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

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Abstract

While 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 on allomorphy), 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 49 case studies from 40 languages (13 language families). Allomorphy and infixation interact in consistent, systematic ways, suggestive of a universal architecture of the morphosyntax-phonology interface. More specifically, the findings support the type of serial architecture proposed by Distributed Morphology and related approaches (Halle and Marantz 1993, 1994, Embick 2010, Bye and Svenonius 2012), and run counter to fully parallel models (e.g., McCarthy and Prince 1993a,b, Prince and Smolensky 1993) and those that take infixation to be "direct" (e.g., Inkelas 1990, Yu 2007, Wolf 2008).

Keywords: Morphology, infixation, allomorphy, suppletion, phonology, typology

1 Introduction

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

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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 2020a. 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 phenomena 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 49 cases of allomorphy involving infixation, spanning 40 languages (and 13 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 direct 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 the study into infixation more generally, and §6 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 the stem edge (specifically, at 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. Infixation, as a process, only looks *inward*, into phonological material and prosodic structure that is 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. (A complete list of findings, corresponding to these sections' (sub-)headings, can be found in Appendix B.)

The findings and implications are brought together in §7, where I argue that they show that (i) infixes really are (underlyingly) prefixes/suffixes (§7.1), (ii) suppletive allomorph choice is prior to and independent from the phonological computation and considerations of optimization (§7.2), and exponent choice, infixation, and (morpho)phonology are cyclic, applying in that order within each cycle (§7.3). These theoretical conclusions support the type of serial architecture proposed by Distributed Morphology and related approaches (Halle and Marantz 1993, 1994, Embick 2010, Bye and Svenonius 2012), and run counter to fully parallel models (e.g., McCarthy and Prince 1993a,b, Prince and Smolensky 1993) and those that take infixation to be "direct" (e.g., Inkelas 1990, Yu 2007, Wolf 2008).

The paper starts in §2 by introducing the terminology used throughout the paper, the categorization criteria used in conducting the study, and basic properties of the language sample. (The full list of case studies is given in Appendix A.) Next, §3 through §6 lay out the empirical findings, which are brought together to form a more complete picture of the morphology-syntax interface in §7. §8 concludes.

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 involving infixes, §2.3, and (iii) properties of the language sample, §2.4. Key terms that I will use throughout the paper 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 (simultaneously) to (i) a semantic meaning and/or morphosyntactic function, and (ii) a set of phonological forms (**exponents**) in complementary distribution; when this set is a non-singleton set, the phonological forms are referred to as **allomorphs** of the morpheme. While both root morphemes and affixal morphemes can have allomorphs, the present study focuses on the latter, as the empirical domain is cases of allomorphy where a morpheme has at least one infixal exponent.

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-[əz]
- 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 allomorphs reasonably be phonologically derived from one **underlying form**?[1] The English allomorphs in (1) present a clear illustrative case: [z], [s], and [əz] are all very closely phonologically related and the alternation among them can be understood through phonologically

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

natural processes (voicing assimilation and vowel epenthesis), conditioned by their particular environments; [z], [s], and [əz] are thus **non-suppletive allomorphs** derived from a single underlying form, which I take here to be /z/. On the other hand, /z/ (underlying [z]/[s]/[əz]), [rən], [∅], and [aj] are all phonologically distant from one another, and there is no clear motivation for deriving one from any other (e.g., deleting [z] after *moose* to derive the zero allomorph). 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 compatible underlying form(s) from a set of suppletive allomorphs in a particular environment; I also refer to this sometimes 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 lexical item (or set of lexical items)
  b. morphological = conditioned by a morphological feature (or set of features)
  c. phonological = conditioned by a phonological feature (or set of features)[2]
  d. prosodic = conditioned by prosodic size, weight, and/or shape

The suppletive allomorphs of the English plural involve **lexical conditioning**, as [rən], [∅], and [aj] appear only with one root or a small set of roots. **Morphological conditioning** is exemplified by the dative morpheme in the Neo-Aramaic language Turoyo (Kalin 2020a), which has the form *n* when appearing after a plural feature (in combination with other factors), and *l* otherwise. A well-known case from Moroccan Arabic illustrates **phonological conditioning** (Mascaró 1996, who cites Harrell 1962): the 3rd person masculine singular clitic has two suppletive forms, *=h* when following a vowel, and *=u* when following a consonant. Finally, among a number of other examples, Paster (2005) (who cites Newman 1965) shows that singular marking in the Native American language Zuni displays **prosodic conditioning**, with *-ʔleʔ* appearing with monosyllabic stems, and *-nne* with polysyllabic stems.

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), and, consequently,

[2] 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; he proposes that all apparent cases of melodic PCSA are analyzable without suppletive allomorphy (without separate phonological representations for the lexical item). 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 Appendix A with the designation "phonological (melody)".)

with respect to what can and cannot condition non-suppletive alternations. So-called **surface allomorphy** involves a non-suppletive alternation that is phonologically or prosodically conditioned and derivable by a phonological process that is plausibly language-general, as is the case for English plural allomorphs [z], [s], and [əz]. The more controversial cases are those that some treat as non-suppletive (phonological distance is small), but would have to involve morphologically- or lexically-restricted phonological processes, like the voicing of the final fricative of the root in some English plurals (e.g., *leaf/leaves*, *house/hou[z]es*). Such alternations are 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. It is only this first type of morphophonology that is robustly encountered in the present study, i.e., cases involving morphologically **restricted** (not language-general) phonological processes. When such alternations are phonologically natural in their specific environments (within the language or in a crosslinguistic perspective), I categorize these cases as non-suppletive. (See §2.3 for more detail.)

2.2 Definition of infixation

I adopt 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 morpheme 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 refer to the morphological constituent that the infix combines with as the **stem of infixation** (or, for short, just the **stem**), and to the infix's position with respect to this stem (usually inside of it) as its **surface** or **infixed** position. The place where an infix **surfaces** (i.e., where it linearly appears on the surface with respect to the stem of infixation) is determined by a condition on its **placement** with respect to a phonological or prosodic **pivot**.[3] There is crosslinguistic evidence that consonants, vowels, syllables, and feet may all serve as pivots for infixation (Ultan 1975, Moravcsik 1977, Yu 2007). I assume that exponents that are simple prefixes or suffixes on all stems *lack* a pivot/placement. (In other words, I use pivot/placement uniquely to describe infixes; I do not use pivot/placement to describe

[3] 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., 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, and in addition, the present study supports the theoretical need for pivots in at least some cases, §6.2.

simple prefixation/suffixation. This descriptive choice has a theoretical justification—see discussion in §7.1.)

I will break down the definition in (3) and exemplify my use of the terminology introduced above using Blevins' illustrative example of nominalization in Hoava (Austronesian, Solomon Islands; Davis 2003), which I reproduce in adapted form in (4). The infixal exponent in its surface/infixed position is enclosed in angled brackets, as per the usual convention.

