Infixes really are (underlyingly) prefixes/suffixes: Evidence from allomorphy on the fine timing of infixation*

Laura Kalin

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Abstract

Infixation and allomorphy have long been investigated as independent phenomena—see, e.g., Ultan 1975, Moravcsik 1977, Yu 2007 on infixation, and Carstairs 1987, Paster 2006, Veselinova 2006, Bobaljik 2012 on allomorphy. But, relatively little is known about what happens when infixation and allomorphy coincide. This paper presents the results of the first cross-linguistic study of allomorphy involving infixation, considering 51 case studies from 42 languages (15 language families). Allomorphy and infixation interact systematically, with distinct sets of behaviors characterizing suppletive and non-suppletive allomorphy involving an infix. Perhaps most notably, suppletive allomorphy is conditioned only at/from the stem edge, while non-suppletive allomorphy is conditioned only in the surface (infixed) environment. The robustness of these and related findings supports a universal serial architecture of the morphosyntax-phonology interface where: (i) infixation is indirect, involving displacement from a stem-edge position to a stem-internal one, counter to several influential theories of infixation (see especially McCarthy and Prince 1993a and Yu 2007); (ii) suppletive exponent choice is prior to (i.e., not regulated by) the phonological grammar (in line with Paster 2006, Pak 2016, Kalin 2020, Rolle 2021, Stanton To Appear, *i.a.*); and (iii) realization—including exponent choice and infixation—proceeds from the bottom of the morphosyntactic structure upward (à la Bobaljik 2000, Embick 2010, Myler 2017).

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1 Introduction

Both allomorphy and infixation introduce complexity into morphological systems, in different ways: allomorphy involves a many-to-one correspondence between form and mean-

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ing/function, while infixation disrupts the linear integrity of forms. Both are found across the world's languages, and have been the subject of much empirical inquiry and theorizing—on infixation, see e.g. Ultan 1975, Moravcsik 1977, 2000, McCarthy and Prince 1993a,b, Hyman and Inkelas 1997, Moravcsik 2000, Halle 2001, Horwood 2002, Yu 2007, Wolf 2008, Samuels 2009, Bye and Svenonius 2012, Blevins 2014, Harizanov 2017; on allomorphy, see e.g. Carstairs 1987, 1990, Inkelas 1990, Bobaljik 2000, 2012, Paster 2006, 2009, Veselinova 2006, Mascaró 1996, 2007, Bonet et al. 2007, Bye 2008, Embick 2010, Bermudez-Otero 2012, Bye and Svenonius 2012, Pak 2016, Scheer 2016, Kalin 2020, Rolle 2021, Stanton To Appear. These studies present a plethora of ideas about how, when, and why infixation and allomorphy take place, and make (unstated) predictions about how the two should interact.

Relatively little is known, however, about what happens when infixation and allomorphy coincide—while there are discussions and analyses of allomorphy involving infixes in individual languages (e.g., Anderson 1972 and Cohn 1992 for Sundanese, Hardy and Montler 1991 for Alabama, Blevins 1999 for Leti, Yu 2017 for Tiene and Katu), no systematic cross-linguistic study of such patterns has ever been undertaken to my knowledge. In this paper, I report on a study of 51 cases of allomorphy involving infixation, spanning 42 languages (and 15 language families), showing that the intersection of these two linguistic phenomena affords a uniquely informative window into the inner workings of the morphosyntax-phonology interface. In particular, the patterns found (and not found!) differentiate among theoretical approaches to morphology and phonology.

The bulk of this paper presents the empirical findings of the study and their immediate theoretical implications, comprising four sections, each related to different empirical domains: §3 considers suppletive allomorphy involving an infix, §4 takes up non-suppletive allomorphy involving an infix, §5 offers insights from this study into infixation more generally, and §6 briefly explores the (non-)optimizing nature of suppletive allomorphy and infixation. The core findings, in very brief, are as follows. Suppletive and non-suppletive allomorphy involving infixes have very different profiles: suppletive allomorphy is conditioned only at/from the stem edge (specifically, the edge that the infix is oriented towards), while non-suppletive allomorphy of an infix is conditioned only stem-internally, in the infix's surface (infixed) position; suppletion is never conditioned by an infix's surface (infixed) environment. Infixation, as a process, is exponent-specific, and only looks *inward*, into phonological material and prosodic structure that is morphosyntactically more embedded than the morpheme that is exponed by the infix. And finally, both suppletive allomorphy and infixation are often non-optimizing, occurring without phonological or prosodic motivation, and may be opaque.

The findings are brought together in §7, where I argue that they show that (i) infixation is indirect, involving displacement from a stem-edge position to a stem-internal one, i.e., infixes really are (underlyingly) prefixes/suffixes (§7.1), (ii) the choice among suppletive exponents for a morpheme properly precedes infixation of an infixal exponent and is not regulated by the phonological grammar (§7.2), and (iii) realization proceeds cyclically from the bottom of a morphosyntactic structure up, with basic linear order among morphemes determined first, then exponence, then infixation (of an infixal exponent), and then (morpho)phonology (§7.3). These theoretical implications support a realizational, serial, piece-based model of the morphosyntax-phonology interface, of which Distributed Morphology and related approaches (e.g., Halle and Marantz 1993, 1994, Bobaljik 2000, 2012, Embick 2010, Bye and Svenonius 2012, Myler 2017) are a particularly natural fit given the set of findings. On the other hand, the theoretical implications are problematic for parallel models of morphology and phonology (like those of McCarthy and Prince 1993a,b, Prince and Smolensky 1993, Mascaró 2007, Wolf 2008, Bermudez-Otero 2012) and for models that take infixation to be "direct" (e.g., Inkelas 1990, Anderson 1992, McCarthy and Prince 1993a, Yu 2007, Wolf 2008, Samuels 2009).

2 Preliminaries: Definitions and the sample

This section lays out a number of preliminaries of the study, including (i) definitions of suppletion, §2.1, and infixation, §2.2, (ii) a decision tree for identifying suppletive vs. non-suppletive allomorphy, §2.3, and (iii) properties of the language sample, §2.4. Key terms are bolded in the places where they are first substantively mentioned/defined.

2.1 Definition of (types of) allomorphy

I use the term **morpheme** to refer to an abstract morphological element corresponding to (i) a meaning or morphosyntactic function,[1] and (ii) a set of phonological forms (**exponents**); when this set is a non-singleton set, the phonological forms are referred to as **allomorphs** of the morpheme. While I assume that both roots and affixes can have allomorphs, the present study focuses on the latter, as the empirical domain is cases of allomorphy where at least one allomorph is infixal.

As an example of allomorphy of an affix, consider the much-used case of the English plural morpheme, (1):

(1) Some allomorphs of the English plural morpheme

a. gorilla-[z]
b. bat-[s]
c. midge-[ɨz]
d. child-[rən]
e. moose-[∅]
f. alumn-[aj]

While I consider all of the distinct phonological forms of the plural suffix in (1a-f) to be allomorphs, not all these allomorphs have the same grammatical status. In particular, I make a binary distinction between suppletive allomorphs and non-suppletive allomorphs, which will be elaborated on below.

The main criterion I will use in determining whether a given allomorph is **suppletive** with respect to another is what Veselinova (2006:15) refers to as "**phonological distance**": how much phonological material is shared between the allomorphs, and, relatedly, can both

[1] In cases of allosemy, this may be more properly characterized as a *set* of meanings or functions.

allomorphs reasonably be phonologically derived from one **underlying form**?[2] The English allomorphs in (1) present a clear illustrative case: [z], [s], and [ɨz] are all very closely phonologically related, and the alternation among them can be understood through phonologically natural processes (voicing assimilation and vowel epenthesis), conditioned by their particular environments; [z], [s], and [ɨz] are thus **non-suppletive allomorphs** derived from a single underlying form, /z/. On the other hand, /z/ (underlying [z]/[s]/[ɨz]), [rən], [∅], and [aj] are all phonologically distant from one another—there is no clear motivation for deriving one from any other nor for positing a shared underlying form. Using the phonological distance criteria, then, /z/, /rən/, /∅/, and /aj/ are all **suppletive allomorphs** (also sometimes called "true" allomorphs), each corresponding to a distinct underlying form for the English plural morpheme. Phonological distance is, of course, a continuum, which means that not all cases are as clear cut as the English plural. I present the decision tree that I use for determining whether a particular alternation is suppletive or non-suppletive for the current study in §2.3.

Exponent choice is the process of selecting a compatible underlying form from a set of suppletive allomorphs in a particular environment; I equivalently refer to this as **suppletive allomorph choice**. The following environmental factors may influence exponent choice (see, e.g., Carstairs 1987, 1990, Bobaljik 2000, 2012, Paster 2005, 2006, Veselinova 2006):

(2) Factors conditioning suppletive allomorphy (exponent choice)
  a. lexical = conditioned by a root or class of roots
  b. morphological = conditioned by a morphosyntactic feature
  c. phonological = conditioned by a phonological feature[3]
  d. prosodic = conditioned by prosodic size, weight, and/or shape

Each will be exemplified with infix allomorphy data in §3.2.

There is a fair amount of controversy in the literature with respect to the line between suppletive and non-suppletive allomorphy (see, e.g., differing views in Embick and Halle 2005, Mascaró 2007, Merchant 2015, Scheer 2016, Sande et al. 2020). When a case of allomorphy is phonologically or prosodically conditioned *and* derivable by a phonological process that is plausibly language-general (like for English plural [z], [s], and [ɨz]), this is called **surface allomorphy**, and it is generally agreed that such alternations are non-suppletive.

The more controversial cases are those where phonological distance is small, but, where the alternation is morphologically or lexically restricted and/or morphologically or lexically conditioned. For example, consider the voicing of the final fricative in *lea<u>f</u>/lea<u>v</u>es* and *hou<u>s</u>e/hou[<u>z</u>]es*, which is both lexically restricted (to certain roots) and morphologically conditioned (it happens in plural forms). Such alternations, if treated as non-suppletive, are

[2]For a more rigorous definition of suppletion, see Mel'čuk 1994.

[3]Scheer (2016) has argued that the only "true" phonologically-conditioned suppletive allomorphy (PCSA) is non-melodic, i.e., is based on higher-level factors like syllable structure, stress, and sonority. Several cases of infix allomorphy in the present sample pose a significant challenge to this view, as melody-conditioned allomorphy is accompanied by positional changes for the exponents. See the case studies in the Appendix with the designation "phonological (melody)".

the purview of so-called "readjustment rules" (Chomsky and Halle 1968, Halle and Marantz 1993, Embick and Halle 2005), which can be subdivided into 3 types (Embick and Shwayder 2018): phonologically-conditioned alternations that only specific morphemes undergo; morphologically-conditioned alternations that have a consistent/general phonological effect; and morphologically-conditioned alternations that only specific morphemes undergo (like the English *leaf/leaves* example). It is only the first type of morphophonology that is robustly encountered in the present study—allomorphy where there is a phonologically-conditioned alternation that is morphologically restricted (not language-general). I make the conservative choice to characterize such allomorphy as non-suppletive just in case it is phonologically optimizing/natural, and otherwise I treat such allomorphy as suppletive. (See §2.3 for more detail and discussion.) As we will see, this choice holds my generalizations to a high bar by characterizing more cases of allomorphy as suppletive. Importantly, if this high bar were lowered (with a more permissive definition of non-suppletive allomorphy), my core findings would remain intact.

2.2 Definition of infixation

I adapt Blevins' (2014) definition of infixation, reproduced in (3). (See Yu 2007:Ch.2,(2) for a comparable definition.)

(3) Infixation as affixation: a definition (Blevins 2014:(1))

> Under infixation a bound [exponent] whose phonological form consists minimally of a single segment, is preceded and followed in at least some word-types by non-null segmental strings which, together, constitute a relevant form-meaning correspondence of their own, despite their non-sequential phonological realization.

I will break down the definition in (3) using Blevins' illustrative example of nominalization in Hoava (Austronesian, Solomon Islands), and in doing so, will introduce some additional terminology that I will use throughout the paper. (The infixal exponent is enclosed in angled brackets, as per the usual convention.)

(4) Infixation in Hoava: nominalizer *-in-* (adapted from Blevins 2014, citing Davis 2003)

a. -in- (NOM) + to (alive) → t<in>o ('life')
b. -in- (NOM) + hiva (want) → h<in>iva ('wishes')
c. -in- (NOM) + va-bobe (CAUS-full) → v<in>a-bobe ('filled object')
d. -in- (NOM) + ta-poni (PASS-give) → t<in>a-poni ('gift')
e. -in- (NOM) + vari-razae (RECIP-fight) → v<in>ari-razae ('war')
f. -in- (NOM) + asa (grate) → <in>asa ('pudding of grated cassava')
g. -in- (NOM) + edo (happy) → <in>edo ('happiness')

The nominalizer in Hoava is a bound derivational morpheme, exponed by the segments *in*. This exponent is infixal, per the definition in (3), because it can be preceded and followed by segments which together form a constituent to the exclusion of the infix, e.g., *h* and *iva* in (4b). I will refer to the constituent that the infix combines with as the **stem of infixation** (or sometimes just the **stem**); the stem of infixation may be monomorphemic, as in (4a-b,f-g), or multimorphemic, as in (4c-e).

Generally-speaking, the **placement** of an infix can be described relative to a phonological or prosodic **pivot**.[4] In the case of Hoava, the infix always appears before the first vowel of its stem.[5] There is crosslinguistic evidence that consonants, vowels, syllables, and feet may all serve as pivots for infixation, with stress able to play a role as well (Ultan 1975, Moravcsik 1977, Yu 2007). Given the phonological/prosodic nature of infix placement, it should come as no surprise that an infix may appear inside a root, (4a-b), inside an affix, (4c-e), or even at the very edge of its stem, (4f-g)—the infix is oblivious to these distinctions, its **surface** position determined solely by its pivot/placement. I thus consider *-in-* to be one and the same infixal exponent throughout (4a-g), in line with the definition in (3). Finally, I assume that what makes simple prefixes and suffixes different from infixes is that the former *lack* a pivot/placement. In other words, I use pivot/placement uniquely to describe infixes; I do not use pivot/placement to describe simple prefixation/suffixation.[6] (This descriptive choice is guided by my findings in this study—see discussion in §7.1.)

The definition in (3) is less restrictive than some definitions of infixation (cf. Ultan 1975, Moravcsik 2000), in particular, in recognizing that the stem of infixation may consist of more than just a root. At the same time, the definition might be *more* restrictive than turns out to be empirically and theoretically justified, in the sense of artificially delineating what "counts" as part of a unified phenomenon and what doesn't. Nevertheless, for practical data-gathering purposes, boundaries have to be drawn somewhere, and I leave it for future work to determine whether those drawn in (3) are the right ones. One could consider, for example, expanding the definition to include morphemes consisting of *sub*-segmental phonological features. Or, the definition could be expanded in the opposite direction, to include *free* morphemes and complex *words* that appear inside of their stems (like English's so-called expletive infixation) or even inside of phrasal constituents (like phonological second-position elements).

