Morphological Units: Stems

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1 Introduction

The term WORD, in one of its senses, refers to a pretheoretically accepted category, present in all languages and operationally definable, at least to a first approximation, as a minimal free form. But the several meanings of the term STEM are all theoretical constructs, neither universally instantiated, nor supported by untutored intuitions or operational tests. Not all theories countenance stems, and those that do define them in various ways, and situate them differently in relation to the equally protean abstractions ROOT, BASE, and LEXEME. Are roots stems of a special kind? Are they lexemes? Is every base of affixation and compounding a stem? These questions are partly about terminology, partly about substance, and their answers are contingent on assumptions about the grammatical architecture, especially the morphology/phonology and morphology/syntax interfaces. A stem is one thing in a theory that distinguishes morphophonology from suppletion, another thing in a theory that treats all stem alternations as allomorphy, and yet another in one that recognizes no morphemes at all.

Let us review the role of the stem from the springboard of two older grammatical frameworks with no aspirations beyond consistency, clarity, and completeteness.

Latin was taught in the Middle Ages through Donatus' 4th century *Ars grammatica*. This grammar represents morphology by PARADIGMS ('examples') of declensions and conjugations. Words contain no morphemes or stems; the inflectional base of a word is its citation form. Words are assigned into PARTS OF SPEECH on the basis of their referential properties and their ATTRIBUTES, and inflected by rules that change their final letter or syllable to express a subset of those attributes. For example, *potēns* 'powerful' is inflected for case and number by rules that modify its nominative singular citation form to Nom.Pl. *potentēs*, Dat.Pl. *potentibus*, and so on. This method of decription partly prefigures modern "a-morphous" realizational morphology (Zwicky 1992, Anderson 1992, Stump 2001, 2013, 2019, Luis and Spencer 2005), and even more so word-based morphology, which depends on operations defined on stored surface forms (Blevins 2006).

So-called traditional grammars, such as Lane (1898) and Smyth (1920), continue the practice of describing inflection by template paradigms, while enriching it by analyzing words into morphemes, grouped into intermediate stem constituents. In this hybrid approach, informed by 19th century comparative linguistics, and through it indirectly by Pāṇini's grammar of Sanskrit,[1]

[1] In the subsequent two centuries, more advanced Pāṇinian formal techniques and insights would continue to trickle through, including morphophonology, rule ordering and the privileged status of transparent order, the distinction between primary and secondary derivation, Blocking and the Elsewhere Condition, Thematic Roles, and inheritance hierarchies, making Pāṇinian grammar the most influential approach to morphology of all time (Kiparsky 2007, in press, Deo 2007).

a word consists of a stem and an inflectional ending, and the stem in turn consists of a root and zero or more derivational suffixes and stem formatives. The stem of *potēns* is *pot-ent-*, whose *-t* remains unchanged before vocalic suffixes, but fuses phonologically with the case ending *-s*.[2] The stem itself is built from of the root *pot-* (seen also in *pot-estās, pot-est, pot-ior* etc.) with the adjective/participle suffix *-ent-*. Stems may become part of ever larger stems through suffixation (*potent-ia, potent-iā-li-, potent-iā-li-ter*), prefixation (*im-, com-, prae-potent-*), and compounding (*omni-potent-*).

The introduction of roots and stems considerably simplifies the morphological description and reveals significant generalizations that cut across derivation and inflection. Inflectional classes can be characterized by assigning lexemes to one or more stem classes, and inflectional stems often become bases for derivational affixation and compounding (Aronoff 1994). But modern theories of morphology cash out these insights in divergent ways. Here we will look at three of them, outlining their main principles and illustrating them with their respective analyses of English verb inflection.

2 Paradigm Function Morphology

Paradigm Function Morphology (Stump 2001, 2013, 2019, Stewart and Stump 2007) is primarily a theory of inflection. It defines a language's inflectional morphology by a system of functions that relate lexemes, stems, paradigm cells, and the word forms that realize them (Stump 2019: 286). A CONTENT CELL in the paradigm of a lexeme L is a pairing of L and a property set σ. The **Stem** function applies to a content cell to yield the stem that realizes that cell. Inflection classes are purely formal classes of stems, with no syntactic or semantic correlates. They arise by PROPERTY MAPPINGS that apply to the morphosyntactic property sets of content cells to yield the property sets of the cells' form correspondents. This is illustrated by the derivation of the past tense form *leaned* (Stump 2019: 294).

(1) a. Content cell: ⟨LEAN, {fin pst}⟩
b. Property mapping: ⟨**Stem**(⟨LEAN, {fin pst}⟩), **pm**$^{\text{weak}}$ ({fin pst})⟩
c. Rule for {fin pst}: X → Xd
d. Realized cell: ⟨ *leaned*, {weak fin pst} ⟩

(1c) derives the past finite form of *lean* by a holistic operation: it does *not* add a suffix, but rather modifies the stem by appending a chunk of phonological material to its right edge. The remaining classes of past tense stems are generated by property mappings similar to (1) except that they perform different operations. These property mappings are restricted to subclasses of lexemes and thereby automatically supersede (1). For example, the operation for *meant* appends *-t* to the stem and laxes and lowers its vowel:

(2) a. Content cell: ⟨MEAN, {fin pst}⟩
b. Property mapping: ⟨**Stem**(⟨MEAN, {fin pst}⟩), **pm**$^{t\text{-class}}$({fin pst})⟩

[2]The *-s* is seen separately after other types of stems, as in *fēlix*, and the fusion applies to all coronal stems, e.g. *pot-es-tāt-s* → *potestās* 'power').

c. Rule for {*t*-class fin pst}: X → X′t
where X′ arises from X through the laxing and lowering of its stem vowel

d. Realized cell: ⟨ *meant*, {*t*-class fin pst} ⟩

For *built* the rule is X → X′t, where X′ arises from X through the devoicing of the final consonant, for *sang* it is X → X′t, where X′ arises from X by replacement of /ɪ/ by /æ/, for *spread* it is the identity mapping X → X, and for strong verbs it is X → X′, where X′ is X with another vowel.

The holistic character of PFM's stem-forming operation obscures some interesting structure that is apparent at a glance in (3), where the classes of past tense forms are grouped from fully regular stems to suppletive stems.

(3) a. Regular weak: leaned, shouted, leaped...

b. Irregular weak:

(i) No change (X → X): (1) rid, shed, spread, wed, (2) beat, beset, bet, burst, cast, cost, cut, hit, hurt, let, put, quit, set, shut, slit, split, thrust, upset, wet

(ii) /-t/ (X → Xt): burnt, dwelt, learnt, spilt, spoilt

(iii) /-t/ with shortening and vowel shift (X → X′t): bereft, crept, dealt, dreamt, felt, kept, knelt, leapt, left, lost, meant, slept, swept, wept

(iv) Shortening and vowel shift (X → X′): (1) bled, bred, fed, led, read, hid, slid, sped, (2) shot, lit, met

(v) Devoicing (X → X′): bent, built, lent, sent, spent

(vi) /-d/ with shortening and vowel shift (X → X′d): fled, heard, said, shod

c. Irregular weak with nucleus/rhyme replacement

(i) /-d/ with nucleus replacement to /oː/: sold, told

(ii) /-d/ with rhyme replacement to /u/: could, should, stood, would

(iii) /-t/ with rhyme replacement to /ɔː/: bought, besought, brought, caught, fought, sought, taught, thought, wrought

d. Strong

(i) Stem vowel → /ʌ/: hung, stuck, dug...