(4) Infixation in Hoava: nominalizer *-in-* (adapted from Blevins 2014)

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 two phonological segments in sequence, *i* and *n*. The nominalizer's exponent, *-in-*, is an infix, which has a condition on its placement such that it must surface as preceding the first vowel, its pivot, in the stem of infixation.[4] The stem, in turn, may be monomorphemic, as in (4a,b,f,g), or multimorphemic, as in (4c-e). In the latter type of case, an infix may appear inside of an affix contained in the stem, or even at the boundary between two morphemes inside the stem (the latter not shown in Hoava); infixation is "oblivious" to this stem-internal morphological structure, its surface position determined solely by its pivot/placement. Along the same lines, the infix is oblivious as to whether it is truly inside the stem (surrounded by stem segments) or not—an infix may find its pivot, and be in the required orientation with respect to that pivot, at the stem edge, and thus not look like an infix, as in (4f,g). (Note that I consider *-in-* to be one and the same infixal exponent in (4a-g), i.e., no allomorphy is involved, and *-in-* is still formally an infix in (4f,g).)

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. 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). 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.

[4] 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.

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

The present study is interested in suppletive and non-suppletive allomorphy involving at least one infixal exponent. Thus a decision must be made for every potential case as to whether it involves allomorphy or not, and if so, as to whether this allomorphy involves a suppletive alternation. Some cases are extremely clear, but many aren't. Understanding how classificational decisions have been made is crucial to the replicability of this (and any) typological study, as well as to interpreting the results.

The questions in (5) guide the choice of suppletive vs. non-suppletive classification; these questions (with added detail) are organized into a decision tree in (6), which lays out concretely how I have gone about making the suppletive vs. non-suppletive classification in a systematic way.

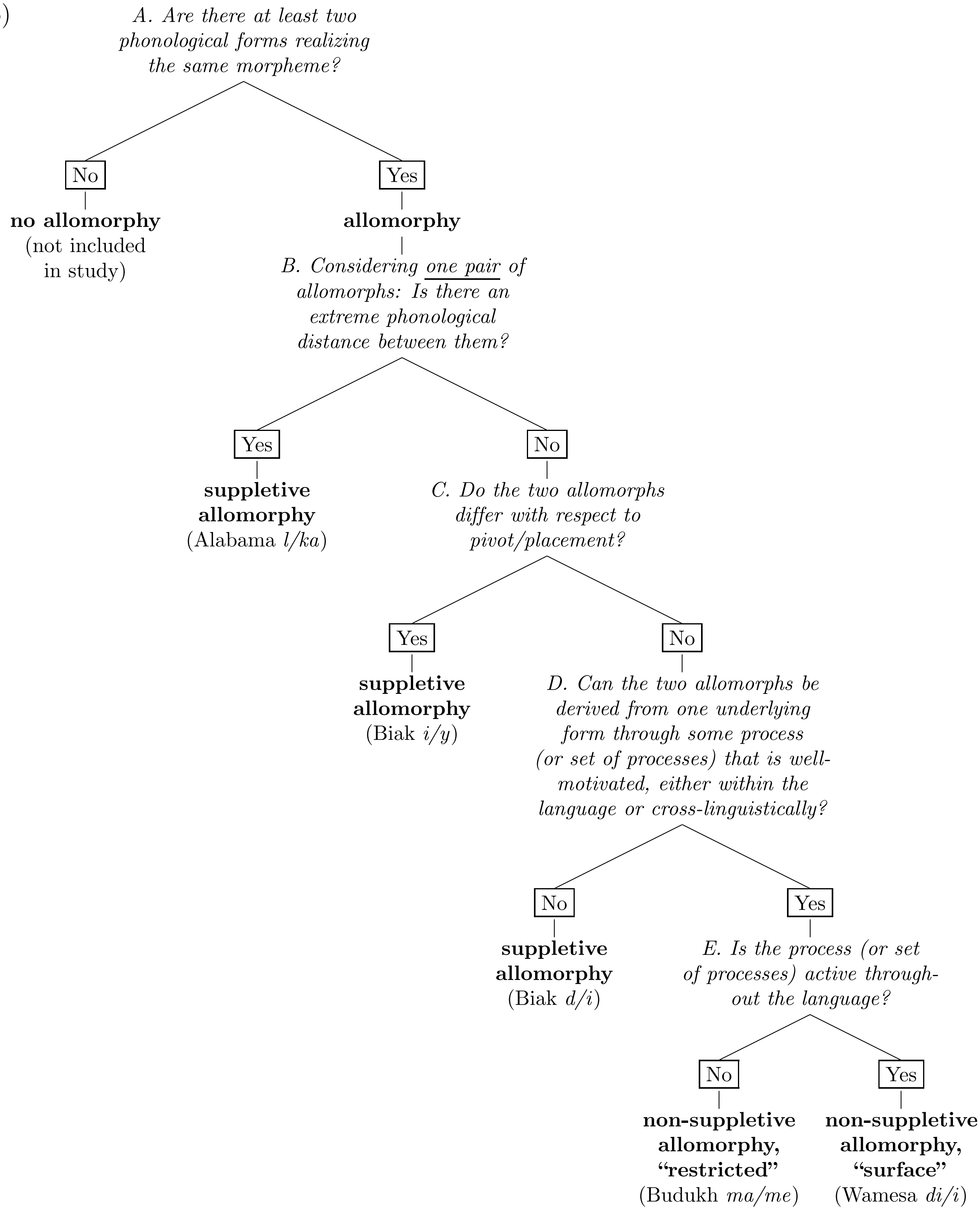
(5)
a. Is there an extreme phonological distance between allomorphs?
b. Do the allomorphs differ with respect to pivot/placement?
c. Can the allomorphs be derived from one underlying form through some well-motivated phonological process?

Through the questions in (5), as organized in (6) into a decision tree, I have attempted to capture the intuition that there are several reasons to posit an underlying (suppletive) difference between allomorphs: (i) when they have wildly different phonological forms (a large phonological distance); (ii) when they differ with respect to phonological pivots (e.g., one is an infix and the other is not); and/or (iii) when there is no crosslinguistically-natural or language-internal phonological process (even if restricted in application) that could plausibly derive the allomorphs from the same underlying form.

A few notes about the decision tree are in order, before we can dive in. First, as discussed in §2.1, I consider all variation in phonological forms of affixes to constitute allomorphy, i.e., I do not reserve the term allomorphy for just suppletive alternations (so-called "true" allomorphy) nor for just non-surface alternations. Second, the decision tree does not reflect that the inclusion of a particular morpheme in the study is dependent on at least one of the allomorphs of the morpheme being an infix, as defined in §2.2. Third, as can be seen in Questions B-E, after the root decision (is there allomorphy or not?), all decisions are relativized to a single pair of allomorphs. This is because a morpheme may have a number of allomorphs, some of which are related to each other suppletively and others non-suppletively. The English plural is a good example of this, as discussed in §2.1—there are (at least) four suppletive allomorphs, each corresponding to a distinct underlying form; each underlying form can, in turn, be related to a number of non-suppletive allomorphs.

Finally, even aided by such a decision tree, it's important to recognize its limits. As I will discuss at the end of this section, not everyone would agree with the outcomes of all these decision points, in terms of classifying such allomorphy as suppletive or non-suppletive. Further, the decisions themselves are often not trivial—each decision point in this decision tree could have its own decision tree.