2.3 Decision tree: Categorizing allomorphy as suppletive or non-suppletive

Since the line between suppletive and non-suppletive allomorphy is infamously murky and controversial, I have codified my categorization process as a decision tree, (5). Understanding

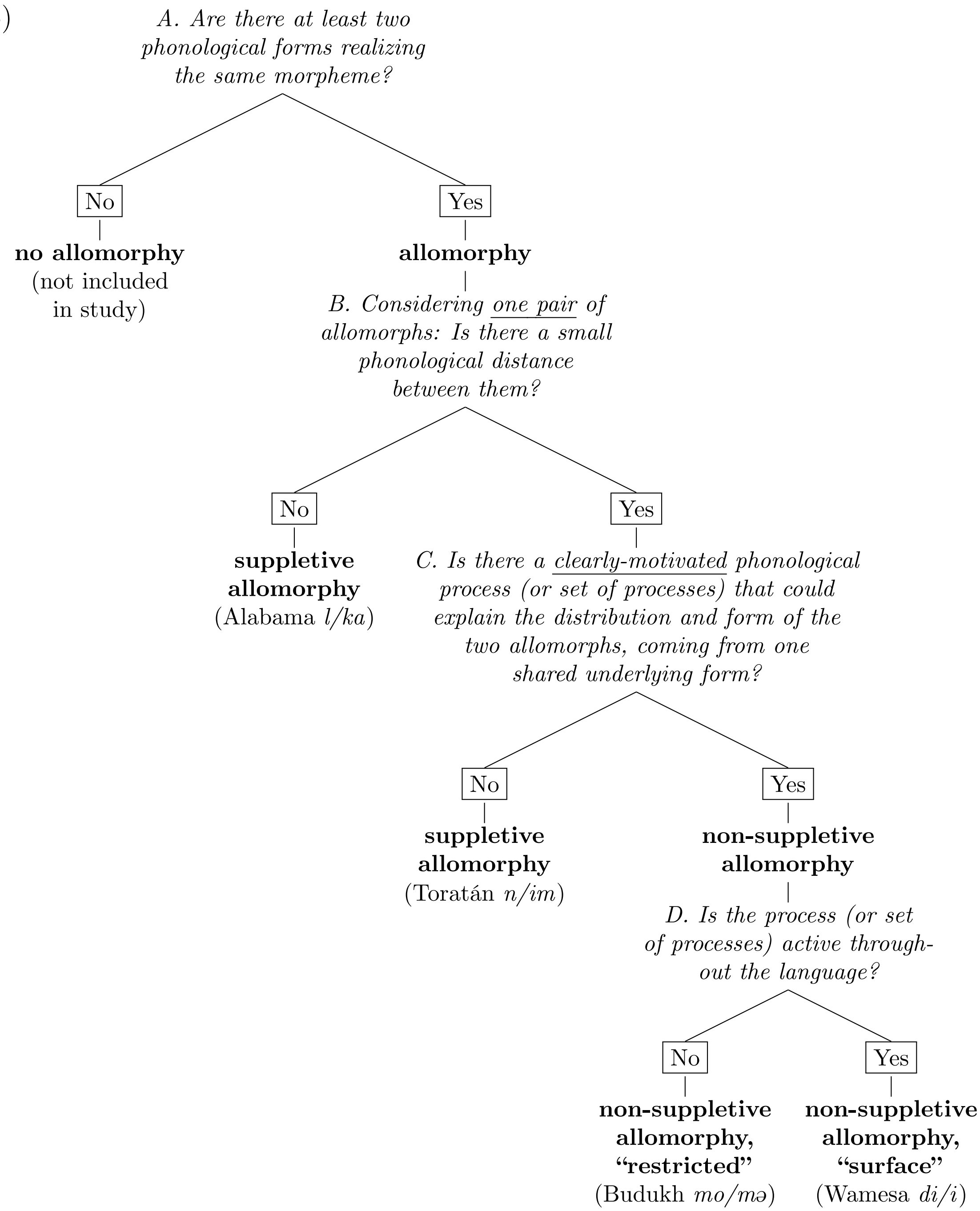
[4]It is a matter of some debate whether infixes (at least uniformly) have pivots, or whether infixes sometimes or always are simply placed into a phonologically optimizing position (see, e.g., discussion in McCarthy and Prince 1993a, Horwood 2002, Yu 2007, Wolf 2008, Bye and Svenonius 2012). I will continue to refer to pivots of infixes for descriptive convenience. In addition, the present study supports the theoretical need for pivots, §6.2, thereby supporting a "subcategorization"-based view of infixation (in line with Yu 2007).

[5]I will ultimately argue that "first" as part of the pivot here is superfluous, being better represented as "closest"; this runs counter to direct infixation approaches like that in Yu 2007. See §7.1.

[6]I diverge terminologically from Yu 2007, in that I won't refer to (e.g.) infixation before the first vowel as "prefixation" to the first vowel. I use "prefixation" and "suffixation" exclusively to describe the position of an affix relative to its stem.

how classificational decisions have been made is crucial to the replicability of this (and any) typological study, as well as to interpreting the results.

(5)



I will exemplify and discuss each outcome in the decision tree, starting at the top. Consider again the Hoava words in (4), where the nominalizer always has the form *-in-*. Such a case is classified as not involving allomorphy ("no" for Question A), and so is not included in the present sample. The middle voice morpheme in Alabama (Muskogean, USA; Hardy and

Montler 1991) gets us one step farther in the decision tree, having two allomorphs, *-l-* and *-ka*. These allomorphs are phonologically distant, and so yield a "no" to Question B, thereby classifying them straightforwardly as suppletive allomorphs. (See §6.3 for more details on this case study.)

The remaining three exits in the decision tree require a bit more discussion. Question C asks—for a given pair where phonological distance is already determined to be small by Question B—is there a process (or set of processes) that could relate both allomorphs to a single underlying form, where the phonological changes are *clearly-motivated* in the environments the allomorphs find themselves. I use "clearly-motivated" as shorthand for phonological processes that are: (i) optimizing (in the intuitive, pre-theoretical sense), e.g., hiatus repair; (ii) well-attested cross-linguistically, e.g., palatalization of a consonant before a high front vowel; or (iii) motivated within the language itself, as part of its general phonological system. If the answer to Question C is no, I categorize the allomorphy as suppletive, and if it is yes, I categorize it as non-suppletive (with one further distinction to be made).

For a suppletive example via Question C, consider the pair of allomorphs *-im-* and *n-* in Toratán, realizing past tense agent voice (Austronesian; Indonesia; Himmelmann and Wolff 1999:13). For starters, *-im-* and *-n-* have a relatively small phonological distance, sharing a nasal feature and differing in the place of that nasal as well as the presence of an initial vowel. Could they perhaps be related to one underlying form via nasal assimilation and vowel epenthesis or deletion? To answer this question, it's important to consider their distributions, as allomorphs. The allomorph *-im-* is an infix, appearing after the first consonant of a consonant-initial stem, e.g., *t<im>umpa* 'jumped down' (from root *tumpa*). The allomorph *n-* is a prefix, appearing before the first vowel of a vowel-initial stem, e.g., *n-empo* 'sat' (root *empo*). While the presence/absence of the vowel in the affix could be taken to be regulated by optimization (cluster avoidance or onset preference), there is no clearly-motivated phonological process that would account for the difference in the bilabial vs. alveolar place of the nasal across the allomorphs, neither within the language nor cross-linguistically. I therefore characterize *-im-* and *n-* as a suppletive pair. As noted at the end of §2.1, this will end up putting my conclusions to a harder test, as compared to a more liberal use of (morpho)phonological processes.

The last distinction to make is in Question D: given a pair of non-suppletive allomorphs, is this allomorphy language-general (derivable by surface phonology) or not? In Wamesa (Austronesian, Indonesia; Gasser 2014:260-261), 3rd singular subject marking has two realizations, *di-* and *-i-*; *di-* appears preceding vowel-initial stems (e.g., *di-api*, from the root *api* 'eat'), and *-i-* appears as an infix, before the first vowel of consonant-initial stems (e.g., *p<i>era*, from the root *pera* 'cut'). This pair of allomorphs makes it straightforwardly through Question A ("yes") and Question B ("yes"). For Question C, considering a hypothetical shared underlying form *di*, the answer is again "yes"—it is easy to understand why the *d* of *di* would be deleted when appearing before the first vowel of a consonant-initial stem, namely, to avoid a complex onset (cf. hypothetical *_p<di>era_). Complex onsets are in fact entirely disallowed in Wamesa (Gasser 2014:39), and repair through deletion of a *non*-root consonant is the most common resolution strategy (Gasser 2014:45,267). Thus, we have a "yes" to Question D—this is a case of surface allomorphy. Note, too, that *di* and *i* can actually also be given a consistent distribution, as an infix that wants to appear before the first vowel of its stem (like the Hoava case in §2.2).

Finally, consider Budukh (Northeast Caucasian, Azerbaijan; Alekseev 1994:279). The prohibitive morpheme has four allomorphs, *-ma-, -me-, -mo-, -mə-* ("yes" to Question A). They are phonologically very close ("yes" to Question B), and all are infixal, appearing after the first syllable of their stem (e.g., *yɨ<mə>x̂ər*, from root *yɨx̂ər*, 'be'). The quality of the vowel in the allomorphs is determined by the quality of the following vowel in the word, i.e., through regressive vowel harmony ("yes" to Question C). But, vowel harmony is not a general process of the language—it is found only with certain morphemes. In addition, different morphemes exhibit different vowel harmony patterns, with the other core harmony pattern in Budukh involving a distinct set of resultant vowels (*i, ü, ɨ, u*) and progressive rather than regressive assimilation. I therefore classify the variation in the prohibitive morpheme as non-suppletive allomorphy that is restricted ("no" to Question D).

In this decision tree, there are two potentially controversial choices I have made. The first controversial choice, which I have mentioned at several points above, is found at Question C (the "no" branch): when a given alternation is *describable* through a phonological change, but this change is *not clearly motivated* (see above for what "clearly motivated" means), should this alternation necessarily be considered to be suppletive? My answer, per (5), is yes, but proponents of more powerful "readjustment" rules might disagree, at least about some of the cases (see, e.g., Embick 2013, Embick and Shwayder 2018). Cases moving from the suppletive to non-suppletive category in Question C would not be problematic for my major findings, and so the stakes are low with respect to this decision; I leave open the possibility that Question C "no" cases are non-suppletive. (See the discussion at the end of §3.1, which would essentially be how these cases would be dealt with, too, if we took them to be non-suppletive.)

The second controversial choice, which would have a more profound effect on my findings, is at Question D (the "no" branch again): are domain- or morphologically-restricted phonological alternations encoded in the grammar as processes (non-suppletively) or as lexically-stored variants (suppletively)? Certainly handling such alternations phonologically, as I've advocated for Budukh above, is more plausible than handling the Question C "no" cases phonologically. But still, some who would hold that the Question C "no" cases are suppletive (as I do) might want to extend this suppletive characterization to Question D "no" cases as well (see, e.g., Mascaró 2007, Merchant 2015). Classifying such cases as suppletive (counter to the current decision tree) would significantly impact my major conclusions. However, I will suggest that the nature of my findings actually furnishes an argument in favor of characterizing these cases as non-suppletive. I will return to this in detail at the ends of §7.1 and §7.2.

2.4 The sample

This study considers 51 cases of allomorphy that involve infixation. These 51 cases come from 42 different languages, belonging to 15 different language families (including isolates), as summarized in Table 1.

Table 1: Language sample (by family)

Family	**#**	**Languages and countries**
Afro-Asiatic	4	Bole, Mupun (Nigeria); Jebbāli (Oman); Turoyo (Turkey)
Algic	1	Yurok (United States)
Austro-Asiatic	5	Bahnar (Vietnam); Jahai (Malaysia); Katu (Lao PDR); Mlabri (Thailand); Nancowry (India)
Austronesian	14	Ambai, Ambel, Biak, Leti, Muna, Toratán, Sundanese, Wamesa, Wooi (Indonesia); Ida'an Begak (Malaysia); Nakanai (Papua New Guinea); Paiwan, Puyuma, Saisiyat (Taiwan)
Cochimí-Yuman	1	Yuma (United States)
Huavean	1	Huave (Mexico)
Kra-Dai	1	Thai (Thailand)
Mayan	1	Tzeltal (Mexico)
Movima (isolate)	1	Movima (Bolivia)
Muskogean	3	Alabama, Choctaw, Creek (United States)
Niger-Congo	3	Eton (Cameroon); Kichaga, Kimatuumbi (Tanzania)
Northeast Caucasian	3	Budukh (Azerbaijan); Hunzib, Lezgian (Russia)
Salish	2	Nxa'amxcin, Upriver Halkomelem (United States)
Torricelli	1	Yeri (Papua New Guinea)
Uralic	1	Estonian (Estonia)

Since infixation is rare to begin with, allomorphy involving infixation is (necessarily) even rarer. I utilized the following resources for identifying case studies: Ultan 1975, Paster 2006, Yu 2007, database searches for keywords (WorldCat, Google Scholar), and word of mouth (pointers from colleagues). The sample is clearly biased towards Austronesian languages, with Afro-Asiatic and Austro-Asiatic languages overrepresented as well. This bias reflects the abundance of infixes in languages of these families and (relatedly) overrepresentation in the sources utilized for finding case studies. The sample is also limited by practical considerations, namely, by what grammars/documentation were available to me online or through my university during the coronavirus pandemic. A complete list of the morphemes that serve as the case studies, and some other basic information about each case study, is given in the Appendix.

To be included in this study, a given case needed to pass Question A of (5), *Are there at least two phonological forms realizing the same morpheme?* In addition, at least one of these phonological forms had to be infixal in the sense defined in §2.2. For each case included in the study, the morpheme/allomorphy at hand was considered carefully in the broader context of the language's phonological and morphological system, and not just in isolation. Therefore another inclusion criterion for a case study was that the available data/description/documentation needed to be clear and thorough enough that I felt reasonably confident in drawing conclusions, especially in terms of what conditions the allomorphy, where the infix is phonologically/prosodically located, and whether a given instance of allomorphy is suppletive or not. Zero allomorphs and ablaut appear as exponents in a couple of the case studies, but never as the only other allomorph apart from the infixal allomorph. Note that throughout, findings are based on my own analysis of the data, which does not always line up with analyses found in the sources themselves.