(ii) /ɪ/ → /æ/: bade, sang, sat...

(iii) ...

e. Suppletive: was, went...

The multifarious stem variation accompanying affixation in the subclasses of the irregular weak verbs (3b) shows intriguing subregularities that the property mappings leave unexplained. Why does the stem vowel lax (shorten) and lower before *-t* and not before *-d* — in other words, why [drɛmt] and [driːmd] but not *[drɛmd] or *[driːmt]? Why are laxing and lowering even coupled at all? How is the [iː] ∼ [ɛ] alternation in the property mapping (2) related to other instances of the same vowel shift alternation seen throughout the phonology and morphology, as in the first two syllables of *repeat* ∼ *repetition* ∼ *repetitive*? Why are the endingless forms in (3b.i), (3b.iv),

and (3b.v) restricted to verbs that end in *-t* or *-d*? What is behind the devoicing of *-d* in *send* → *sent* (3b.v)? Why are the weak past tense forms of the verbs in both (3a) and (3b) identical to the corresponding participles – indeed, with the same lexeme-specific pattern of variation, as in *burnt* ∼ *burned* and (with vowel shift again) *lit* ∼ *lighted*?

Morpheme-based theories answer such questions by distinguishing between affixation, morphophonology (word phonology), and suppletive allomorphy. Stratal approaches, such as Lexical Phonology and Morphology and Stratal OT (overviews: Kiparsky 2015, Bermúdez-Otero 2018) take this modularization a step further by having morphology interact with phonology at two lexical strata, STEMS and WORDS. Verbs of the "irregular" weak class (3b) then turn out to be regular. They have the same past tense suffix /-d/ as the (3a) weak verbs, only attached to stems, rather than to words, where they undergo the processes of the stem phonology, shown in (4) with the constraints that drive them.

(4) a. Closed Syllable Shortening: *V̄C in derived environments (see (5))

b. Final Devoicing: *[–vocalic][+voiced] in derived environments (see (5))

c. Degemination: *C_IC_I

d. Voicing Assimilation: *[+obstruent, αvoiced][+obstruent, –αvoiced]

Degemination and Voicing Assimilation apply across the board, and they have no exceptions. Closed Syllable Shortening and Final Devoicing apply only in morphologically derived environments ("Strict Cyclicity"):[3]

(5) a. Shortening in derived environments: ((kēp) t) → *kept*, ((mēt) d) → *met*, ((hīd) d) → *hid*, ((hīd) n) → *hidden*, ((mēn) d) → *meant*, ((hēr) d) → *heard*,

b. Length maintained in non-derived environments: (kēp) → *keep*, (mēt) → *meet*

Shortening has one lexical exception: *beat, beaten*. Shortening is regularly accompanied by vowel shift (Chomsky & Halle 1968), cf. [ri:ˈpi:t], [ˌrɛpəˈtɪʃn̩]. These processes operate throughout the stem phonology.

(6) a. Voicing Assimilation and Shortening (with vowel shift): /wīd-θ/ → *width*, /skrīb-t/ → *script*

b. Voicing Assimilation and Degemination: /æd-test/ → *attest*, /in-tend-t/ → *intent*

Stem-level Final Devoicing applies exceptionlessly to /-d/, which is the only voiced obstruent suffix that occurs at the stem level (assuming that in *dice* and *pence* are lexicalized as collectives rather than suffixed with plural /-z/ at the stem level).

Tableau (7) shown the derivation of the critical examples in the stem phonology.[4]

[3]Final devoicing applies after obstruents and nasals, but not after liquids and vowels, since they are [+vocalic], e.g. *heard, hid, fled*. Length is retained in *told, sold* because /ɔ/ is disallowed before *-ld* by a constraint that dominates (4a).

[4]Omitted from the tableau for space reasons is the Stem-faithfulness constraint (McCarthy:1999a), which ensures that Degemination (*C_IC_I) is satisfied by deleting the affix consonant, not the stem consonant. The candidates that are thereby excluded are also omitted in (7), sets B, C, and D.

(7)

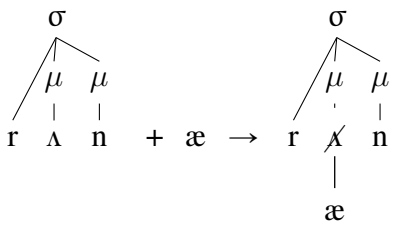
Stem level	*V̄C	*[–voc][+vcd]	*C_1C_1	*[αvcd][–αvcd]	IDENT(vcd)	MAX-μ
A. Input: ((mēn)d)						
1. ((mēn)d)	*	*				
2. ((men)d)		*				*
3. ((mēn)t)	*				*	
4. ☞ ((men)t)					*	*
B. Input: ((send)d)						
1. ((send)d)		*	*			
2. ((send))		*				*
3. ☞ ((sent))					*	
C. Input: ((brēd)d)						
1. ((brēd)d)	*	*	*			
2. ((bred)d)		*	*			*
3. ((bred)t)				*	*	*
4. ((brēd))	*					**
5. ☞ ((bred))						**
D. Input: ((lēv)d)						
1. ((lēv)d)	*	*				
2. ((lev)d)		*				*
3. ((lev)t)				*	*	*
4. ☞ ((lef)t)					**	*
E. Input: ((mēt)d)						
1. ((mēt)d)	*	*		*		
2. ((med)d)		*	*			*
3. ((met)t)			*			*
4. ((mēd))	*				*	*
5. ((mēt))	*					*
6. ((med))					*	**
7. ☞ ((met))						**
F. Input: ((flē)d)						
1. ((flē)d)	*					
2. ☞ ((fle)d)						*
3. ((fle)t)					*	*
G. Input: (mēn)						
1. ☞ (mēn)						
2. (men)						*

The reader may verify that the analysis solves each of the six puzzles that we raised about (3).

For non-concatenative morphology, instantiated by the strong verbs in (3d), Prosodic Morphology offers an insightful alternative to property mappings (McCarthy and Prince 1995). Like PFM, it recognizes that non-concatenative morphology is functionally equivalent to affixation, but

instead of treating affixation as stem modification it does the reverse. Generalizing the classical morpheme, it treats non-concatenative morphology as the addition of affixes whose phonological content is a feature bundle with no segmental or syllabic structure, or a syllable structure. Such underspecified morphemes are combined with their base by the association procedures of autosegmental phonology; simple concatenation is then just the special case that arises when morphemes consist of fully specified segments. The association procedures obey principles which are needed anyway in phonology, including locality, directionality, the OCP, and extrametricality. The simplest analysis of English strong verbs is that their past tense and past participle morphemes are floating vowels (vowels that lacks a skeletal anchor) that overwrite the inherent vowel of the verb. For example, the past tense morpheme in *sang* is a floating /æ/, which associates to the nearest syllable peak, and replaces its underlying distinctive vowel features.