(6)


A. Are there at least two phonological forms realizing the same morpheme?
No
no allomorphy
(not included in study)
Yes
allomorphy
B. Considering one pair of allomorphs: Is there an extreme phonological distance between them?
Yes
suppletive allomorphy
(Alabama l/ka)
No
C. Do the two allomorphs differ with respect to pivot/placement?
Yes
suppletive allomorphy
(Biak i/y)
No
D. Can the two allomorphs be derived from one underlying form through some process (or set of processes) that is well-motivated, either within the language or cross-linguistically?
No
suppletive allomorphy
(Biak d/i)
Yes
E. Is the process (or set of processes) active throughout the language?
No
non-suppletive allomorphy, "restricted"
(Budukh ma/me)
Yes
non-suppletive allomorphy, "surface"
(Wamesa di/i)

I will now briefly exemplify 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 one step farther in the decision tree, having two allomorphs, *-l-* and *-ka*. These allomorphs are phonologically quite distant, and so yield a "yes" to Question B, thereby classifying them straightforwadly as suppletive allomorphs. (See §6.3 for more details on this case study.)

Let's turn to more of the intermediate "exits" in the decision tree. In Biak (Austronesian, Indonesia; van den Heuvel 2006:157-158), 3rd singular subject marking has three realizations, *i-, d-*, and *-y-* ("yes" to Question A). Considering the pair *i-* and *-y-*, they are phonologically quite close ("no" to Question B), but they crucially differ with respect to pivots ("yes" to Question C): *i-* doesn't have a pivot and is simply a prefix, e.g., *i-mar* (3SG-die); *-y-* is an infix with the first consonant as its pivot—*-y-* surfaces after the first consonant, e.g., *v<y>ov* (<3SG>sell). Since both *i-* and *-y-* combine with consonant-initial stems (arbitrarily lexically determined), it is not possible to characterize them as having the same placement relative to some pivot, like it was for Hoava *-in-* in (4), nor like it is below for Wamesa *-di-*. On this basis, then, I classify them as suppletively related. Pushing this example further, let's consider the allomorph pair *i-* and *d-*: both are prefixes (neither has a pivot, so "no" to Question C), and since both are monosegmental, one could imagine an underlying form *di-* from which both are derived. However, the answer to Question D—is there any motivated process for deriving *i-* from *di-* in some cases and *d-* from *di-* in others—is a resounding "no" given the environments of this allomorphy in Biak. The hypothetical *di-* to *d-* transformation is motivatable by vowel hiatus resolution, since *d-* occurs only with vowel-initial stems, e.g., *d-árok* (3SG-straight). However, the *di-* to *i-* transformation is impossible to motivate, as *di-* would be perfectly fine (phonotactically) in *i-*'s environments (*i-* combines with consonant-initial stems, as shown above) and further, the hypothetical *di-* to *i-* transformation would create onsetless words, which are crosslinguistically dispreferred. I therefore take *i-* and *d-* to have a suppletive relationship, as well. Thus all three allomorphs of Biak's 3rd singular subject marker, *i-, d-*, and *-y-*, are classified as suppletive.

The last distinction to make is in Question E. In a language closely related to Biak, Wamesa (Austronesian, Indonesia; Gasser 2014:260-261), 3rd singular subject marking has two realizations, *di-* and *-i-*, with a more regular and phonologically-understandable distribution than the exponents of this same morpheme in Biak. In Wamesa, *di-* appears preceding vowel-initial verbs (e.g., it precedes root *api*, 'eat'), and *-i-* appears before the first vowel (i.e., transparently as an infix) with consonant-initial verbs (e.g., *p<i>era*, <3SG>CUT). This case makes it (uncontroversially) through Question A ("yes") and Question B ("no"). At Question C, there's a substantive decision to make—do *di-* and *-i-* differ with respect to pivot/placement? Although it might seem like they do, since *di-* is always stem-initial while *-i-* is always stem-internal, in fact this is consistent with both having a pivot that requires they be positioned before the first vowel; for vowel-initial words, just like in Hoava, (4), the infix *looks* like a prefix (e.g., *<di>api*; <3SG>eat), while for consonant-initial words, the infix is transparently an infix. Thus Question C is at least arguably a "no". For Question D, considering a hypothetical shared underlying form *-di-*, the answer is "yes", as *-i-* can be derived by consonant deletion, and indeed, the environment in which this happens is one where the initial consonant of the affix would be in a complex onset (e.g., hypothetical underlying form *p*<*di*>*era*, for <3SG>CUT). Complex onsets are 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 the *-di-* to *-i-* transformation is classified here as non-suppletive, surface allomorphy ("yes" to Question E).

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 ("no" to Question B) and all have the same pivot/placement, appearing after the first syllable ("no" to Question C). The vowel in this infix is determined through assimilation with the following vowel in the word, i.e., through regressive vowel harmony ("yes" to Question D). Vowel harmony is not a general process of the language, but rather found only with certain morphemes. In addition, different morphemes exhibit different vowel harmony patterns, with the other core harmony pattern involving a distinct set of resultant vowels (*i, ü, ɨ, u*) and progressive rather than regressive assimilation. I thus classify the variation in the prohibitive morpheme as non-suppletive allomorphy that is restricted ("no" to Question E). I do not, in this paper, attempt to delve more deeply into the different ways a phonological alternation might be restricted.

In this decision tree, there are two potentially controversial choices I have made that I want to draw attention to. The first is found at Question D (in particular, the "no" branch): when a given alternation is *describable* through a phonological change, but this change is "unnatural" in the sense that it is motivated neither by crosslinguistically-common phonological constraints/processes nor by language-internal phonological constraints/processes (like Biak *i-* and *d-*, discussed above), should this alternation necessarily be considered to be suppletive? My answer, per (6), is yes, but proponents of more powerful "readjustment" rules might disagree (see, e.g., Embick 2013, Embick and Shwayder 2018). Cases moving from the suppletive to non-suppletive category (narrowly with respect to Question D "no" cases, or more generally speaking) would not be problematic for my major findings, which would still hold up; the stakes are low with respect to this decision, and I leave open the possibility that Question D "no" cases are non-suppletive.

The second controversial choice, which would have a more profound effect on my findings, is at Question E (the "no" branch again): to what extent are domain- or morphologically-restricted but still "natural" phonological alternations encoded in the grammar as processes (non-suppletively) versus as lexically-stored variants (suppletively)? Certainly handling such alternations phonologically, as I've advocated for Budukh above, is more plausible than handling the Question D "no" cases phonologically, but still, some who would hold that the Question D "no" cases are suppletive (as I do) might want to extend this suppletive characterization to Question E "no" cases (see, e.g., Mascaró 2007). 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 (and the way that they would change if Question E "no" cases *were* suppletive) actually furnishes an argument in favor of characterizing these cases as non-suppletive. I will return to this in detail at the end of §7.1 and the end of §7.2.

2.4 The sample

This study considers 49 cases of allomorphy that involve infixation. These 49 cases come from 40 different languages, belonging to 13 different language families (including isolates), as summarized in Table 1.

Table 1: Language sample (by family)

Family	**#**	**Languages and countries**
Afro-Asiatic	5	Bole, Mupun (Nigeria); Jebbāli (Oman); Sundanese (Sudan); Turoyo (Turkey)
Austro-Asiatic	5	Bahnar (Vietnam); Jahai (Malaysia); Katu (Lao PDR); Mlabri (Thailand); Nancowry (India)
Austronesian	13	Ambai, Ambel, Biak, Leti, Muna, Toratán, 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)
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 are available online during a 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 Appendix A. My focus was on identifying cases of suppletive allomorphy, as these are more difficult to find than non-suppletive cases, and thus suppletion is involved in 31 out of the 49 case studies.