In including only cases that passed Question A, this study excluded cases where one and the same phonological form appeared as infixal sometimes (having a phonological or prosodic placement) and non-infixal other times (as a simple prefix or suffix, lacking a phonological or prosodic placement).[7] Examples of this are found, e.g., with Ulwa construct state markers (Green 1999) and Lakhota subject markers (Albright 2002). Along similar lines, I further excluded cases from this study (even if they technically passed Question A) that looked like so-called "mobile affixes", with one and the same underlying form (but potentially with non-suppletive alternants) variably appearing as a prefix sometimes, an infix sometimes, and a suffix sometimes. This type of exponent mobility introduces what I take to be an orthogonal confound in making generalizations, in particular, with respect to the same-edge observation; see further discussion in §3.4. I leave it as an open question whether one or both of these types of excluded cases might be fruitfully treated as involving homophonous suppletion (more than one suppletive exponent with the same underlying form), though I think that it is more likely that some other grammatical mechanisms are at play.

A final methodological note is in order. First, I will assume that when a pattern is unattested in the sample, it is likely to be *systematically absent* from the world's languages. Second, I will assume, tentatively, that when a pattern is not attested in the world's languages, it is not possible as a language structure. While both of these are controversial assumptions (and rightly so), they are necessary steps in formulating bold and meaningfully-falsifiable hypotheses, and thus in testing and refining theories of natural language grammar. In addition, these assumptions are vindicated every time an apparent counterexample turns out, upon closer inspection, to not be a counterexample at all (as will be seen at various points throughout this paper), and every time an in-depth analysis of a case study reveals the same intricately-interwoven principles at play (see, e.g., Kalin 2020, 2021, In press). For an opposing view, the reader is referred to Bickel 2015 for a recent discussion of the (dis)advantages of categorical/theoretical vs. statistical/cognitive/historical approaches to typology. I leave it to future work to explore the question of whether processing- and diachrony-based explanations can fruitfully explain some of the findings.

[7] Note that this does *not* mean I excluded cases where an infix sometimes satisfies its pivot/placement at the stem edge, like the Hoava nominalizer does, (4f)-(4g).

3 On suppletive allomorphy involving an infix: Core findings and implications

Perhaps the most significant (and surprising) results of the study come from considering cases of suppletive allomorphy where at least one suppletive allomorph is an infix. Out of the 51 cases of infix allomorphy in this study, 32 involve suppletion. The core findings are as follows, and will be elaborated in the indicated sections, with illustrative case studies.

- §3.1: Suppletive allomorphs may differ with respect to pivot/placement
- §3.2: Suppletion involving an infix may be lexically, morphologically, phonologically, or prosodically conditioned
- §3.3: Conditions on exponent choice are distinct from an exponent's pivot/placement
- §3.4: Suppletive allomorphs share an edge orientation
- §3.5: Suppletion is conditioned based on the underlying form of the stem, at the stem edge identifiable via edge orientation
- §3.6: The surface (infixed) environment of an infix cannot condition suppletion

In §3.7, I will briefly state what I take to be the core implications of these findings.

3.1 Suppletive allomorphs may differ with respect to pivot/placement

Suppletive allomorphs of a morpheme may differ with respect to pivot/placement—none, some, or all suppletive allomorphs of a morpheme may be infixal. Most commonly, only one suppletive allomorph of a morpheme is infixal (true of 25 of the 32 suppletive case studies). When more than one suppletive allomorph is an infix (as found in 7 case studies), pivot/placement can vary across these infixal allomorphs. Finally, there is no correlation between being infixal and being (or not being) the elsewhere allomorph of a morpheme.

In Lezgian (Northeast Caucasian; Dagestan), the repetitive morpheme has three suppletive allomorphs, prefixes $q^h i$- and *xU-*, and an infix *-x-*; the most widely distributed of these exponents is the infix (Haspelmath 1993:174-175). In Nakanai (Austronesian; Papua New Guinea), the nominalizer has two suppletive allomorphs, a suffix *-la* and an infix *-il-*, with the suffix being the more widely distributed (Johnston 1980:176-179). In Nancowry (Austroasiatic; Nicobarese Islands), the instrumental nominalizer has two main suppletive allomorphs that are both infixes, but with different pivots (or at least different positions with respect to the same pivot), *-an-* and *-in-* (Radhakrishnan 1981:60-64, Kalin In press).

The implication of these findings is that it is not *morphemes* that have a pivot/placement (i.e., that are infixes), but rather, it is *exponents* of morphemes that have a pivot/placement. In other words, infixation is exponent-specific.

Against this backdrop, it's important to mention a few case studies where it seems that (what could be posited to be) a *single* exponent may sometimes have a pivot/placement, and other times not. For example, in Biak (Austronesian; Indonesia), two of the allomorphs of 3rd singular subject marking are quite phonologically similar to each other: *i-* appears prefixally on all CC-initial roots and some (lexically arbitrary) C-initial roots, (6), and *-y-* appears infixally after the first consonant on all other C-initial roots, (7) (van den Heuvel 2006:157-158). Note especially the homophonic roots in (6b) and (7b).

(6) a. *i-mar*, 3SG-die (root: *mar*, 'die')
b. *i-so*, 3SG-follow (root: *so*, 'follow')

(7) a. *v<y>ov*, <3SG>sell (root: *vov*, 'sell')
b. *s<y>o*, <3SG>throw (root: *so*, 'throw')

It could be reasonable to posit a single underlying form for the two allomorphs, *i*, as this vowel would naturally become the glide *y* when preceding a vowel, like it does when it is infixed in (7). Biak 3rd singular marking might then seem to furnish a counterexample to the statement that pivot/placement is an exponent-level property—here we have a single exponent that is sometimes infixal, (7), and sometimes not, (6). There are 4 case studies in my sample with this sort of profile, all from Austronesian languages.

There are a few ways to analyze cases like Biak. One is to take the two allomorphs—*i* and *y* here—to be suppletively related, one exponent with a pivot/placement (*-y-*) and the other without (*i-*). Another would be to posit one underlying form and allow infixal placement of this exponent to be *conditioned*, with infixation of the exponent found in some contexts, and simple prefixation/suffixation in other contexts. Yet another approach might posit a purely phonological rule of metathesis (à la Halle 2001), though note that in Biak, at least, this would have to be lexically conditioned rather than phonologically motivated. I opt for the first possibility, classifying these 4 cases in my sample as suppletive, which (as discussed in §2.3) puts my conclusions to a harder test. Nothing about my core findings would change if a different analysis of these cases were adopted. Going forward, I assume that (in the general case) infixation is an exponent-level property.

3.2 Suppletion involving an infix may be lexically, morphologically, phonologically, or prosodically conditioned

The same triggers of suppletive allomorphy that are found in cases *without* any infixal exponents (see §2.1) are found in cases *with* infixal exponents, namely, triggers may be lexical (relevant for 21 out of the 32 case studies involving suppletion), morphological (2/32), phonological (13/32), or prosodic (9/32) in nature.[8] All are exemplified below.

Returning to Lezgian, the exponents of the repetitive affix are lexically distributed:

(8) Repetitive in Lezgian (Northeast Caucasian; Dagestan; Haspelmath 1993:174-175)
a. q^hi- / {SAY, THROW, HIT, DO, GO, BE/BECOME}
• e.g.: *q^hi-jağun* 'hit again' (root: *jağun*)

[8]The cited numbers here do not add up to 32 because more than one conditioning factor may be involved in a single case study.

b. xU-[9]/ {GIVE, COME, BRING, EAT, CARRY}
   - e.g.: *x-gun*[10] 'give again' (root: *gun*)

c. -x- / {SEE, GET OFF, MIX, PUT/BUILD, SIT DOWN (and many more)}
   - pivot/placement: follows first vowel
   - e.g.: *ki<x>ligun* 'look again' (root: *kiligun*)

There is also a periphrastic repetitive strategy (Haspelmath 1993:175-176).

Turning to Nakanai, suppletive allomorphy of the nominalizer is prosodically conditioned, based on the syllable count of the stem:

(9) Nominalizer in Nakanai (Austronesian; Papua New Guinea; Johnston 1980:176-179)

a. -il- / bisyllabic stem
   - pivot/placement: precedes stressed (penultimate) vowel
   - e.g.: *t<il>aga* 'fear' (root: *taga*)

b. -la / elsewhere
   - e.g.: *mutele-la* 'generosity' (root: *mutele*)

Lexical roots are minimally bisyllabic (Johnston 1980:259), so the elsewhere allomorph *-la* appears on roots/stems longer than two syllables.

In Toratán (Himmelmann and Wolff 1999), the agent voice past morpheme has two suppletive exponents, distributed based on whether the stem begins with a vowel or consonant:

(10) Agent voice past in Toratán (Austronesian; Indonesia; Himmelmann and Wolff 1999:13)

a. n- / vowel-initial stem
   - e.g.: *n-empo* 'sat' (root: *empo*)

b. -im- / consonant-initial stem
   - pivot/placement: after first consonant
   - e.g.: *t<im>umpa* 'jumped down' (root: *tumpa*)

These allomorphs are thus conditioned by the phonology of the stem.

Morphology is the least straightforward type of conditioning factor in the present sample, as it only ever appears in combination with other factors. Consider, for example, nominalization in Leti:

(11) Nominalizer in Leti (Austronesian; Indonesia; Blevins 1999:390)

a. nia- / Class I verbs
   - e.g.: *nia-keni* 'act of putting, placing' (root: *keni*)

b. -ni- / Class II verbs
   - pivot/placement: before first vowel
   - e.g.: *k<ni>asi* 'act of digging' (root: *kasi*)

[9] The "U" in this exponent represents a high vowel that is subject to vowel harmony, and may be realized as *u*, *i*, or *y* (Haspelmath 1993:56), or may undergo syncope, cf. fn. 10.

[10] The high vowel in the prefix has undergone Pretonic High Vowel Syncope (Haspelmath 1993:36-38).

The choice between the allomorphs is regulated by a verb's "conjugation class", as diagnosable through which set of subject-marking prefixes ("full" for Class I or "reduced" for Class II) a verb appears with (Blevins 1999:387-388, van Engelenhoven 2004:134-138). Membership in Class I or Class II, in turn, is determined by phonological factors (whether the verb is CC-initial or not), morphological factors (whether the verb is denominalized, causativized, or neither), and lexical factors (whether the verb is stative or non-stative; and idiosyncratically exceptional verbs).

Overall, suppletive allomorphy involving an infix is not fundamentally different from more typical suppletive allomorphy in terms of possible triggers, though it may be that the relative *frequency* of different triggers is skewed in cases where infixation is involved. While I'm not aware of any attempt to quantify relative frequencies of different suppletion triggers cross-linguistically, my impression is that there is indeed a skew in my case studies: phonologically- and prosodically-conditioned suppletion is more common than I might otherwise expect (21 total case studies out of 32), and morphologically-conditioned suppletion is less common than I might otherwise expect (2 out of 32 case studies). Perhaps there are interesting clues here about the diachronic pathways to infixation, but I do not explore this further. One further implication I do take from these findings—related in particular to the robustness of prosodic conditioning—is that (re-)prosodification happens at intermediate levels of morphological structure.

3.3 Conditions on exponent choice are distinct from an exponent's pivot/placement

The conditions on choosing an exponent are distinct from (i) whether or not an exponent has a pivot/placement (is an infix), and (ii) if the exponent is an infix, what its pivot and placement are. This is trivially true in cases where exponent choice is lexically or morphologically conditioned: in Lezgian, for example, lexical factors condition exponent choice, and phonological factors govern exponent placement, (8). But this is also true when *both* the condition on exponent choice *and* the pivot/placement are phonological or prosodic in nature. In Nakanai, (9), *-il-* is chosen as the nominalizer exponent when the stem is bisyllabic, and has as its pivot the stressed (penultimate) vowel. It is also possible (though less common) for the conditioning factor for exponent choice to overlap with the pivot, as in Toratán, (10), where it is the first consonant that matters for both.

Kalin and Rolle (To appear) note that this independence of the condition on exponent choice from its pivot/placement shows that both cannot be subsumed under one and the same "subcategorization" mechanism—there must be (at least) two distinct types of subcategorization properties of an exponent, one constraining its *insertion*, and the other its *placement*.

3.4 Suppletive allomorphs share an edge orientation

The previous sections established that suppletive allomorphs of a morpheme may differ in being infixal or not, and that even if multiple allomorphs are infixal, they may differ in their phonological pivot/placement. One thing, however, cannot vary, and that is the *edge* that the allomorphs are oriented towards—suppletive allomorphs share an edge orientation. This means that allomorphs of the same morpheme are all either left-edge infixes or prefixes (e.g., Lezgian, Toratán, and Leti above), or, they are all right-edge infixes or suffixes (e.g., Hunzib and Alabama, below). Moravcsik (1977:124) observes the same: "if there is an adfix that is related to an infix [...] by identity of meaning, [...] the adfix will be prefixed if the position of the infix is counted from the beginning of the stem, and it will be suffixed if the position of the infix is counted from the end of the stem."[11] This is consistent throughout my sample, though an infix's edge orientation is not directly observable for cases of a prominence-based pivot (e.g., Nakanai above, with the infix appearing before the stressed vowel), and there are ambiguous cases involving stems that are too small to be sure if an affix's orientation is to the left or right edge.[12] Assuming internal consistency in ambiguous cases, of the 32 cases involving suppletive allomorphy in my sample, 20 are analyzable as left-edge oriented, and 12 are analyzable as right-edge oriented.[13]

It is important to note here that the present sample systemically excludes (as discussed in §2.4) a series of cases that seem to counterexemplify this claim. Consider, for example, class-number markers in Archi (Northeast Caucasian, Dagestan; Kibrik 1989:307-308), which are sometimes prefixes, sometimes infixes, and sometimes suffixes. Crucially, however, in such cases, there is no suppletion involved, as it is the same underlying exponent (e.g. *w*, the Class I/V singular marker in Archi) appearing in all these positions. This situation (variant position without variant form) may be related to so-called "mobile affixation", where one and the same exponent can appear as a prefix or suffix, as is notoriously found (for example) for a number of affixes in Huave (Huavean, Mexico; Stairs and Hollenbach 1969, Noyer 1993, Kim 2010). Indeed, a quick glance through a number of documented cases of mobile affixation suggests that this is a systematic feature of the phenomenon—the prefix vs. suffix position

[11] Moravcsik (2000:547) makes a related generalization, "If an infix has an alternative position outside the word, that external position is always at the edge of the word to which the infixed position is referenced." However, this latter generalization is intended to be about cases where the *same* exponent sometimes appears as an infix, and sometimes as a prefix or suffix. A number of languages show that this version of the generalization is in fact not accurate, as discussed in this section, below.

