the right distributions. By contrast, training on phonological words leads to pathological or incomplete learning. In Quechua especially, the prosodic asymmetries between roots and affixes are so dramatic that the learner is led astray and lumps every cluster that occurs in frequent suffixes into a complex segment. Gouskova and Stanton speculate that the learning strategy that uses roots as the data for certain types of phonological learning is likely to work also for languages in which root and affix phonology does not show dramatic disparities for the relevant structures (Turkish, for example). If this is right, then we have a learnability argument that phonology needs to be morphologically aware, and that roots are crucial.

To conclude, I want to round up the issues that I consider to still be open. First, we need a better sense of what the right cut is: roots vs. affixes, or roots vs. everything else? Second, we need to revisit the question of whether function morphemes really are restricted in size; this seems to be an oft-repeated saw that does not rest on a robust empirical foundation. Relatedly, while it is true that roots are often licensed to have marked structures that non-roots lack, there are counterexamples, and we need a better typology. Fourth, while the study of lexical affixes is not new, we need a stronger theory of how they come by their phonological and morphological properties—and a theory that does not wash out the results on other aspects of root phonology.

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