(8)



In addition to mutations in segment structure (umlaut, ablaut, lenition), syllable weight, and tone, Prosodic Morphology has successfully addressed phenomena such as infixation, intercalation, metathesis, subtraction, reduplication, echo-words, ideophones, blends, and portmanteaux.

Since PFM already countenances automatic phonology, there would seem to be no principled barriers to implementing morphophonology and prosodic morphology in it. The idea is to move the regular phonological parts of property mappings from the morphology into the phonology to capture the regularities in (4) and to gain a more restrictive typology of property mapping functions. Even better, cyclically interleaving the phonology with the genuinely morphological part of property mapping would endow PFM with the ability to account for base-to-output inheritance effects, and for phonological as well as morphological conditioning of allomorphy and morpheme selection, including their respective locality effects. The real obstacle that PFM poses for an adequate treatment of morphophonology is its rejection of morphemes and of constituent structure in words.

3 Distributed Morphology

Distributed Morphology (DM) is also a realizational approach, but its input comes not from a morphological paradigm-generator as in PFM, but from syntax. Syntactic Merge produces constituent structures that terminate in abstract bundles of morphosyntactic features, which are spelled out by vocabulary items, and may undergo deletion and reordering operations.

A unique tenet of DM is that lexical words are based on monomorphemic category-neutral ROOTS, which only become nouns, verbs, or adjectives by an overt or null derivational affix (Embick 2015: 55, Harley 2014). From any other theoretical perspective, deriving all ostensibly atomic lexical items such as *cat* and *sing* from categoryless roots with null nominalizers and verbalizers is a pointless complication.

DM rejects the category of stem. Embick & Halle (2005) criticize the proposal by Zwicky 1990, Anderson 1992, Aronoff 1994, and others that stems are listed in the lexicon, and argue that stem storage should be reserved for outright suppletive alternants of the *go/went* type. Their arguments are cogent, but fall well short of showing that stems have no place in morphology. Many morphological theories define stems structurally in terms of the morphological derivation, with no intrinsic commitment to lexical storage. This includes stratal approaches, where stems constitute a well-defined domain of phonology and morphology. But DM's deeper, unarticulated reason for rejecting the stem/word distinction is that it is a purely morphological distinction, justified by morphological and phonological evidence, and to some extent even by lexical semantic evidence, but not grounded in syntax. I will give three arguments for recognizing stems.

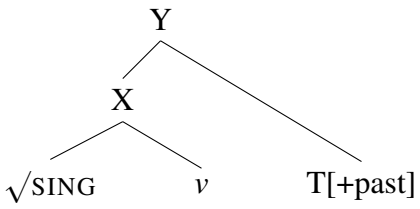
My first argument is that stems are needed to account for level-ordering effects. Even though DM (unlike PFM) readily accommodates morphophonology, its lack of any counterpart to the stem/word distinction complicates its analysis of verbs of types (3b,c). DM treatments of English past tense, much like structuralist ones, end up positing different past tense allomorphs /-t/, /-d/, and -∅, which trigger various effects on the stem (Halle & Marantz' 1993, Embick & Halle 2005, Embick 2015: 194). Since the stem-level shortening in *sleep* → *slept*, *meet* → *met*, *hear* → *heard* is inapplicable to regular word-level past forms like *steeped, heated, feared*, it is effected by a READJUSTMENT RULE, that is, a phonological rule "triggered by certain morphemes, or that are specified to apply to certain morphemes and not others" (Embick 2015: 202, Halle & Marantz 1993: 7). In a different DM analysis of these data, Siddiqi (2019) posits for *dreamt* both an irregular stem and an irregular affix, and for *slept* an irregular stem and a regular affix. The stem allomorphy analysis seems to offer no gain in generality over the readjustment rule of Embick, Halle, and Marantz.

Note that the stem/word distinction cannot be reconstructed by DM's distinction between uncategorized roots and categorized constituents. In particular, to replicate the stratal analysis of strong verbs of section 2, the /-d/ that spells out feature [Past] would have to be mapped by a phonology of uncategorized roots such as (7) into (3b), and by a phonology of categorized elements into (3a). This cannot be done in the current architecture of DM, because roots must be verbalized by a suffix to receive Tense morphology, after which they are no longer roots.

For type (3b.i) weak verbs like *put*, and for all strong verbs, DM analyses posit a null past tense suffix, which can trigger readjustment rules that rewrite the nucleus (or syllable rime) of the stems in various ways; for example, in *sing* it conditions a rule that turns /ɪ/ to /æ/.[5] This approach to stem alternations was sharply criticized by Stump (2001): "What emerges is a grand coincidence: again and again, both within and across languages, a default affix is overridden by an empty affix whose presence triggers a readjustment rule; this recurrent pattern is portrayed not as the consequence of any overarching principle, but as the accidental effect of innumerable piecemeal stipulations in the lexicon of one language after another." Embick (2017) proposes instead that strong verbs are parts of complex lexical items which are inserted into non-terminal nodes; the past tense allomorph *sang* in (9a) is inserted in (9b).

[5]The verbalizing morpheme v is first realized as -∅, deleted immediately after readjustment rule it may trigger takes effect, after which T[past] is realized as -∅, triggers /ɪ/ to /æ/ readjustment, and is immediately deleted. This order is needed to capture the now-you-see-them-now-you-don't behavior of DM's empty morphemes, producing in the case at hand the wrong past tense form **sing*.

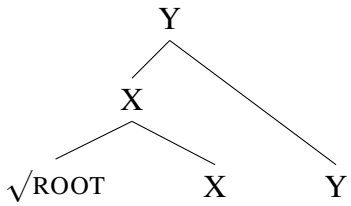
(9) a. $\sqrt{\text{SING}}$,T[+past] ↔ sang
$\sqrt{\text{SING}}$ ↔ sing

b. 

Allomorphy is appropriate for dealing with suppletive alternations such as *went* and *was*, as Minimalist Morphology does (except that it has no lexical insertion). But is not appropriate for ablaut and similar morpholexical processes, which involve phonological patterns of segmental alternation, subject to phonological locality, as is duly recognized both in the earlier DM analysis of it by readjustment rules (*phonological* rules triggered by specific morphemes), and in the Prosodic Morphology's floating vowel analysis (8). About a dozen verbs form their past tenses with *æ*, and generalizations like *brang* are observed in child language. In this respect treating *sang* as a suppletive allomorph of *sing* is a step backward, and towards PFM-style holistic replacement operations on stems, open to the same objections that Embick & Halle (2005) raised against stem storage (section 2).

Fortunately nothing in DM commits it intrinsically to treating non-concatenative morphology by readjustment rules or allomorphy, *pace* Embick 2015:202-6. Indeed, more recently DM has moved towards adopting Prosodic Morphology (Bermudez-Otero 2012aa, Bye 2012, Gribanova 2014, Trommer 2015, Paschen 2018).