[12] In some cases, e.g., Alabama (see (15) and §6.3), a right-edge infix might appear all the way at the left edge of the stem, when the stem is small enough (or vice versa for a left-edge infix). Such cases are not counterexamples to the claim being made here, because the infix can still be stated with reference to a consistent pivot/placement, calculated with respect to a consistent edge. A similar edge ambiguity arises in Nxa'amxcin (Salish; United States), where an exponent that typically looks like a suffix is arguably better (re-)analyzed as a left-edge infix that appears after the first syllable (see e.g. data in Willett 2003:49).

[13] This left vs. right asymmetry is almost certainly due to the overrepresentation of Austronesian languages in the sample.

of an affix does not co-vary with the affix's (suppletive) form.[14] I therefore put aside this pattern as separate from the one at hand, and leave it as a topic for future research.

Since the circulation of the first draft of this manuscript, one potential counterexample has surfaced. Papillon (2021) discusses subject agreement in Sáliba (Sálivan; Colombia; Morse and Frank 1997), and argues that this agreement involves suppletive allomorphs with opposite-edge orientations. However, once mobile affixation is factored out, Sáliba turns out to not be a counterexample after all. In very brief, animate subject agreement affixes in Sáliba are placed variably with respect to their stems, as determined by the phonological shape of the stem: (i) vowel-initial stems take agreement as a prefix, (ii) CVV-initial stems take agreement as a left-edge infix, and (iii) trisyllabic (or larger) stems that end in VV take agreement as a right-edge infix. For most of the agreement affixes, the form of the agreement affix is the same across its three distinct positions, making it a classic example of mobile affixation. For two of the agreement affixes, though, there are suppletive allomorphs of the agreement marker: for 1st singular, *tʃ* is found in positions (i) and (iii), and *d* in position (ii); and for 2nd singular, k^w is found in positions (i) and (ii), and *g* in position (iii). Since a mobile affixation operation is needed to describe the basic agreement data anyways (scoping over *all* the agreement markers), and since the suppletive 1sg/2sg allomorphs are distributed along the same lines as affix position is, it would be highly redundant to encode their position alongside the individual suppletive exponents. Even in Sáliba, then, edge orientation is not a property of individual exponents.

The core finding here remains intact—suppletive allomorphs of a morpheme share an edge orientation. This suggests that *morphemes* have a linear position with respect to the stem, and that the position of a morpheme constrains the position of its exponents (putting aside mobile affixation, as discussed above). Put another way, morphemes are linearized as preceding or following their stem, prior to being exponed, and exponents are then tied in some way to the morpheme's prefixal or suffixal position.

3.5 Suppletion is conditioned based on the underlying form of the stem, at/from the stem edge identifiable via edge orientation

The edge orientation of allomorphs plays a crucial role—it is at/from the relevant edge, and *only* at/from this edge, that can condition suppletion. Suppletive allomorphs find their conditioning environment inwardly, from the perspective of the edge of the stem that is

[14] Paster (2006:66,253-254) notes one case that may be an exception to the generalization that a morpheme cannot have different suppletive exponents based on when it appears as a prefix vs. when it appears as a suffix—Chimariko pronominal markers (isolate, California; Conathan 2002). But, the mobile allomorphs involved in Chimariko are similar enough in phonological form that this may be a case of *non*-suppletive allomorphy, and thus is not (necessarily) a counterexample.

identifiable from its edge orientation, *even for infixes*.[15] This is most visible whenever phonology or prosody is involved in conditioning the allomorphy.

Consider the suppletive allomorphs involved in nominalization in Bahnar, (12). (The exponent in (12a), the sole case of lexical conditioning, is included for completeness.)

(12) Nominalizer in Bahnar (Austro-Asiatic, S. Vietnam; Banker et al. 1979:100-105)

a. a- / {TIE.UP}
   - e.g.: *a-chô* ‘a bundle’ (root: *chô*)

b. bơ- / *m*-initial stems
   - e.g.: *bơ-muih* ‘a field in the woods’ (root: *muih*)

c. -ơn- / elsewhere
   - pivot/placement: after first consonant
   - e.g.: *t<ơn>ăr* ‘woven bamboo’ (root: *tăr*)

In Bahnar, as in Toratán, (10), it is clearly edge-most segments that are involved in suppletive conditioning, and crucially, the conditioning edge is the one the allomorphs cluster close to.

More notably, there are cases where the infixal allomorph does *not* stay immediately local to the conditioning environment at the edge, and/or where affixation destroys the conditioning environment, rendering the allomorphy opaque. Consider Hunzib, (13).

(13) Verbal plural in Hunzib (Northeast Caucasian, Dagestan; van den Berg 1995:81-82)[16]

a. -baa / *aa*-final stems
   - e.g.: *ãqa-baa* ‘be thirsty (pl)’ (root: *ãqaa*) (van den Berg 1995:283)

b. -ά-[17]/ elsewhere
   - pivot/placement: before last consonant
   - e.g.: *e<yά>k’e*[18] ‘burn (pl)’ (root: *ek’e*) (van den Berg 1995:295)

[15] I have not found any examples of outward-conditioning of suppletive allomorphy involving an infix. While this result is expected for lexical, phonological, and prosodic conditioning (which are generally only inward-looking), it is not expected with respect to morphological conditioning (see, e.g., discussions in Bobaljik 2000, Adger et al. 2003). However, recall from §3.2 that only 2 of my case studies involve morphological conditioning at all. The sparsity of morphological conditioning may thus be responsible for this apparent gap, or, perhaps there is a true generalization to be made. Either way, the core implications of my study would remain intact, and so I leave this as an open question.

[16] There are also a few verbs of varying phonological forms that, idiosyncratically, take *baa* as an infix (van den Berg 1995:82).

[17] The vowel [α] is described by the grammar as “lower and more retracted than IPA [ɑ]” (van den Berg 1995:21). Note also that the infix is underlyingly stressed, even if not in the canonical position for receiving stress (van den Berg 1995:81, fn. 92). Consider e.g. *e<yά>k* ‘fall (pl)’ (van den Berg 1995:81). Unlike -*ά*-, -*baa* is not underlyingly stressed—if further suffixation adds more than one additional mora to the word, stress shifts away from -*baa* and it shortens to -*ba*.

[18] The glide *y* is inserted before the infix to break up the illicit vowel cluster; the quality of the glide, as *y*, is conditioned by the fact that the first vowel in hiatus is a front vowel. I have included the glide in angled brackets for ease of parsing, though it may not really be part of the infix. (See fn. 19 for more glide insertion in Hunzib.)

There are two important features of this example for present purposes. First is that the choice of suppletive exponent is in fact always surface opaque, since long vowels are shortened when they do not receive stress, which typically falls on the penultimate mora (van den Berg 1995:22). This can be seen in the example provided for (13a): the long vowel at the end of the stem *ʔãqaa* conditions the choice of *-baa*, and after *-baa* is suffixed, that stem-final long vowel shortens, as stress has moved to *-baa*.

Second, the choice between the suppletive exponents in (13a) and (13b) is crucially made with respect to the final segment of the stem (is it a long *aa*, or not), and yet one of the allomorphs, the infix, actually surfaces in a position that may be non-local to the final segment. The phonological nature of this conditioning can be confirmed with a pair like that in (14), based on the same root:

(14) a. *ũcu* 'hide' → *ũ<wá>cu*[19] 'hide (pl)' (van den Berg 1995:338)
b. *ũcu-laa* 'hide (antipassive)' → *ũcu-la-baa* 'hide (antipassive, pl)'

When the verbal plural combines with a simple root, it is the right edge of the root that conditions the allomorphy, (14a). When the verbal plural combines with a complex stem, it is the right edge of this complex stem that conditions allomorphy, (14b). (For much more detail on this case study, see Kalin 2021.)

Another revealing example is found with the middle voice morpheme in Alabama, (15) (Hardy and Montler 1991).

(15) Middle voice in Alabama (Muskogean, USA; Hardy and Montler 1991:2-3)
a. *-ka* / two-mora final foot (= final heavy syllable, or light-light syllable sequence)
   - e.g.: *albitii-ka* 'be covered, covering' (root: *albitii*)

b. *-l-* / elsewhere
   - pivot/placement: before final consonant (cluster)
   - e.g., *i<l>pa*[20] 'be eaten, food' (root: *pa*)

Allomorph choice is prosodically-conditioned in Alabama, based on the edgemost foot at the (right) end of the stem. Further, it is again the *underlying* prosodic form of the stem prior to affixation that must be visible for exponent choice. After infixation and phonotactic repairs, the underlying prosodic structure of the stem may be obscured. This is the case in the example in (15b), where the apparent stem (minus the infix), *ipa*, would constitute a two-mora final foot, and condition the wrong (unattested) exponent, *-ka*. For more detail on this case study, see §6.3.

Suppletive allomorph choice is conditioned based on the underlying form of the stem, from the perspective of "looking in" from the edge identifiable from an affix's edge orientation. I have found no cases of suppletive allomorph choice being made on the basis of the opposite stem edge, nor based on the surface form of a stem, nor (as will be highlighted in the

[19] As noted in fn. 18, when infixation of *-á-* concatenates non-identical vowels, a glide is inserted to repair this illicit configuration. Here, the glide is *w* because the first vowel in hiatus is a back vowel.

[20] The *i* preceding the infix is due to a language-general phonological process of epenthesis (Hardy and Montler 1991:6).

following section) in an unambiguously stem-internal position. The implication of this finding is a major one with respect to differentiating among theories of infixation: at the point of exponent choice, morphemes have already been *linearized* with respect to their stem. This is true even for morphemes with infixal exponents—thus infixal exponents have a prefixal or suffixal position with respect to the stem, prior to becoming infixed.

3.6 The surface (infixed) environment of an infix cannot condition suppletion

The most remarkable and perhaps most counterintuitive finding of this study is that—out of the 21 total case studies involving prosodically- and/or phonologically-conditioned suppletive allomorphy—suppletion is never unambiguously conditioned in the *surface* (infixed) environment of the infix. Of course, since infixes typically stay very close to the stem edge, in some cases the conditioning environment is local to the infix both in the infix's hypothesized edge-most position (see previous sections) and in its surface (infixed) position. For example, in Bahnar, (12), the first consonant is the conditioning environment for suppletion, and this consonant is immediately local to the infix in its surface position as well as its hypothesized left-edge (prefixal) position. But, even in these ambiguous cases, it's notable that *only material that is at the edge* (and none in the surface/derived environment only) can influence allomorph choice. And in unambiguous cases like Hunzib, (13), we see that it really is the edge—and only the edge—that matters, even when infixation moves the infix *apart* from the conditioning edge.

What would it look like for suppletion to be conditioned stem-internally? Imagine the following invented allomorph distributions:

(16) Invented example 1 (unattested)

a. *-n-* / before a nasal in its infixed position
- pivot/placement: before final syllable
- e.g., *ba<n>mat*

b. *-ka* / elsewhere
- e.g.: *basat-ka*

(17) Invented example 2 (unattested)

a. *-n-* / before a nasal in its infixed position
- pivot/placement: before final syllable
- e.g., *ba<n>mat*

b. *-ka-* / elsewhere
- pivot/placement: before final syllable
  - e.g.: *ba<ka>sat*

In (16), a right-edge infix *-n-* alternates with a suffix *-ka*, based on whether or not the infix would find itself next to a nasal in its pre-final-syllable position. The invented case in (17) is similar, but with both exponents being infixes with the same placement. Neither type of imagined stem-internal suppletion occurs in my sample.

This finding again strengthens the implications of the previous sections: exponent choice is made at/from a stem-edge position, prior to infixation; exponent choice is not made in an infix's surface position. Note that there are several cases of infix allomorphy that have been argued to implicate global optimization. I postpone discussing these cases until §6.3.

3.7 Implications (cumulatively)

The picture of infixation and suppletive allomorphy that we are led to through the findings presented in this section is one where operations are strictly ordered:

(18) linear concatenation $<$ exponent choice $<$ infixation

Affixal morphemes are linearized as preceding or following the stem they combine with, prior to exponent choice. The choice among exponents is made at this stem edge, prior to the infixation (inward displacement) of infixal exponents. At some stage, then, even exponents that end up inside their stem (as infixes) start their morphological "life" preceding their stem (as a prefix) or following it (as a suffix).

Throughout the following sections—and coming together in §7.3—the ordering in (18) will be enriched with the place of phonology (after infixation) and couched within a cyclic, bottom-up framework, where the series of operations in (18) repeats with every exponed morpheme.

4 On non-suppletive infix allomorphy: Core findings and implications

The picture is quite different when considering non-suppletive allomorphy. Recall from §2.3 that what I consider non-suppletive allomorphy are alternations that must be both phonologically-derived *and* phonologically- or prosodically-motivated. The phonological processes involved may be language general (in which case it is "surface" non-suppletive allomorphy) or restricted to a certain morphemes or morphological environments ("restricted" non-suppletive allomorphy). We will see in this section that both general and restricted non-suppletive allomorphy behave alike, in that both are sensitive *only* to the surface/infixed environment of the infix, §4.1-4.2, in stark contrast to suppletive allomorphy. The same observation extends to phonological alternations *around* the infix—the stem may undergo phonological processes (restricted and general) in reaction to the infix, but only in its surface/infixed position, 4.3. The implications of these findings are brought together in §4.4.

4.1 Non-suppletive infix allomorphy is conditioned only in surface (infixed) positions

Non-suppletive alternations of infixes (found in 37 of the case studies) are only conditioned in an infix's surface position. Consider Leti again—Blevins (1999) argues extensively for treating the many variants of this morpheme as linked to just two suppletive underlying forms, as shown in (19), expanded from (11)—see in particular the many non-suppletive variants of the allomorph *-ni-* in (19b). (The discussion here is not exhaustive.)

(19) Nominalizer in Leti (Austronesian, Indonesia; Blevins 1999:390)

a. nia- / Class I verbs
   - e.g.: *nia-keni* 'act of putting, placing' (root: *keni*)

b. -ni- / Class II verbs
   - pivot/placement: before first vowel
   - e.g.: *k<ni>asi* 'act of digging' (root: *kasi*)
   - Non-suppletive alternants (Blevins 1999:391-392):
     – *s<n>uri* 'pour, pouring' (root: *suri*)
     – *d<i>avra* 'act of cutting, cut' (root: *davra*)
     – *r<i>esi* 'victory' (root: *resi*)
     – *r<∅>uru* 'trembling' (root: *ruru*)

The infixal exponent *-ni-* may be affected by two language-general phonological processes, deletion of *i* before a high vowel (as in *s<n>uri*), and deletion of *n* after /d/ or /l/ (as in *d<i>avra*). There is also a restricted process (not language general) whereby *n* is deleted after a non-syllabic sonorant (as in *r<i>esi*), which may compound with deletion of *i* to produce a zero alternant (as in *r<∅>uru*).