To be included in this study, a given case needed to pass Question A of (6), *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.

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 pivot/placement) and non-infixal other times (a simple prefix or suffix).[5] 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, but with a plausibly non-suppletive alternation) that looked like mobile affixes, with one and the same underlying form variably appearing as a prefix, infix, <u>and</u> suffix. 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 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).

The following four sections turn to the empirical findings of the study. Throughout, findings are based on my analysis of the data, which does not always line up with the descriptions/analyses of the case studies in the sources themselves.

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 49 cases of infix allomorphy in this study, 31 involve suppletion. The core findings are as follows:

- §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

[5]Note that this does *not* mean I excluded cases where an infix sometimes finds its pivot/placement at the stem edge. As discussed in §2.2, I still count such exponents as infixal even when they're not properly contained in their stem, like the Hoava infix *-in-* in (4f)-(4g), where it looks like a prefix.

- §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

Illustrative case studies are provided throughout. At the end of every subsection, as well as summarized in §3.7, I will briefly state what I take to be the core implications of the immediate findings. These implications are discussed more fully in §7.

3.1 Suppletive allomorphs may differ with respect to pivot/placement

A relatively obvious point since it is reflected in (6), but nevertheless one worth making explicit, is that suppletive allomorphs of a morpheme may differ with respect to pivots—none, some, or all suppletive allomorphs may have a pivot (i.e., may be infixes). Further, even if more than one suppletive allomorph has a pivot, the pivot (and placement with respect to a particular pivot) can vary across these allomorphs. Having a pivot/placement is orthogonal to being the elsewhere allomorph.

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 2020b).

The implication of this finding is that it is not *morphemes* that have pivots (i.e., that are infixes), but rather, it is *exponents* of morphemes that have pivots. In other words, infixation (pivot and placement before or after the pivot) is exponent-specific, and thus can vary across suppletive allomorphs.

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 19 out of the 31 case studies involving suppletion), morphological (2/31), phonological (12/31), or prosodic (9/31) in nature.[6] All are exemplified below.

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

[6]Note that the cited numbers here do not add up to 31 because more than one conditioning factor may be involved in a single case study.

(7) 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*)

b. xU-[7]/ {GIVE, COME, BRING, EAT, CARRY}
   - e.g.: *x-gun*[8] ‘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:

(8) 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:

(9) 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:

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

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

[7] 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. 8.

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

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

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), semantic factors (whether the verb is stative or non-stative), and lexical factors (idiosyncratically exceptional verbs).

Overall, suppletive allomorphy involving an infix, then, is not fundamentally any different from more typical suppletive allomorphy. And further, the robustness of prosodic conditioning of allomorphy in this sample shows the need for (re-)prosodification at intermediate levels of morphological structure, interspersed with exponent choice.

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

The conditions on choosing an exponent are distinct from whether or not an exponent has a pivot/placement (is an infix), and what its pivot and placement are. This is trivially true in cases where exponent choice is lexically or morphologically conditioned, like for Lezgian and Leti above, but it is also true when both the condition on exponent choice and the pivot/placement are phonological or prosodic in nature. In Nakanai, (8), *-il-* is chosen as the nominalizer exponent when the stem is bisyllabic, and has as its pivot the stressed (penultimate) vowel. While these two conditions sometimes seem to conspire to produce a more "optimal" output, and so might be thought of as related, nevertheless the conditions are not the same as each other. (See §6 for more about optimization.) Comparable examples (some optimizing, some not) can be found below, in Bahnar, (11), Hunzib, (12), Nancowry, (15)/(16), and Alabama, (14). It is also possible (though less common) for the conditioning factor for exponent choice to overlap with the pivot, as in Toratán, (9), where it is the first consonant that matters for both.

Kalin and Rolle (2020) 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.[9] 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).[10] This is consistent throughout the sample, though an infix's edge orientation is not directly observable for cases of a prominence-based phonological 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 the infix's orientation is to the left or right edge. Assuming internal consistency, of the 31 cases involving suppletive allomorphy in the sample, 20 are analyzable as left-edge oriented, and 11 are analyzable as right-edge oriented.[11]

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 of an affix does not co-vary with the affix's (suppletive) form.[12] I therefore put aside this pattern as separate from the one at hand, and leave it as a topic for future research.

The fact that suppletive allomorphs of a morpheme share an edge orientation suggests 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 the exponents are then tied in some way to the morpheme's position (as a prefix or suffix). The following finding strengthens this conclusion.

[9] 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, Moravcsik's 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.

[10] In some cases, e.g., Alabama (see (14) 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.

[11] This asymmetry is almost certainly due to the overrepresentation of Austronesian languages in the sample.

[12] 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 are similar enough in phonological form that this may be a case of *non*-suppletive allomorphy, and thus is not (necessarily) a counterexample.

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

The edge orientation of allomorphs plays a crucial role—it is the relevant edge, and *only* this edge, that can condition suppletion. Suppletive allomorphs find their conditioning environment inwardly, from the perspective of the edge of the stem that is identifiable from its edge orientation, *even for infixes*.[13] This is most visible whenever phonology and prosody are involved in conditioning the allomorphy.

Consider the mainly phonologically-conditioned suppletive allomorphs involved in nominalization in Bahnar, (11). (The exponent in (11a), the sole case of lexical conditioning, is included for completeness.)

(11) 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, (9), 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 the verbal plural exponents in Hunzib, (12).

(12) Verbal plural in Hunzib (Northeast Caucasian, Dagestan; van den Berg 1995:81-82)[14]

a. -baa / *aa*-final stems[15]
 - e.g.: *ʔãqa-baa* 'be thirsty (pl)' (root: *ʔãqaa*) (van den Berg 1995:283)

[13] I have not found any examples of outward-conditioning of suppletive allomorphy involving an infix. While this result is expected for phonological and prosodic conditioning (which are generally only inward-looking), it is not expected with respect to morphological conditioning (see, e.g., discussions in Carstairs 1987, Bobaljik 2000, Paster 2006). I assume this is an accidental gap in my findings, related to the sparsity of morphological conditioning in the sample to begin with, cf. §3.2. See also §5.2 for related discussion.

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

[15] This condition on the suffix *-baa* is stated in accordance with the source's generalization. However, the only common long vowel in Hunzib is *aa* (van den Berg 1995:22), and so all the available data that I have found are actually compatible with stating *-baa*'s distribution more generally, as appearing after all stems that end in a long vowel. Thank you to Jack Merrill for this suggestion.

b. -ά-[16]/ elsewhere
- pivot/placement: before last consonant
- e.g.: *e<yά>k'e*[17] 'burn (pl)' (root: *ek'e*) (van den Berg 1995:295)

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 (12a): 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 (12a) and (12b) 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 (13), based on the same root:

(13) a. *ũcu* 'hide' → *ũ<wά>cu*[18] '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, (13a). When the verbal plural combines with a complex stem, it is the right edge of this complex stem that conditions allomorphy, (13b).

Another revealing example is found with the middle voice morpheme in Alabama, (14) (Hardy and Montler 1991).

(14) 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*[19] 'be eaten, food' (root: *pa*)

[16]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*.

[17]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 18 for more glide insertion in Hunzib.)

[18]As noted in fn. 17, when infixation of *-ά-* 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.

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

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 (14b), 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.

Finally, consider Nancowry's instrumental nominalizer, mentioned briefly in §3.1.