Recent versions of DM posit two layers of affixes: an INNER layer which is added to categoryless roots, comprising suffixes like *-ion*, *-al*, *-ity*, and *-ize*, and an OUTER layer which is added to category-bearing elements, which may include these same affixes and also affixes like *-ness*, which are not part of the inner layer (Embick and Marantz 2008, Embick 2015: 55, 199, Marantz 2013). This is not the same distinction as that that between stem-level and word-level affixes, for however much affixes like *-ion*, *-al*, *-ity*, and *-ize* stack, they do not start behaving like word-level suffixes, either in their morphological combinatorics, or their phonological and semantic properties. It is formally motivated by DM's locality conditions on the selection and interpretation of constituents, and its treatment of blocking as a relation between rules rather than between output expressions. Embick & Marantz (2008: 11) formulate constraints on structures of the form (10) (where order is irrelevant and only the hierarchical relations matter) that have the following effects.

(10) 

a. The combination of a root with a root-attached (inner) affix X may yield a special interpretation. An affix Y attached in the outer domain yield predictable interpretations.

b. The realization of an inner affix X may depend on the root. The realization of an outer affix Y may not depend on the root.

Enforcing conditions (10a,b) leads to underparsing of word structure. Consider cases such as *centrality*, *tonality*, *eventuality*, and *Christianity*, where the inner head X is an adjective head realized by *-al* or *-an*, and the outer head Y is a noun head realized by *-ity*. All is well with the first example: *centrality* predictably means 'the property of being central', and *-ity* is productively added to adjectives in *-al*. But *tonality* means not only 'the property of being tonal', but also 'musical key', and an *eventuality* is not a property but a possible event. So by (10a), these words must be derived with an inner nominal head from $\sqrt{}$*tonal* and $\sqrt{}$*eventual*, which, since they are roots, are unrelated to the nouns *tone* and *event*. And *Christianity* denotes not only 'the property of being Christian', but also a religion and its adherents collectively, and on top of that *-ity* is not productively added to adjectives in *-an*. So both (10a) and (10b) require *Christianity* to be derived from a root $\sqrt{}$*Christian*, unrelated to *Christ*. This does not do justice to the morphological makeup of these words. DM's aversion to the decomposition of lexical morphemes may seem inconsistent with its embrace of numerous invisible functional morphemes, such as the null nominalizer in *cat*, but in fact both are natural consequences of using sentential syntax as the generative engine of word formation.

Besides creating irregularity where there really is none, this line of analysis introduces a locality problem. Condition (10b) would prevent allomorphic selection between roots and inflectional morphology across null verbalizers or nominalizers. That requires adding to the theory an additional proviso that empty nodes with no overt exponents become invisible after they have selected allomorphs and triggered readjustment rules and before the effects of the next morpheme are computed (Marantz 2013: 99, Embick 2015: 185).[6]

Another formal argument against the formulation of the locality principles at (10) is based on prefix+root stems. They generally have non-compositional semantics, and yet the root of the stem is visible to phonology and morphology (Aronoff 1976). Prefixed monosyllabic roots such as *com-mít, re-mít* contrast systematically with monomorphemic polysyllabic roots such as *vómit, límit* in stress as well as in affix selection:

(11) a. commission, remission, committal, remittal, vs. *limission, *vomission, *limital, *vomital

b. *commitation, *remitation, *committive, *remittive, *committory, *remittory vs. limitation, vomitive, vomitory

Since the root determines the suffixation pattern, it must be visible to the derivational head Y in the structure (10) at spellout. But the locality principles do not allow the realization of Y to depend on the root. Moreover, (10a) denies Y access to the internal structure whenever the nominalizations have non-compositional meanings. But a *commission* can be a judicial or administrative body, or a payment for an agent's services, and these meanings cannot be derived from the meanings

[6]Embick implements the invisibility by means pruning empty morphemes, so that nodes separated by them become adjacent ("concatenated"). The pruning operation expunges empty morphemes *after* they have selected allomorphs or triggered readjustment rules, and immediately after they are realized as -∅.

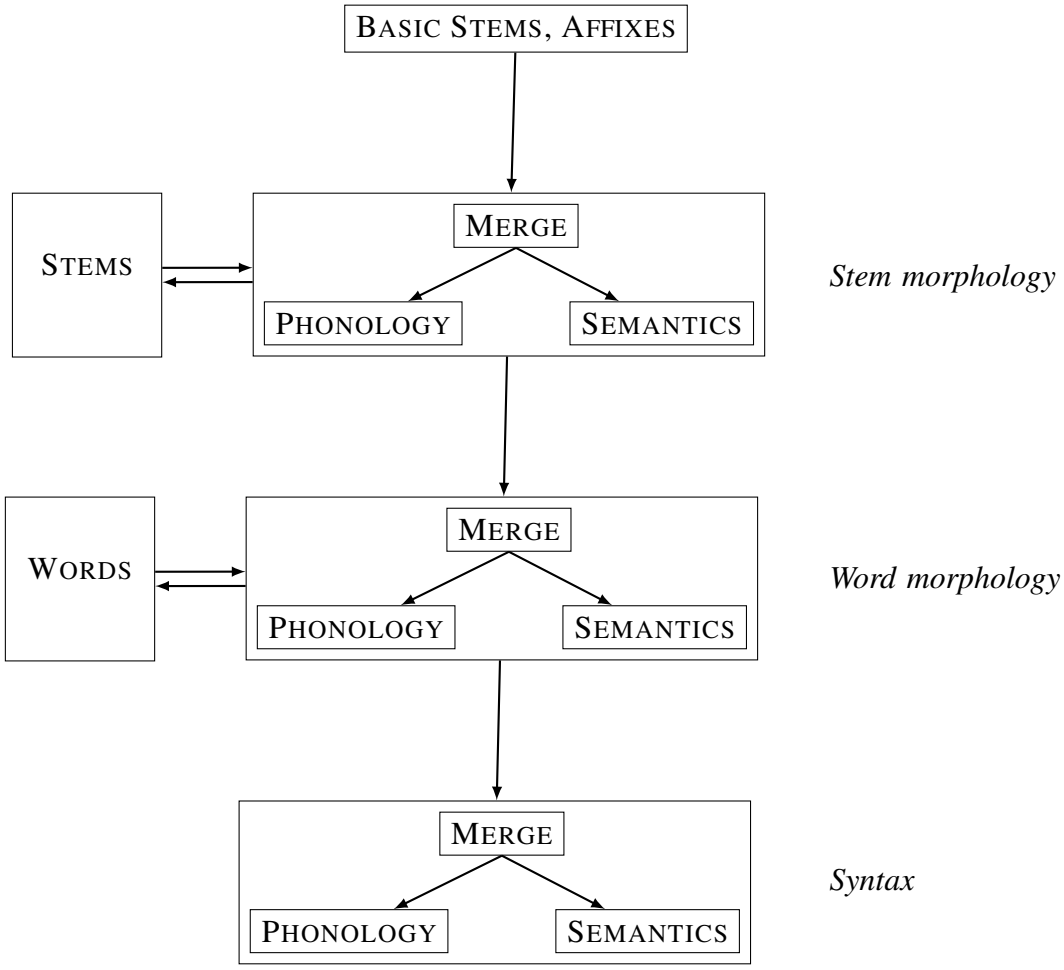
of *commit* and *-ion*, let alone from *com-*, *-mit*, and *-ion*. So *commit* must be a root, like *vomit*. But for stress, root allomorphy, and affix selection it has to be a prefix+root structure. This is a contradiction.