Additional examples abound. I'll mention here some that relate to case studies already discussed above. Non-suppletive allomorphy due to language-general phonological processes is found in Wamesa (as discussed in §2.3), with deletion of the initial consonant of the exponent *-di-* (3SG) when it is in an illicit cluster. Non-suppletive allomorphy due to *restricted* phonological processes is found for Budukh's prohibitive morpheme (see again §2.3), where the phonological process the exponent undergoes is a cross-linguistically natural one (regressive vowel harmony), but one not evidenced throughout the language. Finally, there are a number of cases in the sample where a process is indeterminately but plausibly language-general, like in Bahnar, (12), which has very limited morphology in general—the suppletive allomorph *-σn-* has several non-suppletive alternants, including *-σd-* (e.g., *k<σd>rŏu* 'fish poison') and *-σŋ-* (*k<σŋ>lat* 'a slice'); these repairs happen when infixation creates an illicit consonant cluster (here, **nr* and **nl*) (Banker et al. 1979:103-104).

It is relevant to note here the uniform behavior of general and restricted phonological processes that result in non-suppletive allomorphy—both apply to an infix only in its surface position. The main implication, building on the findings of §3, is that displacement of an exponent into an infixal position from the edge is immediate after suppletive exponent choice, such that *all* phonological processes see the infix in its surface position.

4.2 No hypothetical position for an infix apart from its surface (infixed) position can induce non-suppletive allomorphy

As an equal-but-opposite generalization of that in §3.6, non-suppletive allomorphy is *never* sensitive to the morpheme's hypothesized edgemost underlying position (as a prefix or suffix), unless of course that environment is still immediately local to the infix in its infixed position.

What would this even look like, if it were possible? Consider Hunzib from (13)—when the infixal exponent -*ά*- ends up in hiatus with another vowel in its infixed position, a glide is inserted, with the glide's quality determined by the frontness of the preceding vowel (see fn. 18 and 19, and Kalin 2021). If the phonology could "see" the infix -*ά*- in the morpheme's underlying (stem-final) position, we might expect the final segment of the stem to impact glide insertion/quality. Consider the root in (20); if the phonology could see the infix in its hypothesized stem-final position prior to infixation, **αhu*<*α*>, we would potentially expect glide *w* to be inserted to break up the *u*<*α*> sequence prior to infixation, deriving the unattested form in (20b) after infixation.

(20) Root: *αhu* 'take'

a. Attested verbal plural: *α*<*ά*>*hu* (p. 284)

b. Not attested: **α*<*wά*>*hu*

Or, we might expect the underlying stem-final vowel to affect *which* glide is inserted, as it would with the root in (21). Generally-speaking, the sequence *e*<*α*> is broken up by the glide *y*, while the sequence *u*<*α*> is broken up by the glide *w*. It's clearly only the latter environment, in the infix's surface position, that impacts glide choice, (21a), and not that of the underlying environment, which would produce (21b) after infixation.

(21) Root: *uĉ'e* 'cut'

a. Attested verbal plural: *u*<*wά*>*ĉ'e* (p. 82)

b. Not attested: **u*<*yά*>*ĉ'e*

In no case does the infix undergo a phonological process (restricted or general) in its hypothesized pre-infixation position.

The environment where an affix "started" (as a prefix or suffix) determines suppletive exponent choice (§3.5), but this environment *cannot* influence non-suppletive allomorphy—all phonological processes treat the infix in its surface position. The implication, as noted in the previous section, is that infixation is immediate; an infix cannot linger in its stem-edge position, but must find its pivot/placement immediately.

4.3 An infix may condition phonological stem changes only in its surface (infixed) position

An infix, in its surface position, may also condition changes in the stem, both changes that reflect surface phonology and changes that fall into the more restricted (non-general) category. We have already seen some examples of the general kind: for example, in Alabama, (15), when infixation creates an illicit consonant cluster, a general process of vowel epenthesis is triggered (see fn. 20 and §6.3). An example of a restricted phonological process affecting the stem is found in Lezgian, (8). Recall that the infix *-x-* is a lexically-conditioned suppletive allomorph of the repetitive. When infixation of *-x-* creates a cluster with a voiced velar obstruent, there is sometimes devoicing of the (stem) obstruent, e.g., *egeč'un* 'enter' becomes *e<x>keč'un* 'enter again' (Haspelmath 1993:175). This is not a general process of the language, but can be seen as a natural one, involving voicing assimilation.

I have found no cases in my sample where a change in a stem segment seems to be conditioned by an infixal exponent in its underlying (non-infixal) edgemost position. Returning to the Hunzib examples in (20)/(21), we might expect hiatus between the infix (in its underlying position) and the final vowel of the stem to condition deletion of that stem-final vowel—indeed, deletion of an unstressed vowel is the usual repair for hiatus in the language (see Kalin 2021). However, as is obvious from all the Hunzib examples, the final vowel of the stem does not delete.

Again, the implication here is that after exponent choice, the exponent does not linger in its underlying position. Phonological processes affecting both the stem and the infix "see" the infix only in its surface environment.

4.4 Implications (cumulatively)

Non-suppletive alternations of both the general and restricted kinds pattern together—phonological processes impact an infix, and its stem environs, only with respect to the infix in its stem-internal (infixed) position. Thus, while the evidence from suppletion (given in §3) points to the need for a stem-edge underlying position for all morphemes (in which position suppletive exponent choice is made), when an exponent is chosen that is infixal, infixation of this exponent is immediate.

5 On infixation: Core findings and implications

While the present study only includes a narrow slice of infixes, nevertheless it reveals a few patterns that are likely generalizable to infixation beyond just cases of infix allomorphy: infixation is uniformly inward §5.1-5.2, and infixal positioning may be opaque, §5.3.

I do not think this study, given its narrowness, is a particularly useful window into the nature of infixal pivots more generally, but I will offer a few observations. By far the most common infixal pivots/placements in this sample are before or after the first or last consonant or vowel. Prominence-based pivots are rare in my sample (2 out of 51 cases: Jahai and Nakanai), in line with their general rarity (Yu 2007). There is a also some evidence for non-canonical pivots, including after the penultimate vowel (Choctaw) and before the final consonant cluster (Alabama). (See Samuels 2009:150 for pivots found across different studies of infixation.)

5.1 Infixes displace inwardly, never outwardly

Infixes only ever move inwardly, into more embedded phonological material. This may seem like a trivial observation, and indeed, I am not aware that anyone has stated this explicitly before (perhaps because it was taken to be self-evident). However, while this *is* trivial when the infix is the outermost affix in a word, it is *not* trivial when the infix is not the outermost affix. In such cases, an infix's pivot could hypothetically be found by moving outward into less embedded phonological material, but, notably, this never seems to happen.

Recall from Leti, (11), that the nominalizing morpheme has an infixal allomorph *-ni-*, which wants to be before a vowel, e.g., *k<ni>asi* 'act of digging' (from root *kasi*). Nominalized verbs can be re-verbalized, appearing as "zero-derived verb stems for resultative constructions", in which case they take Class I inflectional prefixes marking person/number (Blevins 1999:388). Consider the complex word in (22).

(22) Leti (Blevins 1999:389-390)

ta-s<ni>òi
1PL.INCL.I-<NOM>shift
'we (incl.) inherit'

Assuming that *-ni-* is an infix that starts at the left edge of the root *sói*, there's no a priori reason why *-ni-* shouldn't have the option of moving to precede the vowel to its left in (22) (hypothesized underlying order **ta-<ni>sòi* → unattested **t<ni>a-sòi*), rather than moving to precede the vowel to its right (hypothesized **ta-<ni>sòi* → attested *ta-s<ni>òi*). Both the attested rightward displacement in (22) and the hypothetical leftward displacement move the infix exactly one segment away from the leftmost edge of the root, both create consonant clusters, both result in vowel hiatus, and both are well-formed in the language (despite their markedness).[21] Of course, modeling (22) as resulting from stepwise exponence offers an explanation, as laid out in (23).

(23) sòi ('shift') → s<ni>òi ('inheritance') → ta-s<ni>òi 'we (incl.) inherit'

If the (outer) prefix has not yet been exponed at the point of infixation of *-ni-*, then it is natural that *-ni-* cannot satisfy its pivot/placement by moving into the prefix. For a complete stepwise derivation of this type of example, see §7.3.

Even in a complex words where an infix's pivot/placement could be found by displacing locally in either direction, the infix does *not* have the option of displacing *away* from its stem. This finding falls out naturally if, as in (23), there is no phonologically-contentful "outer" material at the point where an infix displaces into its stem. If there were phonologically-contentful "outer" material, some additional stipulation would need to be made, to constrain the direction of infixation.

[21] Note that the problem cannot be the creation of a *tn* onset, as this is permitted, e.g., *t<ni>eti*, 'chopping' (Blevins 1999:390). Note also that the infix can surface inside an affix in Leti, so long as that affix is inward relative to the nominalizer, e.g. *-ni-* + *va-kini* (RECIP-kiss) → *v<ni>a-kini* 'reciprocal kissing' (Blevins 1999:400).

5.2 An infix can satisfy its pivot/placement inwardly at the stem edge, never outwardly

Related to the finding above, an infix can surface at the stem edge when its pivot/placement can be satisfied inwardly (with respect to more embedded material) in that location. For example, returning to Leti again, the infix wants to be before a vowel, and can satisfy that requirement at the left edge when the stem is vowel-initial (Blevins 1999), e.g., *<ni>atu* 'knowledge' from root *atu*. However, the opposite is not true—an infix cannot surface at the stem edge when its pivot/placement could hypothetically be satisfied *outwardly*, i.e., with respect to *less* embedded material.

Consider, for example, the right-edge infix in Hunzib, *-ά-*, (13), which has as its placement that it wants to be before a consonant. We might thus expect that if a consonant-initial suffix is added to the right edge of the word, outside of the verbal plural, that *-ά-* could stay at the right edge of the root. This is not borne out—even when there is such a suffix attaching to the stem *after* the infix does, the infix must find its pivot/placement inwardly, i.e., *in its stem*, (24).

(24) Hunzib (van den Berg 1995:82)

r-i<yά>ƛe-n
PL.CLASS-kill<V.PL>-PRET.GER
'killed (iterative, plural object)'

More concretely, we do not find the hypothetical form **r-iƛe<yά>-n* (with glide insertion), nor **r-iƛ<ά>-n* (with vowel deletion of the unstressed root-final vowel), where *-ά-* satisfies its pivot/placement at the right edge of its stem, with respect to the outer suffix, *-n*.

Strengthening the conclusion from the previous section, the finding here is most naturally understandable if an infix must find its pivot/placement right away, and that when it does so, the only visible phonological material is that of its stem (i.e., of more embedded material).

5.3 Infixal positioning may be opaque

While all the infixes in my sample can be described as aligning themselves with respect to a consistent phonological pivot, their pivot/placement is not always transparently satisfied on the surface, due to phonological changes to the stem induced by infixation.

In Alabama ((15) and §6.3), for example, the middle voice infix *-l-* always precedes the final consonant (cluster), but when this positioning leads to a phonotactically illicit consonant sequence, *i* is epenthesized to break it up. Thus, in a form like *ho<l>isso* 'be written, book' (from stem *hosso*, 'write') (Hardy and Montler 1991:2), the infix has satisfied its pivot if the underlying, pre-repaired form is considered (**ho<l>sso*), but not on the surface post-epenthesis, where it precedes a vowel.

Deletion can also create opacity. In Nancowry, the causative has two suppletive allomorphs, *ha-* and *-um-*.

(25) Causative in Nancowry (Austro-Asiatic, Nicobar Islands; Radhakrishnan 1981:54-56)

a. *ha-* / monosyllabic stems
   - e.g., *ha-pin* 'to thicken something' (root: *pin*) (Radhakrishnan 1981:111)

b. *-um-* / disyllabic stems
   - pivot/placement: follows first vowel
   - e.g., *p<um>loʔ*[22] 'to loosen something' (root: *paloʔ*) (Radhakrishnan 1981:150)

As analyzed by Kalin In press, the causative infix has as its pivot/placement that it follows the first vowel. In this position, it always creates hiatus, which is prohibited in unstressed syllables. This hiatus is resolved by deletion of the first vowel—in other words, the infix's pivot is deleted. In forms like *p<um>loʔ*, then, the infix has not (obviously) satisfied its pivot/placement on the surface, as the infix looks like it is post-consonantal; only the pre-repair form shows the infix's pivot/placement being satisfied, **pa<um>loʔ*.

The implication of this opacity is that satisfaction of an infix's pivot/placement can properly precede phonological processes that apply to the derived form. It is an open question whether an infix's pivot/placement is *always* satisfied *prior* to phonological processes, or whether satisfaction *alongside* phonological processes is also possible in some cases.

5.4 Implications (cumulatively)

Putting together all of these observations about infixation, it's easy to see that they go hand in hand with the findings of §3 and §4. An infixal exponent takes its surface (infixed) position immediately after the exponent has been chosen, and before any other affixes are added (or at least exponed), and before (or perhaps sometimes simultaneous with) phonology. In other words, word-formation, including exponent choice and infixation, is cyclic and applies from the bottom up.

6 On optimization: Core findings and implications

Finally, in this section I briefly consider the empirical landscape of this study in terms of optimization. By optimization, I mean to refer to whether a particular operation has an effect that is phonologically improving (optimizing), phonologically neutral (non-optimizing), or phonologically worsening (anti-optimizing), given a rather general set of phonological/phonotactic preferences that are known to be active across languages, like a preference for onsets, a dispreference for codas, avoidance of hiatus, etc. (Note that I do *not* mean "optimizing" in the strict Optimality Theory sense, where what is optimizing depends on one's theory of possible constraints and a particular ranking of those constraints.)

I turn first to suppletive allomorphy, §6.1, then infixation, §6.2, and finally to putatively globally optimizing cases of infix allomorphy, §6.3.

6.1 Suppletive allomorphy involving an infix may be optimizing, but often is not

To consider whether suppletive allomorphy is optimizing in this sample, I will consider exponents as whole packages—their suppletive conditioning (i.e., the environments they appear in) plus their pivot/placement if they have one (i.e., for an infixal exponent, its surface position). Note that lexically- and morphologically-conditioned suppletion is generally not optimizing, because the criteria for exponent choice is not phonological in nature. See, for example, Leti (11) and Lezgian (8) above. (Note that I am *not* claiming here that infixation itself cannot still be optimizing in such cases, just that the choice between exponents is not optimization-driven; see §6.2.)