(15) Instrumental nominalizer in Nancowry (Austro-Asiatic, Nicobar Islands; Radhakrishnan 1981:60-64)

a. *-an-* / monosyllabic stems
  - pivot/placement: follows first consonant
  - e.g., *k<an>ap* 'tooth' (root: *kap*) (Radhakrishnan 1981:61)

b. *-in-* / disyllabic stems
  - pivot/placement: follows first vowel
  - e.g., *t<in>koʔ*[20] 'to prod' (root: *tikoʔ*) (Radhakrishnan 1981:97)

Kalin and Rolle (2020) show that there is opacity involved here, as well. On the basis of the underlying forms of the roots for the examples in (15a) and (15b), it is clear which allomorph to choose—one root is monosyllabic, the other is bisyllabic. But not so once infixation and vowel hiatus resolution has taken place: the output of infixation of the exponents is, in both cases, bisyllabic. (For more detail on this case study, see Kalin 2020b. Note, in particular, that there is *not* a constraint in Nancowry that prefers disyllabic outputs.)

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 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 concatenated with *and 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 suppletion involving an infix 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

[20] The first vowel is lost due to illegal vowel hiatus created by infixation after the first vowel.

edge-most position (see previous sections) and in its surface (infixed) position. For example, in Bahnar, (11), 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, (12), 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.

Nancowry's causative morpheme provides another perspective on this generalization, as discussed by Kalin (2020b):

(16) 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*[21] 'to loosen something' (root: *paloʔ*) (Radhakrishnan 1981:150)

As laid out in (16), *ha-* is a prefix appearing with monosyllabic stems, and *-um* an infix appearing with disyllabic stems. What is particularly informative here is that *-um-* actually ends up preceding a single syllable in its surface position, which is precisely the environment for the *other* exponent, *ha-*. Infixation clearly fails to feed prosodically-conditioned exponent choice. (The same point could be made with the earlier Nancowry case, as well, (15).) Thus, similar to the examples in §3.5, exponent choice must be made from an edge (the left edge in this case), looking inward at the underlying form of the stem, prior to infixation.

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

(17) 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*

(18) Invented example 2 (unattested)

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

[21] As also seen in (15), the first vowel is lost due to illegal vowel hiatus created by infixation after the first vowel.

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

Neither type of imagined stem-internal suppletion occurs in my sample. Perhaps this is expected where only one exponent is an infix, (17), but it also holds with respect to two infixes that have the same pivot/placement, (18).

Again strengthening the implications of the previous sections, exponent choice is made at 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, e.g., Hardy and Montler 1991, Goudswaard 2004, Yu 2017. I postpone discussing these cases until §6.3, where I will argue that they do not *necessitate* a global treatment nor falsify the present generalization.

3.7 Implications (cumulatively)

The picture of infixation and suppletive allomorphy that we are led to through the findings presented in this section is that 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).

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 non-suppletive allomorphy involves phonologically-derived and phonologically- or prosodically-motivated alternations. Further, the phonological processes involved may be language general ("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, 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.

The section unfolds as follows:

- §4.1: Non-suppletive infix allomorphy is conditioned only in surface (infixed) positions
- §4.2: No hypothetical position for an infix apart from its surface (infixed) position can induce non-suppletive allomorphy

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

Every subsection will include a brief statement of the immediate implications, which are brought together in §4.4 and then again with respect to the full set of findings in §7.3.

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

Alternations in non-suppletive infixal allomorphs 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 (10)—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—non-suppletive alternations are found in 36 of the 49 case studies. 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. The Hunzib verbal plural infix -α- takes an initial glide in certain phonological configurations (see fn. 17 and 18); this is again a case of restricted phonology—while the configuration being repaired is illicit in the language (distinct adjacent vowels), the repair itself (glide insertion) is different from the general hiatus repair process in the language (vowel deletion). Finally, there are a number of cases in the sample where a process is indeterminately but plausibly language-general, like in Bahnar, (11), which has very limited morphology in general—the suppletive allomorph *-ơn-* has several non-suppletive alternants, including *-ơd-* (e.g., *k<ơd>rŏu* 'fish poison') and *-ơng-* (*k<ơng>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 again glide insertion in Hunzib (fn. 17 and 18)—if the phonology could at any point "see" the infix *-ά-* at the morpheme's underlying (stem-final) position, we might expect the final segment of the stem to impact glide insertion. Take the root in (20), for example—if the phonology could see the infix in its hypothesized stem-final position prior to infixation, **αhu<α>*, we would expect glide *w* to be inserted to break up the *u<α>* sequence, producing (after infixation of the derived non-suppletive allomorph *-wα-*) the form in (20b), **α<wα>hu*; this is not borne out, (20a). Or, we might expect the underlying stem-final position of the infix to affect *which* glide is inserted, as it would be 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).

(20) Root: *αhu* 'take'
   a. Attested verbal plural: *α<ά>hu* (p. 284)
   b. Not attested: **α<wά>hu*

(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: In Nancowry, (15)/(16), infixation triggers deletion of the stem vowel in hiatus (see fn. 20/21); and in Alabama, (14), when infixation creates an illicit consonant cluster, a general process of vowel epenthesis is triggered (see fn. 19 and §6.3).

A restricted kind of phonological process affecting the stem is found, for example, in Lezgian, (7). Recall that the infix *-x-* is a lexically-conditioned suppletive allomorph of the repetitive, and surfaces after the first vowel. 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. 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. The phonology never sees the infix in its stem-edge underlying position.

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:

- §5.1: Infixes displace to their surface position inwardly, never outwardly

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

- §5.3: Infixal positioning may be opaque

The implications of these findings are discussed in §5.4 and brought together with the rest of the findings to inform a complete picture of infixation and allomorphy in §7.3.

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 49 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 a comparison of pivots found across different studies of infixation.)

5.1 Infixes displace their surface position 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 it *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, (10), 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). Of course, modeling (22) as resulting from stepwise morphological structure-building/exponence and infixation 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 step-wise derivation of this type of example, see §7.3.

A similar point can be made with the distributive object marker in Yuma (Cochimí-Yuman, USA; Halpern 1947b:93-94): this marker appears before the first consonant of its stem (the root), as in *a<c>n^{y}úv* ‘to be a fighter’ (from root *an^{y}úv*). Even when there is a prefix consisting of a single consonant, like *c-* ‘CAUS’ (Halpern 1947a:22)), the infix still must move into its stem to find its pivot:

(24) Yuma (Halpern 1947b:94)
c-a<c>k^{y}ew
CAUS-<D.OBJ>bite
‘to bite several times’

Like in Leti, the infix *must* find its pivot in the stem of infixation, and cannot find it outwardly, e.g., deriving **<c>ac-ak^{y}ew* in this case (this environment for the infix would trigger vowel epenthesis, hence the additional *a* after the infix in this hypothetical form). Again, a serial derivation where infixation precedes exponence of the outer affix offers an explanation, (25).

(25) ak^{y}ew → a<c>k^{y}ew[22] → c-a<c>k^{y}ew ‘to bite several times’

Thus, even in a complex word where the 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. The implication of the inward-only movement of an infix is that, at the point where an infix displaces into its stem, there is no phonologically-contentful “outer” material; in other words, infixation is cyclic and immediate.

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

[22] These intermediate forms are not defined in the source, though they are morphologically decomposed.