The upshot is that, contrary to (10), the immediate constituents of a stem are visible to the next round of merge even if the structure is unproductive or non-compositional, and that semantic and phonological properties, including idiosyncratic ones, are cyclically inherited in the derivation. Moreover, DM's lack of a stem level makes it ill equipped to support stratal morphology and phonology, and causes unnecessary formal complications and loss of generalization.

4 Minimalist Morphology

The version of Minimalist Morphology adopted in Stratal OT (Wunderlich 1996, Wunderlich & Fabri 1994, Kiparsky 2019) merges stems and affixes and incrementally computes the morphosyntactic, phonological, and semantic properties of the resulting combinations from the properties of their parts. Thus, Minimalist Morphology unifies morphology and syntax as phases of one combinatoric system. Merge applies recursively in the morphology to derive fully interpreted words that are inputs to the syntax, where it continues, but subject to syntactic locality constraints. The correlation between phonology and derivational potential is modeled by organizing the morphology into two strata, the stem level and the word level.

(12)



The morphology is INTERACTIONIST in the sense of Scheer (2011), in that morphological combinations are phonologically and semantically interpreted as soon as they are formed. Because affixes attach to bases and not to each other, morphological derivations are necessarily bottom-up (stem-outward).[7] Bracketing erasure takes place when a new head is added. Thus the root in *com-mit* is visible when *-ion* is added but becomes inaccessible in the next cycle. *A fortiori* the morphological provenience of morphosyntactic features is invisible to the syntax, where *cleaned, dreamt*, *met* and *went* are just past tense verbs, and *dogs, men,* and *cattle* are just plural nouns.

The interleaving of word-building and interpretation, coupled with bracketing erasure, accounts for morphological locality effects, determines the semantic scope of morphemes in words, and constructs the binary right- or left-headed constituents on which structural relations such as C-command within words are defined. It predicts, without further stipulation, cyclic inheritance effects in lexical phonology, the Mirror Principle, and the inward sensitivity of morphological selection, all of them manifestations of the same architectural commitment.

The basic categories are STEMS and WORDS. The correlation between phonology and derivational potential is modeled by organizing the morphology into two strata, the stem level and the word level. Stem affixes are attached to stems to produce a stem, word affixes are attached to words to produce a word. FREE stems can be promoted into words, which then accept word suffixes. TERMINAL AFFIXES (such as *-ity*) allow no further derivation at their level, so that the constituents they head *must* be promoted.

In the spirit of minimalism (Chomsky 1995: 246), lexical items which do not undergo stem-level derivation can be lexically entered as words. For example, *elephant* originates in the lexicon as a stem of the category Noun, and hence allows stem derivatives such as *elephantine, elephantic, elephantoid, elephantous, elephantiasis, elephanticide, elephantologist*, as well as word derivatives such as *elephantlike, elephantish*, while *cat* is just a word of the category Noun, and only allows word derivatives like *cats, catty, cattish, cattery, catlike, catese, cathood, catness*. The verb *sing* originates in the lexicon as a stem, on which the inflected forms *sang, sung* and the derivative *song* are built, while *fling* is just a word. *Long* is a stem, as revealed by derivatives like *longitude, longevity, elongate, prolong, length, lengthen*, while *wrong* is just a word; that is why the comparative of *long* is *longer* /lɔŋgər/ whereas the comparative of *wrong* is *wronger* /rɔŋər/, where the treatment of /ŋg/ reveals the category of the base. All these stems are FREE: for example, the stem *long* yields a word *long*, from which e.g. *longish, longness* are derived. An example of a BOUND stem is *pap-* (*papal, papacy*), which corresponds to the word *pope* (*popish, popedom*). Bound stems are not cyclic constituents, hence they are not subject to prosodic minimality or derived environment effects, and enter into mutual selectional relations with their affixes (see (16) below).

Affixes are specified for whether they get attached to stems or words, and what the category of the resulting combination is. For example, the representation of the derivational suffix *-ee* of *draftee, detainee, invitee, standee* includes at least the information in (13):

(13) a. Phonological form:

[7] Contrast DM, where the order in which affixes are spelled is not intrinsically related to the order in which they are compositionally interpreted, and must therefore be ensured by an extrinsically imposed constraint (Embick 2010: 42).

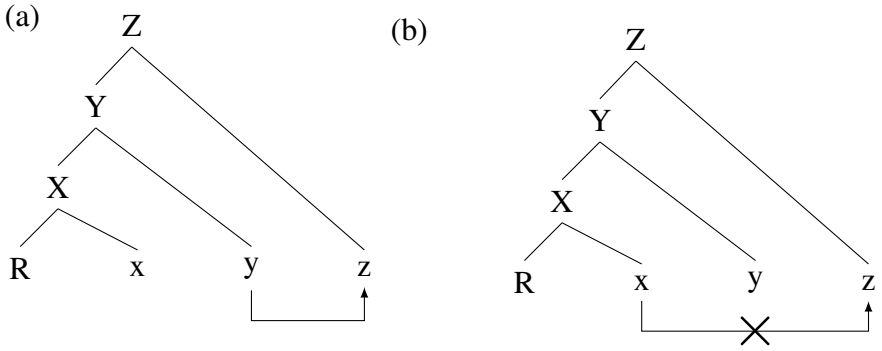
b. Morphophonological properties (indexation, Pater 2010):
ALIGNRIGHT > NONFINAL (attracts main stress)
MAX(STRESS) > *CLASH (preserves the foot structure of base)

c. Meaning: the set of human individuals that are the Undergoer of some event
$[\![/e:/]\!] = \lambda P \lambda x \lambda e[P(e) \wedge \text{human}(x) \wedge \text{Undergoer}(e,x)]$

d. Categorial and subcategorization properties:
$]_{\text{Word,N}}$ ___ $]_{\text{N}}$ (turns Words of the category Verb into Nouns)

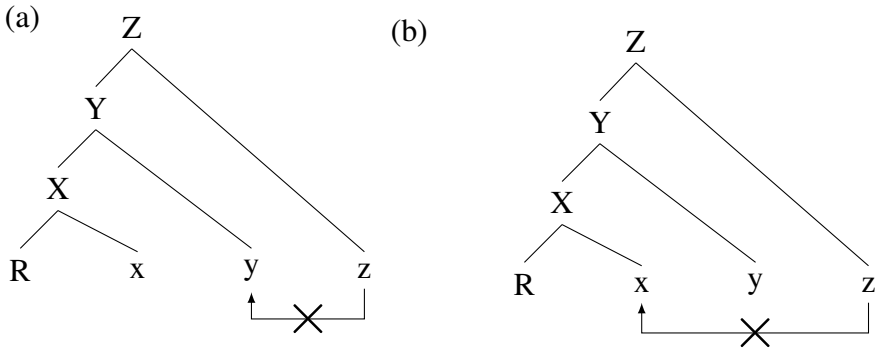
Inward dependencies must be local head-to-head dependencies:

(14) a. z can depend on y and on Y, and y can depend on x and on X
b. z can't depend on x or on R, and y can't depend on R

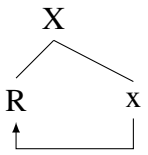


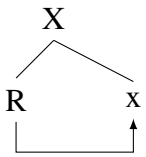
Outward morphological dependencies, even local ones, are entirely ruled out:

(15) a. y can't depend on z,
b. x can't depend on y or on z,
c. R can't depend on y or on z



Since roots are not cyclic categories, it follows that in the first cycle, roots can morphologically depend on their sister affixes and vice versa.

(16) (a) 

(b) 

The issue of semantic idiosyncrasy that we raised in the preceding section can now be placed in a larger context. Because complex words inherit separate phonological, morphological, and semantic properties from their components, derivatives may be exceptional in some ways and regular in others. Items generated by the morphology are interpreted and become inputs to any further applicable morphology. The interpretation may involve the assignment at any stage (not just an inner layer as in DM) of idiosyncratic restrictions or modifications of the properties otherwise inherited by default, which are then passed on to their derivatives. An example of idiosyncratic semantics is the following. The words *insane, sanity, saneness* derived from *sane* 'of sound mind' are phonologically and semantically regular. With the root extension *-it*, *sane* produces a bound stem *san-it-* with a special meaning 'hygienically clean', inherited by its derivatives *sanitize*, *sanitary*, *sanitation*, and in turn passed on to their derivatives *sanitization, sanitizable, sanitizability, insanitary, unsanitary, sanitariness*. This exception has in turn an exception, *sanitarium*, where *san-it-* combines with *-arium* in the special meaning 'institution for the treatment of convalescents and invalids', which would then be inherited by its derivatives. It would be absurd to locate all these meanings of the derived words in the root, like the homunculus of 18th century preformationist biology.

5 Stems and words as morphological levels

The LEVEL-ORDERING HYPOTHESIS says that phonology and morphology are interleaved and operate at two levels, the stem and the word. Its core empirical claim is that these two levels are identified by constituency and affix ordering as well as by their proprietrary phonologies (Allen 1978, Siegel 1979, Giegerich 1999, 2005, Kiparsky 2015, Bermudez-Otero 2018; this conspectus draws on Kiparsky 2019). In English the phonological diagnostics of word-level morphology include hiatus, syllabic sonorants at the suffix boundary, coda clusters, stressed light syllables, superheavy syllables, stress clashes and lapses. The two productive adjective-forming suffixes *-ish* and *-ic* will serve us as a minimal pair to illustrate this correlation between morphology (17a,b,c) and phonology (17d-i).

(17) a. *Bound bases* require *-ic*: *diabolic* vs. *devilish*.

b. *Word suffixes* can precede only *-ish*: *farmerish, insiderish, painterish, middlingish, rustyish, steadyish*, vs. **-er-ic*, **-ing-ic*, **-y-ic*.

c. *Fixed phrases* productively host *-ish*: *bad karmaish, big cityish, couldn't-care-lessish, devil-may-care-ish, Franco Zeffirelli-ish, go-aheadish, good-fellowish, Norman Rockwellish, old fogeyish, old masterish, out-of-townish, small townish, Lord Byronish, sore-thumbish, symbolic-logicish*. Unproductive with *-ic*: **behavioral scientific, *closed syllabic, *environmental catastrophic, *heavy metallic, *Lord Byronic, *Jespersen's cyclic, *Indian Oceanic*. Exceptions ("bracketing paradoxes"): *electron microscopic, linear algebraic, ?non-Euclidean geometric*.

d. *Stress: -ic* is pre-stressing, *-ish* is stress-neutral: *Babylónic* vs. *Bábylonish*.

e. *Presuffixal (trochaic) shortening*: *Pre-Ràphaelı̋tic* vs. *Pre-Ráphaelı̀tish* (exception: *Spanish*).

f. *Hiatus:* Prevocalic lax vowels (such as [ə] and [ɪ]) are not allowed at the stem level. Violations with *-ic* are removed in three ways: (i) by deletion, e.g. *allometric (< allometry), amoebic (< amoeba), Anatolic, aortic, diasporic, Haggadic, hierarchic*, in the case of *-a* also (ii) by lengthening (*choleraic, formulaic, Mishnaic, stanzaic, Voltaic*) and (iii) by epenthesis (*Asiatic, enigmatic*). Word-level *-ish* admits hiatus: *busyish, earlyish, familyish, gloomyish, Pollyannaish, primadonnaish, puppyish, thirtyish*.

g. *r-vocalization:* [r] in *cylíndric* vs. [ɻ] in *cýlinderish*.

h. *l-velarization*: many American dialects have dark [ɬ] in *hellish* but light [l] in *angelic*, like *belly*.

i. *Word-final coda simplification*: [ŋg], [nʤ] in *diphthongic, phalangic* vs. [ŋ] in *strongish, wrongish, youngish*.

The level-ordering hypothesis predicts what is arguably the single most far-reaching overall generalization about affix ordering in English, that stem-level affixes come inside word-level affixes in words. Stem-level suffixes precede word-level suffixes, stem-level prefixes follow word-level prefixes, and when the affixes are on opposite sides of the word, the stem-level affix is closer to the base in the constituent structure. For example, *humor-ous-ness* is a possible word (an actual one, as it happens), but **funni-ness-ous* is not a possible word. This aspect of the level-ordering hypothesis has been often criticized by morphologists working on English (see most recently Saarinen & Hay 2014 and Lieber 2019). The scepticism is largely due to a failure to appreciate the scope and nature of the theory's claims, although serious conceptual and empirical issues certainly remain. Some of the commonly underappreciated points supporting level-ordering are the following.

Level-ordering pervades the phonology. Identifying stem-level derivational suffixes as stress-shifting and word-level derivational suffixes as stress-neutral is a tempting but erroneous shortcut. For example, *-ee*, *-esque*, and *-ette* regularly bear the main word stress, but in the first place final stress is *not* a stem-level property, and moreover by every applicable morphological and phonological criterion these are actually word-level suffixes. The reliable stress diagnostic of a stem is that it obeys the quantity-sensitive English (Chomsky & Halle 1968).

Level-ordering pervades the morphology. It is not just about derivational affixes. As pointed out above, the two layers also divide inflection, e.g. *slept* vs. *leaped*, *sat* vs. *flitted*, also in nouns: *mice* vs. *rats*, *caucuses* vs. *stimuli*. They are also pertinent to compounding, as in the types *handcuff* vs. *handcart* (Allen 1978: 129). Kiparsky (2019) documents 82 stem suffixes and 48 word suffixes for English.