Going back through the cases already considered in this paper that involve phonological or prosodic conditioning, which are better candidates for being optimizing, the findings are a real mix. An obviously optimizing case is found in Toratán, (10), where the agent voice past morpheme is the prefix *n-* with vowel-initial stems and infix *-im-* with consonant-initial stems. Suppletive choice in this case aligns with avoiding an onsetless syllable/word (favoring *n-* over *-im-* with vowel initial words) and avoiding complex onset clusters (favoring *-im-* over *n-* with consonant-initial words). The avoided configurations are crosslinguistically marked, though not illicit in Toratán more generally.

In Nakanai, (9), the choice between *-il-* and *-la* is conditioned by stem size, *-il-* appearing before the penultimate vowel of bisyllabic stems. An important consideration here is that stress is on the penult, and so the infix appears in a position where stress placement (on the stem) is preserved. The suffix, on the other hand, results in a shift in stress, as it adds a syllable to the end of the stem. If there is more pressure to preserve stress in bisyllabic stems than in larger ones (Donca Steriade, p.c.), then this suppletive allomorphy in Nakanai can be seen as optimizing as well. Similar to the situation in Toratán, though, preserving the stress of bisyllabic stems is not a hard constraint in Nakanai, as there are a number of suffixes that induce stress shift on bisyllabic stems. Both cases can be seen as displaying The Emergence of the Unmarked (TETU).

Most of the rest of the cases in the sample are non-optimizing. For example, in Bahnar, (12), where *bơ-* is chosen for *m*-initial stems and *-ơn-* appears elsewhere (with pivot/placement being after the initial consonant), there is no phonological/phonotactic motivation for this split—*bơ-* would be a fine prefix for all stems, and *-ơn-* would be a fine infix for all stems. This can be confirmed with a dictionary of Bahnar (Banker et al. 1979), which shows robustly that the sequences that are avoided through this suppletive allomorphy are permissible.

Two anti-optimizing cases come from Nancowry, discussed in detail in Kalin (In press). Here I'll comment just on the causative, from (25). Recall that the exponent *ha-* is chosen for monosyllabic stems, and *-um-* for disyllabic stems; the latter is an infix, which Kalin (In press) argues is best understood as the infixal pivot/placement being after the first vowel. The crucial observation for here is that *ha-* would make a perfectly fine prefix for all stems, not just monosyllabic ones; and conversely, the choice of *-um-* over *ha-* leads to a phonotactic problem (vowel hiatus) where there otherwise would not have been one, with no clear payoff.

With respect to exponent choice, then, while there certainly are a few clearly optimizing cases in the sample, most are non-optimizing, and there also seem to be some anti-optimizing cases. This aligns with general findings for prosodically- and phonologically-conditioned suppletive allomorphy—see, especially Paster 2005, 2006. Taking these results at face value, it may seem that they implicate the need for exponent choice to be regulated by the phonology for some cases and by the morphology in other cases. However, in §7.2 I will argue that the cumulative findings of the study argue that the latter—exponent choice *prior to* phonology—is the only option.

6.2 Infixation may be optimizing, but often is not

Putting aside suppletion and considering *just* infixation, we see a similar sort of picture—sometimes the fact that an exponent is an infix, as well as its pivot/placement, is optimizing, sometimes it's non-optimizing, and sometimes it's anti-optimizing.

A number of examples of infixal exponents discussed so far in this paper are optimizing either language-internally or understandable as TETU effects. For example, in Bahnar, (12), there isn't an optimizing motivation for choosing between the two suppletive allomorphs *bơ-* and *-ơn-*, as discussed above. But, once one exponent is selected over the other, it is indeed optimizing that the prefixal one is prefixal, and the infixal one infixal—all syllables must have an onset in Bahnar (Banker et al. 1979).

Non-optimizing infixation is also found in many languages of the sample. Consider Hunzib's infixation of *-ớ-*, (13). The exponent *-ớ-* would be perfectly fine as a suffix—this exponent would sometimes create vowel hiatus as a suffix, but it does this in infixal position sometimes too. Recall also that this exponent is *not* in general constrained to appearing in the naturally stressed (penultimate) position (cf. fn. 17). Lezgian, too, furnishes a case of non-optimizing infixation: the exponent *-x-*, (8), by appearing after the first vowel, always introduces a coda; sometimes this serves to avoid a complex onset (e.g., *ki<x>ligun* 'look again', from root *kiligun*) but sometimes it is totally gratuitous, leaving a word without an onset altogether (e.g., *a<x>watun* 'fall off again', from root *awatun*).

Finally, let's consider some anti-optimizing cases. Leti, (19), is a particularly clear example of anti-optimizing infixation, as discussed by Blevins (1999:§5): "In terms of prosody and phonotactics, /ni-/ is a perfectly well-formed syllable, and particularly well-positioned before the initial C of a class II verb. On the other hand, the output of infixation creates syllable-initial CC clusters and VV sequences, both of which are marked cross-linguistically and within Leti." Similarly, in Wamesa, infixation of *-di-*, described in §2.3, is anti-optimizing (Gasser 2014:261), creating illicit vowel and consonant clusters that would be absent without infixation, and not serving to avoid marked syllable structures.

These findings, along with the abundance of non-suppletive allomorphy in the stem and/or affix in the presence of infixation (§4), show that creating some kind of illicit phonotactic configuration is not a synchronic deterrent of infixation. The findings thus support of a model of infixation for which at least *some* infixes have their surface location regulated via a condition on their placement, i.e., through the explicit use of pivots (in line with Yu

2007). I leave it as an open question whether *all* infixes have pivots, or whether some are regulated simply by the phonology. (See also the discussion in §5.3.)

6.3 Putatively globally optimizing cases can be analyzed locally and are sometimes not actually optimizing

A few case studies of infix allomorphy have been singled out as necessitating global optimization considerations. In this section we'll look closely at one such case study, from Alabama (Hardy and Montler 1991), and I'll mention a few others as well. I'll argue that global optimization is not necessary in any of the cases.

In Alabama, syllables maximally have two onset consonants and one coda consonant (Rand 1968:98). Syllables can be light (no coda, no long vowel), heavy (coda consonant or long vowel), or extra heavy (coda consonant and long vowel). Hardy and Montler (1991) and Montler and Hardy (1991) argue for a phonotactic constraint on derived verbs that they call the Alabama Verb Frame (AVF), which requires all derived verbs to end in a three-mora heavy-light foot (Hardy and Montler 1991:5), i.e., one of the following two configurations:

(26) Alabama Verb Frame (AVF)
  a. ...VC.CV
  b. ...VV.CV

The AVF seems to play a role in constraining exponent choice and exponent placement for a number of morphemes, most importantly here, the middle voice morpheme, whose exponents and their distribution are described in (27) (repeated in a simplified form from (15)).

(27) Middle voice in Alabama (Hardy and Montler 1991:2-3)
  a. *-ka* / two-mora final foot (= final heavy syllable, or light-light syllable sequence)
  b. *-l-* / elsewhere (pivot/placement: before final consonant (cluster))

Hardy and Montler (1991) argue that the *location* of middle voice (as an infix sometimes and suffix other times) is driven by the AVF, (26), in combination with a stipulated requirement that affixation of *l* must add a mora to the stem (though not necessarily through *l* itself being moraic). Further, for historical reasons, just in case the middle voice exponent would end up as a suffix, *-ka* appears instead of *-l-*.

Let's consider whether the AVF and mora-adding condition make the right predictions. The idea, as laid out by Hardy and Montler (1991:(12)) is as follows: (i) if a stem already conforms to the AVF, (28b-c), then it'll take an infix so as to "preserve the configuration"; and (ii) if a stem does not conform to the AVF, (28a) and (29a-c), then the stem will take a prefix (which I analyze as still being an infix) or suffix to "complete the configuration".

(28) Alabama middle voice: *-l-* allomorph (sometimes with vowel epenthesis)

a.	pa → i<l>pa	'be eaten, food'
b.	coopa → coo<l>pa	'be bought, sale'

c. talwa → ta<l>ilwa[23] 'be sung, song'

(29) Alabama middle voice: *-ka* allomorph (sometimes with vowel deletion)

a. taɬa →taɬ-ka[24] 'be woven, weaving'
b. bat → bat-ka 'get whipped, paddle'
c. albitii → albitii-ka 'be covered, covering'

In the end, the output of this affixation is always a final heavy-light foot, in conformity with the AVF. But, this conformity with the AVF is often not due to the affixation itself, but rather through phonological stem changes around the affix, in particular, vowel epenthesis in (28a,c) and vowel deletion in (29a).

The AVF and mora-adding condition are not sufficient to predict the distribution of the middle voice exponents on their own. For example, the account as offered in Hardy and Montler (1991) cannot explain why CV stems like *pa* are made to conform to the AVF via "prefixation" of *l* and vowel epenthesis (attested *i<l>pa*) rather than suffixation of *-ka*, accompanied by vowel deletion and vowel epenthesis (unattested **ip-ka*). Nor can it explain why a CVCV form like *taɬa* cannot be made to conform to the AVF via infixation (unattested **ta<l>ɬa*) instead of suffixation and vowel deletion (attested *taɬ-ka*).

A careful consideration of the *full* set of constraints needed to predict the distribution of the middle voice exponents shows that the pattern in (28)-(29) still cannot straightforwardly be accounted for as optimizing. In particular, there are a number of confounds in ranking constraints, including (i) *-l-* is placed "gratuitously" far inside the stem—it could be closer to the edge and still result in an additional mora and conform to the AVF, e.g., **coop<l>a*, **ip<l>a*, and **tali<l>wa/*taliw<l>a*; and (ii) if suffixation and vowel deletion are preferred over infixation, as they must be for *taɬ-ka* to be preferred over **ta<l>ɬa/*taɬ<l>a*, then the attested output *coo<l>pa* over unattested **coop-ka* is unexplained.

I therefore conclude that the Alabama middle voice exponents are best understood as distributed and placed based on arbitrary (non-optimizing) conditions, along the lines of their description in (27). Once exponent choice and pivot/placement is determined, conformation to the AVF and to the mora-adding condition is regulated by vowel epenthesis and vowel deletion, i.e., by phonological processes, not morphological ones. Alabama middle voice is included in my typological database as involving edge-based prosodically-conditioned suppletive allomorphy.

Yu (2017) puts forward two other cases of infix allomorphy that, he argues, require global optimization. One case comes from Katu-L (Austroasiatic; dialect of Katu spoken in the Lao P.D.R.). As described by Costello (1998), nominalization in Katu-L takes a number of different forms, some prefixal and some infixal, distributed lexically. Yu (2017), with a closer eye on the phonological forms of the examples, argues that while *most* of these nominalizing exponents are distributed arbitrarily, a small subset—those taking the infixes *-an-* or *-r-*—are

[23]While this particular example is not a good one because of the *l* in the stem, it's the only example of this stem-type offered by Hardy and Montler (1991). I assume that the infixal location is accurately indicated here, as *preceding* the cluster, based on the distribution of other exponents that also have this same position, e.g., second person *-c-* in *ta<c>ilwa* 'you sing' (Hardy and Montler 1991:9).

[24]Note the loss of the stem-final vowel for ...V.CV roots.

differentiated from each other on the basis of optimization: *-an-* combines with monosyllabic stems in the lexical set, while *-r-* combines with disyllabic stems in the lexical set. For the verb *katas* 'to name', for example, the nominalized form is *ka<r>tas*, and for *cai* 'to judge', the nominalized form is *c<an>ai*. Words in Katu-L are maximally bisyllabic (Costello and Sulavan 1996), so assuming that Katu-L *prefers* bisyllabic words, the choice of *-an-* vs. *-r-* and their respective infixal placements can be predicted based on optimization (with other aspects of Katu-L phonotactics taken into account as well).

There are a few reasons to doubt the need for global optimization for the Katu-L nominalizers. Stem-size can condition even non-/anti-optimizing suppletive allomorph choice, as seen in §6.1. And, given the overwhelming role of lexical arbitrariness in the Katu nominalizer system, it is not clear what motivation there is for positing that one small corner of this system is determined via optimization rather than just lexical conditioning. Finally, it has recently been argued by Rolle 2021 that the alternation between the two infixes at hand, *-an-* and *-r-*, is actually *non*-suppletive allomorphy (both are underlyingly *-rn-*). The Katu nominalizer is included in my typological database as involving lexically-conditioned suppletive allomorphy, but counting it instead as non-suppletive would not impact my results.

The second relevant case from Yu (2017) is that of the Tiene stative/reversive (Niger-Congo; DRC), drawing on data and discussion in Hyman and Inkelas 1997. However, Rolle (2021) shows that forms bearing the stative or reversive are extremely rare, as noted in the primary documentation of the language itself. Across all available documentation, Rolle found just 10 stative examples and 6 reversive examples. Given this rarity, Rolle argues that there is no synchronically-separable affixation involved in the reversive or stative at all. I therefore did not include Tiene in my study.

The final language I will mention is Ida'an Begak (Austronesian, Malaysia; Goudswaard 2004, 2005), where both the past tense morpheme (realized as *ni-*, *-i-*, or *-ən*) and the dependent morpheme (*m-*, *-u-*, or *-əm*) seem to involve globally-determined suppletive allomorphy, with the first vowel in the stem crucially involved in regulating the choice between the two infixal exponents of each morpheme (Goudswaard 2004). However, as noted by Goudswaard herself (Goudswaard 2004:§4), it is straightforward to derive the infixal variants from one underlying form, based on vowel reduction in a pre-penultimate syllable and nasal deletion to maintain bisyllabicity. Under this analysis, *-i-* and *-ən* both come from underlying *-in-*, and *-u-* and *-əm* both come from underlying *-um-*.[25] Goudswaard emphasizes that what is *not* derivable in the phonology is the prefixal variant. I therefore suggest a reanalysis along exactly these lines, where the past tense morpheme and the dependent morpheme each have two suppletive forms (*ni-* and *-in-* for the past tense; *m-* and *-um-* for the dependent), and the infixal exponents each have two non-suppletive variants. Under this alternative analysis, vowel-initial stems take the prefixal suppletive allomorph, while consonant-initial stems take the infixal one; no global suppletive choice is involved at all. Because of the tentativeness of this alternative analysis, I have not included the dependent or past morphemes in Ida'an Begak in my typological database for this paper.

[25] Other factors influencing non-suppletive variation of/around the infix include metathesis and vowel coalescence, as discussed by Goudswaard 2004.

The takeaway of this section is that putative cases where suppletive allomorph choice must be made *by* the phonology are either unsustainable or amenable to reanalysis.

6.4 Implications (cumulatively)

The findings in this section suggest that neither infixation nor prosodically-/phonologically-conditioned suppletion can be uniformly modeled as optimizing, i.e., as regulated by the phonological component. The implications of these findings are discussed in much more detail throughout the following section.