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*-, (12), which has as its pivot/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, that -*ά*- could appear 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*, (26).

(26) 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*, where -*ά*- (surface allomorph *yά*) satisfies its pivot/placement at the right edge of its stem, with respect to the outer suffix, -*n*.

The same can be seen at the left edge in Ambel (Austronesian; Indonesia), with respect to agreement marking. Class III verbs mark singular participant subjects with an infix -*y*-, which surfaces after the first consonant, e.g., *m<y>át* (<PARTIC.SG>die, 'I die', root: *mát*) (Arnold 2018:180). In the second person singular, such verbs additionally take a consonantal prefix marking second person, *N*- (a place-assimilating nasal). In such cases, the infix still displaces into its stem to find its pivot/placement, (27).

(27) Ambel (Arnold 2018:180)

n-t<y>um
2SG-<PARTIC.SG>follow
'you (sg) follow'

The infix cannot surface at the edge and satisfy its pivot with respect to the prefix, e.g., with some phonotactically repaired version of **n-<y>tum*.

Strengthening the conclusion from the previous section, the finding here shows that 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 ((14) 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. Epenthesis can create such opacity, as well as deletion, the latter found in Nancowry. In Nancowry, the causative infix *-um-*, (16), surfaces after the first vowel, and thus always creates illegal hiatus; this hiatus is resolved by deletion of the first vowel (cf. fn. 21 and 20)—in other words, the infix's pivot is deleted. In forms like *p<um>loʔ*, then, just like in Alabama, 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, we find 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.

6 On optimization: Core findings and implications

Finally, in this section I briefly consider the empirical landscape of this study in terms of optimization. I make a three-way distinction between optimizing, non-optimizing (i.e., not optimizing, but also not anti-optimizing), and anti-optimizing patterns. The findings are summarized as follows:

- §6.1: Suppletive allomorphy involving an infix may be optimizing, but often is not
- §6.2: Infixation may be optimizing, but often is not
- §6.3: Putatively globally optimizing cases can be analyzed locally and are sometimes not actually optimizing

As always, the final subsection, §6.4, summarizes the implications of these findings.

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) and 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 (10) and Lezgian (7) 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, (9), 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, (8), 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 mentioned thus far in the paper, and indeed in the whole sample, are non-optimizing. In Bahnar, (11), 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. Similarly, in Hunzib, (12), there does not seem to be any reason to prefer the infix or the suffixal allomorph, which are distributed based on whether the final segment is a long vowel or not. Note that suffixation of *-baa* always leads to stress shift and to vowel-shortening, and infixation of underlyingly stressed *-á-* in *-baa*'s environments would lead to precisely the same stem changes; similarly, infixation of *-á-* can lead to stress shift, and *-á-* does not always end up in the "naturally" stressed position (see fn. 16). Alabama's middle voice allomorphy is also non-optimizing (as will be discussed in detail in §6.3).

Two anti-optimizing cases come from Nancowry, (15) and (16), as discussed in detail in Kalin (2020b). Here I'll comment just on the causative, as represented in (16). Recall that the exponent *ha-* is chosen for monosyllabic stems, and *-um-* for disyllabic stems; the latter is an infix, which Kalin (2020b:7) argues is best understood as the infixal pivot/placement being after the first vowel. As discussed in fn. 20 and 21, as well as §5.3, infixation thus always creates illicit vowel hiatus that needs to be resolved by stem vowel deletion. The crucial observation for our purposes here is that *ha-* would make a perfectly fine prefix for all stems, not just monosyllabic ones; the choice of *-um-* over *ha-* leads to a phonotactic problem where there otherwise would not have been one, with no clear payoff.[23]

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 suppletion—see, e.g., 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. In Bahnar, (11), while there isn't an optimizing motivation for choosing between the two suppletive allomorphs *bơ-* and *-ơn-* (as discussed above), once one 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). Optimization of the TETU-type is found in Toratán, (9), with the VC exponent appearing after the first consonant, though this infixation is not motivated language-internally, as vowel-initial word/syllables are permitted. Similarly, infixation of *-il-* in Nakanai, (8), can be seen (as discussed above) as optimizing on the basis of maintaining stress placement.

Non-optimizing infixation is also found in many languages of the sample. Consider Hunzib's infixation of *-á-*, (12). The exponent *-á-* 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. 16). Lezgian, too, furnishes a case of non-optimizing infixation: the exponent *-x-*, (7), 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

[23]The only potential payoff of choosing *-um-* over *ha-* with bisyllabic stems is to maintain bisyllabicity. But, this is not motivated within the language—there is, in fact, another infix *-am-* (agentive nominalizer) that combines with bisyllabic stems and derives trisyllabic words (Radhakrishnan 1981:56-58). I leave as an open question whether this might be considered optimizing, as a TETU effect.

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. And in Nancowry, as well, looking again at the causative, (16), the *fact* of infixation of *-um-* is optimizing (to avoid an onsetless syllable), but the pivot/placement of *-um-* is anti-optimizing—it would be optimally placed before the first vowel, rather than after it, thereby avoiding vowel hiatus. (See Kalin 2020b.)

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, in general, 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. I leave it as an open question whether *all* infixes have pivots, or whether some are regulated simply by the phonology. (See also §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, rather than having suppletive conditioning environments. In this section we'll look closely at two such case studies, from Alabama (Hardy and Montler 1991) and Katu (Yu 2017).[24]

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:

[24] I will also mention two other cases very briefly here. First, Yu (2017) discusses another case study of putatively globally optmizing infix allomorphy, that of the Tiene stative/reversive (Niger-Congo; DRC), drawing on data and discussion in Hyman and Inkelas 1997. However, Nicholas Rolle (p.c.) notes that forms bearing the stative or reversive are extremely rare, with only 10 stative examples across all available sources, and 4 reversive examples. Further, only the stative actually shows the relevant allomorphy, with 4 examples of one allomorph, and 6 of the other. Given this rarity, Rolle argues that there is no productive morphology involved here at all.

The second set of case studies that bears mentioning is the past tense morpheme and dependent morpheme in Ida'an Begak (Austronesian, Malaysia; Goudswaard 2004, 2005). Goudswaard (2004) analyzes both as involving globally-determined suppletive allomorphy, with the first vowel in the stem crucially involved in regulating the choice between two infixes. However, I think it is likely that the data are analyzable with local conditioning at the left edge of the stem, in combination with some of the purported suppletive alternations actually being non-suppletive. I leave a complete re-analysis of this data for future work.

(28) 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 (29) (repeated in a simplified form from (14)).

(29) 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 the middle voice exponent (as an infix sometimes and suffix other times) is driven by the AVF, (28), 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 take a closer look at the distribution of the middle voice exponents, (30)–(31), and 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, (30b-c), then it'll take an infix so as to "preserve the configuration"; and (ii) if a stem does not conform to the AVF, (30a) and (31), then the stem will take a prefix (which I analyze as still being an infix) or suffix to "complete the configuration".

(30) 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[25] 'be sung, song'

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

a. tała →tał-ka[26] '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 heavy-light syllable, though often not through the affixation itself, but rather through phonological stem changes around the affix, in particular, vowel epenthesis in (30a,c) and vowel deletion in (31a).

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

[25] 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).

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

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 (30)-(31) 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 (29). 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.