Most morphologies are level-ordered. Cross-linguistic support for level-ordering has been found for about 40 languages so far.[8]

[8]Kikamba (Roberts-Kohno 1998), Hebrew (Koontz-Garboden 2001), Auca (Kim 2003), Russian (Blumenfeld 2003, Gribanova 2008), Finnish (Kiparsky 2003, 2019, Anttila 2006), Portuguese (File-Muriel 2004, Bermúdez-Otero and Luís 2009, Bisol 2016), English (Collie 2007, Turton 2016), Nuuchahnulth (Stonham 2004, 2007, 2009),

Not all affixes on a given level must have identical phonology. Contra Raffelsiefen (1999), variation need not be dealt with by positing additional subtrata. For example, as noted above, the word level contains suffixes with inherent primary stress as well as unstressed suffixes. Their inherent stress can be encoded as an inherent stress in the lexical entry. More generally, exceptional behavior of affixes can be represented in Stratal OT by coindexing them with a constraint ranking (Pater 2006). Strata are *systematic* groupings and multiplying them for the sake of idiosyncrasies affords no insight and just complicates the grammar.

Level-ordering is compatible with additional ordering restrictions within a given level (contra Haspelmath & Sims 2010: 228). Some affix combinations are excluded simply because they would produce no useful compositional meaning, e.g. **falsityhood, *weirdnesshood* 'the property of being the property of being false/weird'. Some affixes have phonological requirements that restrict their distribution: **realizal* is not a possible word because nominalizing *-al* needs a base with a final main stress. In addition, there are purely arbitrary selectional constraints, such as those that rule out the combination **-less-hood*, as in **aimlesshood*.

Level-ordering is independent of the stratification of the vocabulary into native and non-native (or "Romance") items. They weakly correlate, but they certainly do not coincide. Each stratum contains native and non-native lexical and functional vocabulary. The *-al* of *signal* is a stem suffix and the *-age* of *signage* is a word suffix, but both are non-native. The abovementioned word-level suffixes *-ee*, *-esque*, and *-ette* are of Romance origin. *-th* is a stem suffix and *-ness* is a word suffix, but both are native. Most of the inflectional morphology of English is native, and yet it is level-ordered, as we saw in section 2. Moreover, native English suffixes may select non-native stems and vice versa, and native and non-native derivational affixes can be combined in either order (Bauer, Lieber & Plag 2013, Ch. 27, Lieber 2010: 189). The dissociation is absolute in languages like Dakota and Arabic, where the entire level-ordered morphology is native. To demonstrate the independence of level-odering and the native/non-native distinction in English derivational morphology, consider the stem-level adjective-forming ending *-ful*$_A$, which is is unstressed and reducible to [-fəl] or [fl̩], and the word-level nominal *-ful*$_N$, which bears secondary stress and retains a full vowel. Both suffixes are native and indeed cognate.

(18) a. *Semantics:* In addition to their basic meaning 'full of X', *X-ful* adjectives often have non-compositional meanings, e.g. *bountiful, plentiful* 'abundant', *needful* 'requisite', *pitiful* 'to be pitied', *worshipful* 'honorable', *restful* 'quiet', *successful* 'having success'. Nominal *X-ful*$_N$ without exception means 'as much as X will hold': *bucketful, spoonful, a fistful of dollars, a needleful of thread, a neckful of gold.*

b. *Bases: -ful*$_A$ admits bound stems (*baleful, wakeful, wistful, vengeful*). In contrast, *-ful*$_N$ admits only words as bases.

Karimojong Lesley-Neuman 2007, Korean (Yun 2008, 2009), Chamorro (Anttila, Fong, Benus, and Nycz 2008), Japanese (Sasaki 2008), Tundra Nenets (Kavitskaya and Staroverov 2008), Arabic (Rakhieh 2009, Jarrah 2016), Dzongkha (Downs 2011), Dogrib (Jaker 2012, Jaker and Kiparsky 2017), Latin (Roberts 2012), Rumantsch (Anderson 2013), Oroch (Tolskaya 2014), Lardil (Staroverov 2014), Shona (Downing 2015), Moronone (Andersen n.d.), Spanish (Bermúdez-Otero 2013, Martinez-Gil 2016), Classical Nahuatl (Kužmicki 2016), Catalan (Mascaro 2016), Dholuo, Anywa, and Päri (Mackenzie 2016), Tunica (Baković 2016), Welsh (Iosad 2017), Lulamogi (Hyman 2017), Polish (Rubach 2008, 2011, 2017, 2018, Todd MS.), Macedonian (Rubach 2011), Dakota (Paschen 2018, Kiparsky 2019), Lardil, Tigrinya, Arabic, Maltese, and Yowlumne Yokuts (Kiparsky 2019).

c. *Affix ordering:* *-ful*$_{\text{A}}$ almost never occur with bases containing word suffixes (exception: *meaningful*). *-ful*$_{\text{N}}$ allows this productively, as nonce forms such as *a boilerful of hot water, a kingdomful of radio listeners, a neighborhoodful of frat boys* attest.

d. *Compounds:* Only *-ful*$_{\text{N}}$ is added to compounds: *dessertspoonful, greenhouseful, rucksackful, suitcaseful*.

e. *Plurals:* Only *-ful*$_{\text{N}}$ is added to (semantically interpreted) plural nouns: *bucketsful (= bucketfuls), droppersful, pitchersful, scoopsful*.

f. *playful*$_{\text{A}}$ [-fl̩] : *a trayful*$_{\text{N}}$ [-ˌfʊl], *harmful* : *an armful*, *faithful* : *a mouthful*, *awful* : *a crawful*, *sceneful* 'picturesque' : *a screenful*.

g. *-ful*$_{A}$ can attract primary stress to a preceding stressed syllable: *ínsìght* > *insíghtful, fórethòught* > *fòrethóughtful*. In contrast, *-ful*$_{N}$ does not care about the stress of its base and never triggers any stress shift on it: *a médicine-càbinetful of barbiturates*, *an eyedropperful of chloride*, *a dormitoryful of students*.

h. *happy-Tensing:* American speakers who tense /ɪ/ word-finally and before word suffixes (as in *happiness*) do so also before *-ful*$_{\text{N}}$, e.g. [ˈsɪriˌfʊl] (*a cityful of characters*), *bellyful, trolleyful*, vs. [ɪ] before *-ful*$_{\text{A}}$, as in [ˈpɪrɪfl̩], *beautiful, dutiful, merciful, plentiful*.

i. *Degemination:* The geminate *-ff-* in *beliefful, mischiefful* is reducible to a single *-f-* in normal speech (OED); in contrast, nominal *-ful* in words like *carafe-ful, handkerchief-ful, knifeful, shelf-ful, troughful* degeminates only in allegro speech, if at all.

j. *Diphthong raising ("Canadian Raising"):* *sighful*$_{\text{A}}$ [ˈsʌɪ-] (rhymes with *stifle*) vs. *sky-ful*$_{\text{N}}$ [ˈskaɪ-] (as in *a skyful of stars*), *eyeful*$_{\text{N}}$.