7 Discussion and big picture implications

This section is organized around the major implications of the findings in this study, offering answers to some long-debated questions in the field. Are infixes, at some derivational point or level of representation, *actually* prefixes/suffixes? The findings here offer a clear yes, §7.1. Can suppletive exponent choice be made alongside/by the phonological component? The findings say no, it can't, §7.2. §7.3 brings these implications together with the rest of the findings to propose a model of the fine timing of the morphosyntax-phonology interface.

7.1 Infixes really are (underlyingly) prefixes/suffixes

Does an infix linearly concatenate with the stem it combines with (i.e., as following or preceding the stem) before taking its surface (infixed) position inside the stem? Or does an infix slot directly into its infixed position without a preliminary step of linear concatenation?

The findings of this study offer a clear answer: morphemes *are* linearly ordered with respect to their stems (as prefixes or suffixes), prior to infixation. The findings do *not*, however, tell us what the nature of this linearization is—e.g., the ordering could be a byproduct of the syntactic structure (à la Kayne 1994, Bye and Svenonius 2012, *i.a.*), or the ordering could come from idiosyncratic properties of each phrase, head, or morpheme involved (e.g., Harley 2011); the ordering could formally be a part of syntax, or a part of morphology. But crucially, however linear order is determined, this linearization must be established *prior* to both exponent choice and infixation.[26] And further, this basic prefixal/suffixal underlying order must *not* be encoded by individual exponents (contra Inkelas 1990, Yu 2007, Idsardi and Raimy 2013, Sande et al. 2020, a.o); only deviant *re*-ordering (i.e., infixation) is encoded at the level of the exponent.

The first relevant finding that bears on this question, discussed in §3.4, is that suppletive allomorphs of a morpheme all cluster at one edge of a stem; thus, allomorphy may involve a left-edge infix and a prefix, as in Bahnar, (12), or a right-edge infix and a suffix, as in Hunzib, (13), but never a mismatch. (Recall that prominence-based infixes usually can't be used to establish edge orientation.) This is already suggestive of an affixal morpheme

[26] Note that mere "immobilization", which establishes adjacency among syntactic nodes but not precedence, is not enough prior to exponence, contra Idsardi and Raimy 2013.

having a single underlying position, as preceding or following the stem, from which position individual allomorphs may stray (to a limited degree) if they are infixes.

The strongest evidence for a preliminary step of prefixation/suffixation comes from the observations laid out in §3.5 and §3.6, that not only do suppletive allomorphs of a morpheme share an edge orientation, but also, it is the relevant edge (around which suppletive allomorphs cluster) and *only* this edge that is relevant for phonologically- and prosodically-conditioned suppletive allomorphy. Again, this has a natural explanation if, at the point of suppletive allomorph choice (which itself necessarily precedes infixation, as will be discussed in §7.3), a morpheme already has a linear position with respect to the stem—suppletive exponent choice is made at/from one edge of the stem, and if an exponent is chosen that is an infix (has a pivot/placement), the exponent will subsequently displace to a stem-internal position. A further implication is that infixes are constrained to finding the closest (or perhaps second closest) instance of their pivot; an exponent *cannot* be given the instruction to find the "last X" or "first X" (counter to the descriptive way I encoded pivots/placements in all examples above, and counter to some theories of infixation discussed below).

If there were no linearization of an affixal morpheme with respect to its stem prior to infixation, then we would not expect to find one stem edge privileged over the other, neither with respect to infixal location (relative to the position of other suppletive allomorphs), nor with respect to suppletive conditioning environment. In particular, we might expect to find the following sorts of cases: (i) one suppletive allomorph of a morpheme is a prefix and the other is a right-edge infix (or vice versa, with a suffix and left-edge infix), (ii) one suppletive allomorph of a morpheme is a left-edge infix and the other is a right-edge infix, (iii) a left-edge infix has as its conditioning environment (for suppletive allomorph choice) a phonological or prosodic trigger at the right edge of the stem (or vice versa), or (iv) an infix has as its conditioning environment (for suppletive allomorph choice) a phonological or prosodic trigger in the infix's surface/infixed position. I have found no such cases.

The literature has offered a plethora of accounts of infixal positioning, which can be grouped into what I call *indirect* and *direct* accounts: indirect accounts of infixation are those where an infix has a preliminary prefixal/suffixal location with respect to its stem, while direct accounts of infixation deny any non-infixal linearized position of the infix. Indirect infixation characterizes an otherwise very diverse set of proposals—see, e.g., Anderson 1972, Moravcsik 1977, Halle 2001, Horwood 2002, Plank 2007, Embick 2010, Bye and Svenonius 2012, Bacovcin and Freeman 2016. It is *indirect* infixation that is supported by the present study, though only a proper subset of indirect proposals receive support once other findings are also considered (see §7.2-§7.3).

Direct infixation accounts come in two sub-types, (i) those that take affixes to still have an abstract prefixal/suffixal nature with respect to the stem, and (ii) those that take infixes to be infixes through and through. In proposals of the first type, while there is no *literal* step of prefixal/suffixal concatenation prior to infixation, infixes are still prefixes/suffixes in some abstract way (see, e.g., Cohn 1992, Prince and Smolensky 1993, McCarthy and Prince 1993a, Zoll 1996, Buckley 1997, Hyman and Inkelas 1997, Kaufman 2003, Klein 2005, Wolf 2008). In such proposals, the underlying designation of an affix as a prefix or suffix serves to constrain what stem edge the infix appears near (left or right), as well as how far away it may be from that edge. In this camp are the classic optimization-based accounts of infixation, where an affix might *want* to (e.g.) be a prefix, but it will be realized stem-internally as an infix in order to (e.g.) avoid creating an onsetless syllable at the beginning of the word.

The second type of direct infixation account denies that there is any designation of infixes as prefixes or suffixes, however abstract (see, e.g., Anderson 1992, Inkelas 1990, Yu 2007, Samuels 2009). For example, for Yu (2007:48), "infixes are formally no different from prefixes and suffixes, except for the fact that, while prefixes and suffixes target morphological constituents, infixes target phonological ones".[27] There is no step of prefixal/suffixal linearization in these accounts, nor any "pull" to the edge coming from an affix's supposed underlying nature. Infixes are infixes through and through—pivots/placements must specify "first X" and "last X", and this proximity to a particular edge has a purely diachronic source, not tied to any synchronic explanation. The findings of the present study argue against direct infixation approaches of both types.

It is worth pausing for a moment to consider whether the conclusion argued for in this section would be impacted if the division between suppletive and non-suppletive allomorphy were drawn in a different place, cf. (5) and the discussion at the end of §2.3. In particular, what would happen if *all* alternations apart from those that can be reduced to language-general surface phonology were treated as involving suppletion (i.e., taking a "no" response to Question D in the decision tree to diagnose suppletive allomorphy)? This would mean, for example, reclassifying some of the infixal alternants in Leti and Budukh (see §4.1) as being suppletively related, thereby implicating the infixed environment in suppletive allomorph choice. Importantly, this would not impact the specific claim of this section—that infixation is fed by prefixation/suffixation—because there are still clear cases of exponent choice needing to be made at the stem edge prior to infixation (§3.5). This thought experiment is continued at the end of the following section.

7.2 Suppletive allomorph choice precedes phonology

Can suppletive allomorph choice be regulated by considerations of phonological optimization, or of the phonological grammar more generally? Or is suppletive allomorph choice prior to and independent of such considerations?

The literature is divided on this question. Some accounts hold that phonologically- and prosodically-conditioned allomorphy is always regulated by the phonological component of

[27] Yu's (2007) core arguments against other types of approaches are as follows. With respect to optimization-based accounts of infixation, Yu (2007) notes that "infixation can occur for no obvious prosodic or phonotactic gains" (p. 30) and that, if optimization-based accounts were on the right track, "hyperinfixation should be the norm rather than the exception" (p. 38). With respect to indirect/derivational accounts of infixation, where the infix starts as a prefix/suffix, Yu's arguments are centered on readjustment-type accounts (e.g., Halle 2001), where infixation is derived by moving phonological constituents around, e.g., by swapping the first two onsets of a word, or by preposing the stem's onset. Such accounts can model only a (very) proper subset of cases of infixation (see Yu 2007:32-33). To my understanding, none of Yu's criticisms apply to the account argued for in this paper, which combines a derivational step of prefixation/suffixation with a pivot-based approach to infixation, §7.3.

the grammar (see, e.g., McCarthy and Prince 1993a,b, Mester 1994, Kager 1996, Hyman and Inkelas 1997, Horwood 2002, Wolf 2008), capturing the fact that such allomorphy is often optimizing. Other accounts hold the opposite view, that suppletive allomorph choice is always prior to and independent from the phonological component (see, e.g., Halle and Marantz 1993, Trommer 2001, Paster 2006, Bye 2008, Embick 2010, Bye and Svenonius 2012, Pak 2016, Dawson 2017, Kalin 2020, Rolle 2020, Stanton To Appear), capturing the fact that such allomorphy, even when phonologically- or prosodically-conditioned, may be non-optimizing and even anti-optimizing. Finally, there are accounts that split phonologically- and prosodically-conditioned suppletive allomorphy into two types—non-/anti-optimizing allomorphy, which is determined prior to phonology, and optimizing allomorphy, regulated by the phonology (see, e.g., Booij 1998, Mascaró 2007, Bonet et al. 2007, Nevins 2011, Bermudez-Otero 2012, Yu 2017, de Belder 2020). When looking only at one case or one language, it is hard to argue for one of the absolute approaches as compared to the hybrid dual-route approach. Considering the languages here, one might take Toratán's optimizing suppletive allomorphy, (10), to fit better with the morphology-with-phonology approach, but Bahnar's non-optimizing suppletive allomorphy, (12), to fit better with the morphology-before-phonology model, thereby supporting a hybrid approach that allows both orderings.

However, it is possible to make an argument for the non-hybrid, morphology-before-phonology approach on typological grounds. Paster (2006:§6.4) notes that, if optimizing and non-optimizing suppletive allomorphy were distinct in their timing (the former in the phonology, the latter before the phonology), then we'd expect to find two different empirical profiles for them. In particular, optimizing suppletive allomorphy would be sensitive only to surface phonology and could be conditioned non-locally (and potentially outwardly); non-optimizing suppletive allomorphy would be sensitive only to underlying phonological forms and conditioned locally (and inwardly). As Paster (2006) shows, however, this division is not borne out, and rather, all suppletive allomorphy has the characteristics expected if suppletive allomorph choice is always made prior to the phonology.

The findings in this paper add a new typological argument in support of the non-hybrid, morphology-before-phonology approach. If suppletive allomorph choice could be made in the phonological component/alongside the phonological computation, then (i) the surface (infixed) environment should be able to influence suppletive allomorph choice, and (ii) there should be true cases of suppletive allomorphy that are not analyzable locally, but rather only globally. Of the 21 cases of phonologically- or prosodically-conditioned suppletive allomorphy, none have characteristic (i) or (ii)—see §3.6 and §6.3, respectively. It is notable, in this context, that there is such a sharp divide between suppletive and non-suppletive allomorphy on this front. As seen in §3.5 and §3.6, suppletive allomorph choice is regulated *only* from the underlying edgemost (prefixal/suffixal) position of a morpheme (see §7.1), while non-suppletive allomorphy is regulated *only* in the surface/infixed position of an exponent, §4.1–§4.2.

Again, it is worth pausing to consider the consequences of the assumptions made in §2.3—if a more conservative view of non-suppletive allomorphy were adopted, where only strictly surface allomorphy is treated via phonological processes, then would these conclusions hold up? In fact, this *would* be very problematic for the argument that suppletive allomorph choice always precedes phonology, as there would be a number of cases (see §4.1) of suppletive exponent choice in stem-internal/infixed position (under this hypothetical expansion of suppletive cases to non-suppletive "restricted" cases). In turn, the subsequent finding would be that suppletive exponent choice could be made from the edgemost position *or* in the infixed position, thereby necessitating a hybrid dual-route approach to suppletive allomorphy.

Importantly, though, the findings of the present study actually provide evidence *against* characterizing what I label "restricted" alternations (phonologically-conditioned, phonologically natural, but not language-general) as suppletive, as encoded in (5). For all 37 infixes that undergo alternations in their surface/infixed positions (at least 18 of which are of the "restricted" type), these alternations involve a *small phonological distance*. Put another way, there are *no cases* of alternations conditioned in a surface/infixed position that involve a *large phonological distance*. For comparison, considering the 21 cases of phonologically- or prosodically-conditioned *suppletion* that take place at/from the edge of the stem, a third of them (7 out of 21) involve a large phonological distance. (10 involve a small phonological distance, and 4 are somewhere in between.) All else being equal, if suppletion could be conditioned in a stem-internal/infixed position, we'd expect at least *some* of the internally-conditioned alternations to have a large phonological distance. But, none do. I therefore conclude that the inclusion of "restricted" alternations in the non-suppletive category is justified, and so the conclusion in this section holds as well—suppletive allomorph choice precedes phonology.

7.3 Putting it all together: Cyclicity and derivational ordering

In this section I synthesize the implications of §3 through §6 with those discussed in §7.1 and §7.2 to lay out the fine timing of the morphosyntax-phonology interface.

The following binary ordering statements are supported by the present findings, where $<$ indicates a derivational precedence relation ($\alpha < \beta = \alpha$ derivationally precedes β).

(30)
a. exponent choice $<$ infixation (§3.1, §3.5, §3.6, §6.1)
b. linear concatenation $<$ exponent choice & infixation (§3.4, §3.5, §3.6, §7.1)
c. infixation $<$ (morpho)phonology[28] (§4.1, §4.2, §4.3, §5.3, §6.2)
d. exponent choice $<$ (morpho)phonology (§6.1, §6.3, §7.2)

Cumulatively across (30), the internally-consistent ordering arrived at is shown in (31).

(31) linear concatenation $<$ exponent choice $<$ infixation $<$ (morpho)phonology

There is a derivationally early step of linear concatenation of morphemes, establishing affixal morphemes as preceding or following their stems. (See the discussion at the beginning of §7.1 about how this ordering may fall out from syntactic structure, or be established early in

[28] These findings do not, however, rule out that infix placement is *sometimes* handled by the phonology.

the morphology.) It is in this linearized position where exponence happens, i.e., where the choice among suppletive exponents is made. Some exponents are infixal (have a phonological pivot/placement), and once chosen, they displace (if needed) to the closest stem-internal position where they can satisfy their pivot/placement. Finally, phonological processes apply, potentially deriving non-suppletive alternations of and around infixal exponents.