I'll turn now briefly to Katu-L (Austroasiatic; dialect of Katu spoken in the Lao P.D.R.). As described by Costello (1998), nominalization in Katu takes a number of different forms, some prefixal and some infixal. Applying the decision tree in (6) to this data, and building on the discussion in Yu 2017, gives us the following suppletive underlying forms: *phar-, ar-, aN-, tar-, tri-, i-, -an-, -arn-*, and *-r-*. Costello (1998) presents the distribution of these suppletive forms as essentially arbitrary (lexical), not offering any generalizations.

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 infix *-an-* or *-r-*—are differentiated from each other on the basis of optimization. More specifically, considering just the lexically-circumscribed set of verbs (which itself is not predictable) that appear with either *-an-* or *-r-*, the available examples suggest that the choice between *-an-* and *-r-* is predictable: *-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)—assuming that Katu-L *prefers* bisyllabic words, the choice of *-an-* vs. *-r-*, as well as their infixal placement, can be predicted based on optimization (with other aspects of Katu-L phonotactics taken into account as well).

Yu (2017:5) takes this case study to support the conclusion that "global optimization, which crucially references the well-formedness of output structures, is needed in allomorph selection to complement the often times limited selectional power of subcategorization restrictions." However, I would like to raise two objections to this characterization of the Katu nominalizer. First, subcategorization is certainly capable of differentiating among monosyllabic and bisyllabic stems (see e.g. Paster 2005), and so the distribution of *-an-* and *-r-* is certainly describable without global optimization. Second, 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, eschewing the prosodic conditioning altogether.

In this section, I carefully considered two putative examples of optimizing infix allomorphy. For Alabama, I argued that the system is not, in fact, optimizing. And for Katu, I suggested that an account based on subcategorization (prosodic or lexical) is sufficient, and an account in terms of global optimization is not needed and perhaps not even desirable. In §7.2, I argue that suppletive allomorph choice uniformly precedes phonology. The main takeaway of this section is that putative cases where suppletive allomorph choice must be made *by* the phonology may be 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. And what is the fine timing of the morphosyntax-phonology interface? This is taken up in §7.3.

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: there *is* a step of linear concatenation, establishing a morpheme as a prefix or suffix, 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 morphosyntactic 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). But crucially, however, linear order is determined, this linearization must be established *prior* to both exponent choice and infixation.[27]

[27]Further, it must not be that *individual exponents* encode whether they precede or follow their stem (i.e., whether they are prefixes or suffixes), contra Inkelas 1990, Yu 2007, Sande et al. 2020, a.o. The findings here

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, (11), or a right-edge infix and a suffix, as in Hunzib, (12), 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 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 factors into 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 position with respect to the stem—suppletive exponent choice is thus made *at this edge*, and if an exponent is an infix, the exponent will subsequently displace to a position relative to that starting edge. Note that this also has implications for stating an infix's pivot/placement—"closest X" (and perhaps "second closest X") are statable, but not "first X" or "last X".

If there were no step of linearization of affixal morphemes with respect to the 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 three broad types for our purposes here.[28] One batch of otherwise diverse accounts holds that infixes do indeed concatenate first as prefixes or suffixes, and then undergo phonological displacement to become infixes (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 this family of accounts that is supported by the findings in this study in terms of their treatment of infixes as bona fide prefixes/suffixes, though only a subset of these accounts receives support once other findings are also considered (see §7.2-§7.3).

indicate that it is only deviant *re*-ordering (i.e., infixation) that can be encoded at the level of the exponent. (See also the discussion of mobile affixation in §3.4.)

[28]These three types map loosely, but not perfectly, onto Yu's (2007) groupings of accounts into (i) derivational versions of the Phonological Readjustment theory of infixation; (ii) constraint-based versions of the Phonological Readjustment theory of infixation; and (iii) versions of the Phonological Subcategorization theory of infixation.

On the other hand, there are two types of accounts that deny any derivational step of linearization prior to infixation—under these accounts, infixes take their infixed position *directly*, without stopping off first as a prefix or suffix. Some accounts in this broad category hold that, 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); the underlying designation of an affix as a prefix or suffix basically 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 group of accounts in the direct infixation category deny 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". 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 may specify "first X" and "last X", and this proximity to an edge has a historical source.[29] The findings of the present study argue against direct infixation approaches.

It is worth pausing for a moment to consider whether the present findings would be impacted if the division between suppletive and non-suppletive allomorphy were drawn in a different place, cf. (6) 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? This would mean, for example, reclassifying some of the infixal alternants in Leti, Hunzib, and Budukh (see §4.1) as involving suppletion. Importantly, this would not impact the specific claim of this section—that infixation is preceded by a step of prefixation/suffixation—because there are still clear cases (§3.5) of exponent choice needing to be made at the stem edge prior to infixation, even within languages (e.g., Hunzib) that would then *also* need to allow exponent choice to be made in the internal (infixed) position. This thought experiment is continued at the end of the following section, where it has a more significant impact.

[29]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). (Hyperinfixation is when an infix strays very far from its supposed abstract position as a prefix/suffix, potentially all the way to the other edge of the stem.) With respect to 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.

7.2 Suppletive allomorph choice precedes phonology

Can suppletive allomorph choice be regulated by considerations of phonological optimization? 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 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, Rolle 2020), 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, (9), to fit better with the morphology-with-phonology approach, but Bahnar's non-optimizing suppletive allomorphy, (11), 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 and independent of considerations of phonological optimization. While this does, necessarily, mean that some intuitive optimization-based explanations are lost, it may be that these optimizing systems are better captured diachronically rather than synchronically.

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 via subcategorization. Such cases are absent from my findings—see §3.6 and §6.3. 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* in the underlying edge-most (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? Indeed, 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. In turn, the subsequent finding (under this different division between suppletive and non-suppletive allomorphy) would be that suppletive exponent choice could be made in the edge-most 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 *for* characterizing what I label "restricted" alternations (phonologically-conditioned, phonologically natural, but not language-general) as non-suppletive, as encoded in (6). Specifically, all alternations of exponents that are conditioned in their surface/infixed positions involve a *small phonological distance* (on phonological distance, see §2.1) and are phonologically natural. Put another way, there are *no cases* of alternations conditioned in a surface/infixed position that involve a large phonological distance, or that are completely unmotivated phonologically/phonotactically. This is highly suspicious if suppletion could be conditioned either in the surface environment or in the underlying environment—if it could, then we'd expect the same range of phonological distance and (anti-/non-)optimizing alternations in the surface environment as found in the underlying edge environment. I therefore conclude that the inclusion of "restricted" alternations in the non-suppletive category is correct, 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).

(32)
a. suppletive exponent choice < infixation (§3.1, §3.6, §6.1)
b. linear concatenation < infixation (§3.4, §3.5, §7.1)
c. linear concatenation < suppletive exponent choice (§3.4, §3.5, §3.6)
d. infixation < (morpho)phonology (§4.1, §4.2, §4.3, §5.3, §6.2)
e. suppletive exponent choice < (morpho)phonology (§6.1, §6.3, §7.2)

Cumulatively across (32), the internally-consistent ordering arrived at is shown in (33).

(33) linear concatenation < suppletive exponent choice < infixation < (morpho)phonology

There is a derivationally early step of linear concatenation of morphemes, such that affixal morphemes are established as prefixes or suffixes on their stems. It is in this position that suppletive exponents are chosen. 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.