Striking support for level-ordering comes from morphology/phonology covariation in a class of CHAMELEON AFFIXES that have a dual affiliation (Giegerich 1999, Ch. 2). They make stems from stems, and words from words, which differ in their respective phonological and morphological properties, often also in function and meaning. Where the morphology is consistently word-level, so is the phonology, and where the morphology is consistently stem-level, so is the phonology. This systematic co-variation is valid down to the level of individual lexical items. Raffelsiefen (1999) had already cited doublets like *compárable* : *cómparable*, but as *objections* to the theory, although the fact that their respective stratal properties line up in the predicted way obviously *confirms* it. The stem adjective has a partly lexicalized meaning, the word-level adjective is entirely compositional. Most speakers contrast *cómparable* [ˈkɒmpərəb(ə)l] in the meaning 'similar' and *incómparable* [ɪnˈkɒmpərəb(ə)l] in the meaning 'peerless' with *comˈpārable*, [kəmˈpɛ(ə)rəb(ə)l], *uncompˈārable* [ʌnkəmˈpɛ(ə)rəb(ə)l] in the meaning 'what can/cannot be compared', as a technical term in semantics 'ungradable'.[9] The phonological reflex is that shortening applies in the stem phonology, and in turn affects stress placement. In the word phonology, the stem is inert. The level-ordered analysis of English grammar predicts that meaning and stem form align in this way and not the other way round.

A more cogent criticism is that level-ordering is posited on merely empirical grounds. An adequate theory should provide a causal explanation of *why* morphology and phonology should be

[9]For such speakers, the statement "*devoid* and *entire* are cómparable non-compárable adjectives" is true and not contradictory, and the statement "*empty* and *full* are cómparable compárable adjectives" is true and not redundant.

organized into the universal categories of stem and word. The absence of such an explanation does not falsify the level-ordering hypothesis, it means that it is as yet incomplete.

What would falsify it is counterevidence of ony of the following types: mismatches between the ordering properties of affixes and their phonological behavior, affixes with systematically inconsistent phonology, and instances of stem-level suffixes or prefixes outside word-level ones. In addition, like any empirical hypothesis, it is open to disconfirmation by more accurate, predictive, and explanatory accounts of the data. To my knowledge nobody has produced any counterevidence of the first two types against the level-ordering hypothesis. The third type of counterexample, however, is instantiated by the four affix combinations *-ist-ic, -abil-ity, -iz-at-ion*, and *-ment-al*, as in *governmental*, *nationalistic, analyzability*, and *standardization*. But *-ment, -ist, -able*, and *-ize* are chameleon suffixes, by all phonological and morphological criteria. The distribution of *-ment-al* follows directly from its dual status. The other three combinations have fused into single composite stem suffixes, distributionally portmanteau-like affix bundles of the type *-abil-ity, -ist-ic*. They are not exceptions to level-ordering at all, but actually predicted by level-ordering, once the possibility of affix bundling is recognized.

Haspelmath & Sims (2010: 227) maintain that productivity predicts English affix ordering and the phonology of stem and word suffixes better than level-ordering does, for "most integrated affixes in English are quite unproductive anyway, so it seems unnecessary to invoke a level ordering architecture in order to explain why they do not attach to words derived with neutral affixes." They reason that *-ity* is the most common "integrated" (stem) suffix, that it is unproductive in comparison to "neutral" (word) suffixes, and that therefore all other stem suffixes are a fortiori unproductive. To test their conjecture, I extracted the nouns in the online OED that end in seven stem suffixes and seven word suffixes, and counted how many of them occur first in the 20th century, reasoning that this is at least a rough index of their productivity (Haspelmath & Sims 2010: 130).

(19)

Stem suffixes ("integrated")				*Word suffixes ("neutral")*			
	Total	1900-			Total	1900-	
-ic, A.	7397	1750	24%	-age, N.	1229	150	12%
-ite, N.	3088	610	20%	-dom, N.	326	35	10%
-ity, N.	2994	418	14%	-less, A.	1793	111	6%
-al, A.	7204	874	12%	-ish, A.	1347	85	6%
-ive, A.	2151	176	8%	-hood, N.	314	15	5%
-ance, N.	880	62	7%	-ness, N.	4290	230	5%
-ous, A.	5376	172	3%	-like, A.	403	20	5%

The most frequent stem ("integrated") suffixes turn out to be *-ic* and *-ite*, with *-ity* in third place. More importantly, judging from these data, the commonest stem-level derivational suffixes are on the whole *more* productive than the commonest word-level ("neutral") derivational suffixes, in absolute as well as proportional terms. This undercuts H&S's productivity-based explanation for level ordering effects.

Another counterproposal, due to Fabb (1988), is that independently needed selectional restrictions on affixes account for all missing affix combinations, and therefore level-ordering does no extra work. Fabb divides suffixes into four groups. The largest group, according to him, requires an unsuffixed base. He lists 28 suffixes in this group. He is right about four of them, deverbal

-al (*removal, bestowal*), *-age* (*breakage, cleavage*), *-ful* (*resentful, forgetful*) and *-y* (*inquiry*), and wrong about the other 24. One of these is denominal *-ful*, which as we already saw attaches also to derived nouns, e.g. *truthful, meaningful, prayerful*, and what is especially significant, productively in nonce forms to *any* kind of noun. Each of the 24 occur after at least ten suffixes, and some of them after as many as twenty-five. All are productive, and abundant in colloquial online discourse. It would be closer to the truth to say that they can be added to any word of the right category, whether simple or suffixed, as long as the combination makes sense.

The other critical group contains six suffixes that he claims attach outside just one other suffix: denominal *-er* (*vacationer*), deadjectival *-y* (*residency*), *-ary*$_N$ and *-ary*$_V$ (*revolutionary*), *-ic* (*modernistic*), and *-(at)ory* (*modificatory*). Fabb assimilates this group to the first by analyzing the suffix pairs as single compound suffixes. Compound suffixes (affix bundles) are justifiable if they have a distinctive distribution of their own. Of the six cases, only *-ist-ic* is justifiable. The other proposed analyses, such as *vacat* + *-ion-er* and *revolut-* + *-ion-ary*, introduce gratuitous bracketing paradoxes, which are moreover of a type that cannot be accounted by the mechanisms available for real bracketing paradoxes. In any case, each of these suffixes actually falsify the selection-based analysis, since they do attach outside other suffixes as well. Fabb's data actually confirm the generalization that stem-level suffixes never follow word suffixes, which is lost in an approach that relies exclusively on selectional restrictions. For details, I refer to Kiparsky 2019.

I conclude that level-ordering achieves better empirical coverage than productivity-based and selection-based accounts of affix ordering, and outperforms any other single overall generalization about affix ordering in the literature. Affix ordering is just one facet of a much larger cross-linguistic complex of morphological and phonological phenomena that level-ordering addresses with remarkable success. The distinction between the stem level and the word level is therefore essential to the understanding of word structure.

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