Further, the findings of this study support *cyclicity* of exponent choice, infixation, and (morpho)phonology (in particular, (re-)prosodification).[29] Cyclicity is used here to mean that a set of operations repeats with every morpheme, starting from the most embedded morpheme in the structure and working upwards; every morpheme thus defines a cycle. The evidence for cyclicity of exponent choice comes from the fact that suppletion based on phonological and prosodic factors is uniformly inward-looking; see §3.5 and Paster 2006. The evidence for cyclicity of infixation comes from the fact that infixes only ever displace inwardly (§5.1) and can only satisfy their pivot/placement inwardly (§5.2); this goes hand in hand with a bottom-up exponence model. Crucially, if realization were simultaneous across a domain (e.g., Prince and Smolensky 1993, Mascaró 1996, Svenonius 2012, Rolle 2018), or could go from the outside in (Deal and Wolf 2017), the following sorts of patterns are predicted to exist: outward-moving infixes, infixes that can satisfy their pivot/placement at the stem edge looking outward, and outwardly-conditioned suppletive allomorphy. None of these patterns are found in my study.[30]

Finally, the evidence for cyclicity of (morpho)phonology comes from (i) the fact that prosodic constituents/weight are a robust conditioning factor in suppletive allomorphy involving infixes, §3.2, as well as (ii) the fact that infixes may have prosodic pivots (Yu 2007). For prosodic factors to matter for suppletion and infixation, which are themselves cyclic, there must also be (re-)prosodification throughout the cyclic morpho(phono)logical derivation.[31] (See Kalin In press for a detailed case study of Nancowry making this argument on expanded grounds.)

Putting together cyclicity and the overall ordering in (31), I propose the following derivational timing of the morphosyntax-phonology interface:

(32) Derivational timing
  a. Build the abstract morphosyntactic structure
  b. Bottom-up realization: Go to the most embedded unexponed morpheme, and apply a cycle of morphology and morphophonology, in this order:
    (i) Concatenation (i.e., establish linear precedence)
    (ii) Exponent choice (**suppletive allomorphy**)

[29] There is a lot of evidence for cyclicity more generally—see, e.g., Chomsky and Halle 1968, Kiparsky 1982, 2000, Carstairs 1987, Anderson 1992, Bobaljik 2000, Wolf 2008, Embick 2010, Bye and Svenonius 2012, Myler 2017. On cyclicity of infixation in particular and its interaction with exponent choice and/or prosodification, see Embick 2010:§3.4.3, Bacovcin and Freeman 2016, Harizanov 2017.

[30] See also Kiparsky to appear, who argues that the Nez Perce data that are analyzed by Deal and Wolf 2017 do not necessitate outwardly-sensitive phonologically-conditioned suppletive allomorphy.

[31] Evidence for the cyclicity of other morphophonological processes comes from cases where an infix appears between two morphemes that have some sort of allomorphic relationship, e.g., one conditioning a non-suppletive alternation of the other. See Kalin 2021, in prep.

(iii) Linear displacement (**i.e., infixation, for infixal exponents**)
(iv) Prosodification, restricted/cyclic phonology (**"restricted" allomorphy**)
(Repeat (i)-(iv) until there are no more unexponed morphemes in domain)

c. Apply surface phonology (**non-suppletive surface allomorphy**)
(Repeat (a)-(c) for every phase/spell-out domain)

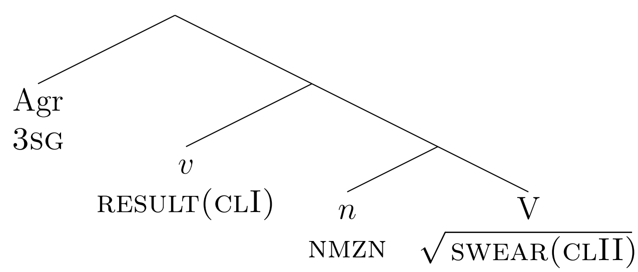
A few commitments made in (32) are underdetermined by the present findings. First, I have couched this timing within a late insertion model. For a recently-compiled list of arguments for late insertion, see Kalin and Weisser 2021. Next is linearization, in particular, whether it applies over the whole structure prior to the first step of cyclic operations or is the first of the cyclic operations in (32b),[32] and, whether it is an actual *step* or just transparently read off the structure at the point of exponent choice. Last is whether infixation and restricted/cyclic phonology are simultaneous or sequential. The fact that infixation can be opaque and non-optimizing/anti-optimizing, as seen in §5.3 and §6.2, indicates that sequentiality (as represented in (32)) is at least possible. But, it may also be that there is an option for simultaneity, with the phonology responsible for displacing the exponent to its infixal position. (This would essentially be a hybrid/dual-route approach to infixation.)

Let's run through a derivation to see exactly how (32) works in practice, using the following example from Leti (Blevins 1999:389), cf. (19) and §5.1.

(33) na-l<i>òkra
3SG.I-<NMZN>swear
'he has sworn'

The first step is building the morphosyntactic structure, (34). I assume, building on the discussion in Blevins (1999:388), that a null *v* resultative head (not shown above in (33)) mediates between the inflectional agreement prefix and the nominalized verb, and is responsible for the classification of the derived form as Class I.

(34)



Starting from the most deeply embedded morpheme, the root, (35) through (38) goes through (cyclic) concatenation, exponent choice, infixation, and (morpho)phonology (prosodification not shown for this case, as it is not relevant), culminating in surface phonology, (39).

[32]Considerations of modularity point away from an early step of linearization over the whole structure, because this would require linearizing while also maintaining the underlying hierarchical structure (for the purposes of bottom-up exponence). Thank you to Gillian Ramchand, Craig Sailor, and Neil Banerjee for helpful discussion of this point at GLOW.

(I assume class membership—indicated with subscripts on the relevant exponents—and morphological boundaries survive until surface phonology.)

(35) **Cycle 1**

a.	Concatenation:	$\sqrt{\text{SWEAR}}$
b.	Exponent choice: $\sqrt{\text{SWEAR}} \rightarrow$ *lòkra*$_{II}$	lòkra$_{II}$
c.	Linear displacement: n/a	- - -
d.	Restricted/cyclic phonology: n/a	- - -
→	Output:	lòkra$_{II}$

(36) **Cycle 2**

a.	Concatenation:	NMZN-lòkra$_{II}$
b.	Exponent choice: NMZN → *-ni-* / Class II verbs	<ni>lòkra$_{II}$
c.	Linear displacement: *-ni-* → __V	l<ni>òkra$_{II}$
d.	Restricted/cyclic phonology: $n \rightarrow \emptyset$ / [[-syll,+son]__ ...]$_{\text{NOM}}$	l<i>òkra$_{II}$
→	Output:	l<i>òkra$_{II}$

(37) **Cycle 3**

a.	Concatenation:	RESULT-l<i>òkra$_{II}$
b.	Exponent choice: RESULT → $\emptyset_I$	$\emptyset_I$-l<i>òkra$_{II}$
c.	Linear displacement: n/a	- - -
d.	Restricted/cyclic phonology: n/a	- - -
→	Output:	$\emptyset_I$-l<i>òkra$_{II}$

(38) **Cycle 4**

a.	Concatenation:	3SG-$\emptyset_I$-l<i>òkra$_{II}$
b.	Exponent choice: 3SG → *na-* / Class I verbs	na-$\emptyset_I$-l<i>òkra$_{II}$
c.	Linear displacement: n/a	- - -
d.	Restricted/cyclic phonology: n/a	- - -
→	Output:	na-$\emptyset_I$-l<i>òkra$_{II}$

(39) Surface phonology: n/a *naliòkra*

The crucial cycle is Cycle 2, (36), where both infixation and morphophonology take place. (Recall from the beginning of §4.1 that this instance of n deletion is not language-general.) The derivation successfully captures the fact that the nominalizing morpheme is at the left edge of its stem, that the infix displaces inwardly, not outwardly (cf. §5.1), and that the infix undergoes phonological alternations only in its surface position.

A bottom-up, cyclic, serial derivation like that shown above can successfully account for all infixation and allomorphy patterns found in the present study.

8 Conclusions

This paper presented the findings of a large-scale study of allomorphy involving infixation. The overall picture that has emerged is that allomorphy and infixation interact in consistent, systematic ways, suggestive of a universal architecture of the morphosyntax-phonology interface. I hope this study provides a useful backdrop for investigating individual case studies of allomorphy and infixation, and for informing models of morphology and phonology.

The most major theoretical implications are that (i) infixes really are (underlyingly) prefixes/suffixes, (ii) suppletive allomorph choice precedes phonology, and (iii) exponent choice, infixation, and (morpho)phonology/prosodification are cyclic. Similar conclusions to these have been reached by recent investigations of root-and-template morphology; see especially Kastner 2019. These implications provide strong novel support for a derivational, realizational, piece-based approach to morphology. One such model that is particularly well-suited to accommodate these findings is Distributed Morphology (Halle and Marantz 1993, 1994, Embick 2010). Notably, the findings are *not* compatible with theories that take infixation to be "direct" (e.g., Yu 2007), that make some/all suppletive choices in the phonology (e.g., Mascaró 2007, Wolf 2008, Bermudez-Otero 2012), or that lack a serial architecture altogether (e.g., McCarthy and Prince 1993a,b). The findings are also challenging to explain in word-and-paradigm theories (e.g., Stump 2001, 2016), related to the representational (rather than derivational) nature of many such models.

A natural next step in this research is to look at other non-concatenative/displaced elements—like ablaut, mora affixation, mobile affixes, endoclitics, and second position clitics—and compare their behavior to the present results. Doing so can help to diagnose how many distinct phenomena we are really dealing with: if the behavior of any of these displacing elements is just like that of canonical infixes with respect to allomorphy, then we might conclude that these phenomena are fundamentally the same as infixation. Shifting the focus away from the behavior of the displacing elements themselves, another relevant question in supporting the model proposed here is about what sorts of stem-internal processes survive the intrusion of an infix, and which don't. I am pursuing this question in ongoing work (Kalin 2021, in prep).

9 Appendix: List of case studies

Table 2: Case studies (by family and language)

Language (country)	Morpheme	Edge	Suppletive condition	Main source(s)
Afro-Asiatic				
Bole (Nigeria)	distributive	left	lexical	Gimba 2000, Zoch 2017
Jebbāli (Oman)	plural	right	prosodic, lexical	Al Aghbari 2012
Mupun (Nigeria)	pluractional	right	lexical	Frajzyngier 1993
Turoyo (Turkey)	past	left	(none)	Jastrow 1993, Kalin 2020
Algic				
Yurok (United States)	intensive	left	(none)	Garrett 2001
Austro-Asiatic				
Bahnar (Vietnam)	nominalizer	left	phonological (mel.), lexical	Banker 1964
Jahai (Malaysia)	causative	left	prosodic, lexical	Burenhult 2002
Katu (Lao PDR)	nominalizer	left	lexical	Costello 1998
Mlabri (Thailand)	nominalizer	left	(none)	Rischel 1995
Nancowry (India)	causative	left	prosodic	Radhakrishnan 1981, Kalin In press
	instrumental	left	prosodic	Radhakrishnan 1981, Kalin In press
Austronesian				
Ambai (Indonesia)	2sg subject	left	(none)	Silzer 1983
	3sg subject	left	(none)	Silzer 1983
Ambel (Indonesia)	sg partic. sbj	left	lexical	Arnold 2018
Biak (Indonesia)	2sg subject	left	phonological, lexical	van den Heuvel 2006
	3sg subject	left	phonological, lexical	van den Heuvel 2006
Ida'an Begak (Malaysia)	reciprocal	left	phonological (mel.), lexical	Goudswaard 2005
Leti (Indonesia)	nominalizer	left	phonological, lexical, morphological	Blevins 1999, van Engelenhoven 2004
Muna (Indonesia)	irrealis	left	(none)	van den Berg 1989
Nakanai (PNG)	nominalizer	right	prosodic, lexical	Johnston 1980
Paiwan (Taiwan)	agent focus	left	(none)	Ferrell 1982
Puyuma (Taiwan)	AV/intransitive	left	phonological (melody)	Teng 2008
	perfective	left	phonological (melody)	Teng 2008
Saisiyat (Taiwan)	agent voice	left	(none)	Zeitoun et al. 2015
Sundanese (Indonesia)	plural	left	(none)	Cohn 1992
Toratán (Indonesia)	AV past	left	phonological	Himmelmann and Wolff 1999
	UV past	left	phonological (mel.), lexical	Himmelmann and Wolff 1999
Wamesa (Indonesia)	2sg subject	left	(none)	Gasser 2014
	3sg subject	left	(none)	Gasser 2014
Wooi (Indonesia)	2sg subject	left	(none)	Sawaki 2016
	3sg subject	left	(none)	Sawaki 2016
Cochimí-Yuman				
Yuma (United States)	verbal pl (PL3)	left	(none)	Halpern 1947, Gillon and Mailhammer 2015
Huavean				
Huave (Mexico)	passive	right	lexical	Kim 2008

Table 3: Case studies (by family and language) continued

Language (country)	Morpheme	Edge	Suppletive condition	Main source(s)
Kra-Dai				
Thai (Thailand)	specialization	left	(none)	Huffman 1986, Blevins 2014
Mayan				
Tzeltal (Mexico)	intransitivizer	right	lexical	Slocum 1948
Movima (isolate)				
Movima (Bolivia)	irrealis	left	(none)	Haude 2006
Muskogean				
Alabama (United States)	middle voice	right	prosodic	Hardy and Montler 1991
Choctaw (United States)	iterative	right	(none)	Ulrich 1986, Broadwell 2006, Lombardi and McCarthy 1991
Creek (United States)	dual/plural	right	phonological (melody)	Martin 2011
	perfective	right	phonological	Martin 2011
Niger-Congo				
Eton (Cameroon)	G-form	right	prosodic	Van de Velde 2008
Kichaga (Tanzania)	intensive	right	(none)	Yu 2007, Inkelas p.c.
Kimatuumbi (Tanzania)	perfective	right	pros., phono. (mel.), morph.	Odden 1996
Northeast Caucasian				
Budukh (Azerbaijan)	prohibitive	left	(none)	Alekseev 1994
Hunzib (Russia)	verbal plural	right	phonological	van den Berg 1995, Kalin 2021
Lezgian (Russia)	repetitive	left	lexical	Haspelmath 1993
Salish				
Nxa'amxcin (United States)	inchoative	left	lexical	Willett 2003
Upriver Halkomelem (U.S.)	verbal plural	left	lexical	Galloway 1993, Thompson 2009
Torricelli				
Yeri (Papua New Guinea)	additive	left	lexical	Wilson 2014
	imperfective	left	lexical	Wilson 2014
Uralic				
Estonian (Estonia)	illative	right	prosodic, lexical	Hirvonen 2020

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