The findings of this study support *cyclicity* of exponent choice, infixation, and (morpho)phonology (in particular, (re-)prosodification). Cyclicity is used here to mean that a set of operations repeats with every morpheme, starting from the most embedded morpheme in the structure.[30] The evidence for cyclicity of exponent choice comes from the fact that suppletion based on phonological and prosodic factors is uniformly inward-looking, §3.5.[31] The evidence for cyclicity of infixation comes from the findings of §5—infixes only ever displace inwardly (§5.1) and can only satisfy their pivot/placement inwardly (§5.2). 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.[32] (See Kalin 2020b for a detailed case study of Nancowry making this argument on expanded grounds.)

Putting together cyclicity and the overall ordering in (33), I propose the following derivational timing of the morphosyntax-phonology interface.

(34) Derivational timing

a. Build the abstract morphosyntactic structure and linearly concatenate it

b. Go to the most embedded unexponed morpheme, and apply a cycle of morphology and morphophonology:

(i) Exponent choice (**suppletive allomorphy**)

(ii) Linear displacement (**for infixal exponents**)

(iii) Prosodification & restricted phonology (**non-suppl. "restricted" allo.**)

(Repeat (i)-(iii) until there are no more unexponed morphemes in domain)

c. Apply surface phonology (**non-suppletive surface allomorphy**)

A few ordering commitments made in (34) are underdetermined by the present findings. First is linearization, in particular, whether it applies over the whole structure prior to the

[30] 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. 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.

[31] Note that I did not find any examples that bear out the claim of Deal and Wolf (2017) that, in limited circumstances, outer exponents can be supplied first: I found no outward-moving infixes, no infixes that could be satisfied at the stem edge looking outward, and no outwardly-conditioned suppletive allomorphy.

[32] 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 2019a,b.

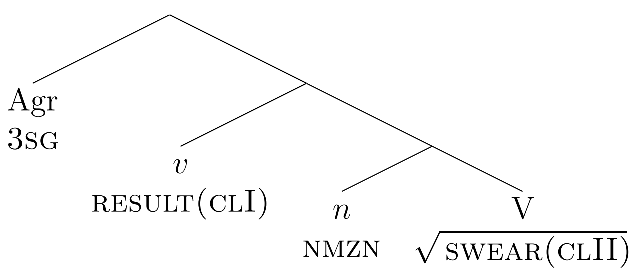
first step of cyclic operations, as represented in (34a), or whether it is the first of the cyclic operations in (34b). Second is whether infixation, (34b-ii), and early phonology, (34b-iii) are simultaneous or sequential. The fact that infixation can be opaque and non-optimizing/anti-optimizing, as seen in §5.3 and §6.2, indicates that sequentiality (as represented in (34)) 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 (34) works in practice, using the following example from Leti (Blevins 1999:389), cf. (19) and §5.1.

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

The first step is building the morphosyntactic structure, (36), and linearizing it, (37). I assume, building on the discussion in Blevins (1999:388), that a null *v* resultative head (not shown above in (35)) mediates between the inflectional prefix and the nominalized verb and is responsible for the classification of the derived form as Class I.

(36)



(37) [3SG- [RESULT(CLI)- [NMZN- [$\sqrt{\text{SWEAR(CLII)}}$]]]]

Starting from the most deeply embedded morpheme, the root, (38) through (41) will take you through (cyclic) exponent choice, infixation, and (morpho)phonology (prosodification not shown for this case, as it is not relevant), culminating in surface phonology, (42). (I assume class membership—indicated with subscripts on the relevant exponents—and morphological boundaries survive until surface phonology.)

(38) Cycle 1

a.	Exponent choice: $\sqrt{\text{SWEAR(CLII)}}$ → *lòkra*$_{II}$	*lòkra*$_{II}$
b.	Linear displacement: n/a	- - -
c.	Restricted phonology: n/a	- - -
→	Output:	*lòkra*$_{II}$

(39) Cycle 2

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

→ Output: *l<i>òkra*$_{II}$

(40) Cycle 3

a. Exponent choice: RESULT(CLI) → ∅ — ∅$_I$-*l<i>òkra*$_{II}$
b. Linear displacement: n/a — - - -
c. Restricted phonology: n/a — - - -
→ Output: ∅$_I$-*l<i>òkra*$_{II}$

(41) Cycle 4

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

(42) Surface phonology: n/a — *naliòkra*

The derivation here 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 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 case studies are listed in Appendix A, and the findings are listed in Appendix B (corresponding to the paper's section/subsection headings). 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.

The most major theoretical implications are that (i) infixes really are (underlyingly) prefixes/suffixes, (ii) suppletive allomorphy precedes phonology, and (iii) exponent choice, infixation, and morphophonology/prosodification are cyclic. These implications are very naturally accommodated within a general architecture like that assumed by Distributed Morphology (Halle and Marantz 1993, 1994, Embick 2010), providing strong novel support for this type of theory of morphology. 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). Similar conclusions have been reached by recent investigations of root-and-template morphology; see, e.g., Kastner 2019.

While I plan to expand the current sample in the future (especially to get better geographical and genetic coverage), and to extend the findings to neighboring domains—e.g., mobile affixation and allomorphy *around* infixes—I hope this study provides a useful backdrop for investigating individual patterns of allomorphy and infixation, and for informing models of morphology and phonology.

9 Appendix A: List of case studies

Table 2: Case studies (by family and language)

Language (country)	Morpheme	Edge	Suppl. 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
Sundanese (Sudan)	plural	left	(none)	Cohn 1992
Turoyo (Turkey)	past	left	(none)	Jastrow 1993, Kalin 2020a
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
	instrumental	left	prosodic	Radhakrishnan 1981
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	lexical	van den Heuvel 2006
	3sg subject	left	phonological	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 (mel.)	Teng 2008
	perfective	left	phonological (melody)	Teng 2008
Saisiyat (Taiwan)	agent voice	left	(none)	Zeitoun et al. 2015
Toratán (Indonesia)	AV past	left	phonology	Himmelmann and Wolff 1999
	UV past	left	phonological (melody), 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 1947b, Gillon and Mailhammer 2015
Huavean				
Huave (Mexico)	passive	right	lexical	Kim 2008
Kra-Dai				
Thai (Thailand)	specialization	left	(none)	Huffman 1986, Blevins 2014

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

Language (country)	Morpheme	Edge	Suppl. condition	Main source(s)
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	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
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	lexical, prosodic	Hirvonen 2020

10 Appendix B: List of findings

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

- On non-suppletive infix allomorphy
    - Non-suppletive infix allomorphy is conditioned only in surface (infixed) positions (§4.1)
    - No hypothetical position for an infix apart from its surface (infixed) position can (§4.2) induce non-suppletive allomorphy
    - An infix may condition phonological stem changes only in its surface (infixed) position (§4.3)
- On infixation
    - Infixes displace their surface position inwardly, never outwardly (§5.1)
    - An infix can satisfy its pivot/placement inwardly at the stem edge, never outwardly (§5.2)
    - Infixal positioning may be opaque (§5.3)
- On optimization
    - Suppletive allomorphy involving an infix may be optimizing, but often is not (§6.1)
    - Infixation may be optimizing, but often is not (§6.2)
    - Putatively globally optimizing cases can be analyzed locally and are sometimes not actually optimizing (§6.3)

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