Stratal Phonology

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1 Introduction

Words in the Wakashan language Nuuchalnuth of Vancouver Island have a clear bipartite structure, as argued in detail by Stonham (2007) (see also Kim & Pulleyblank (2009a)). Inner – lexical – suffixes provide lexical content akin to lexical roots. Outer – grammatical – suffixes encode inflectional information like Tense-Aspect, Mood and agreement. Strikingly, this semantic and functional distinction also corresponds to substantially different morphological and phonological properties: Outer suffixes linearly strictly follow inner affixes. Root and suffix allomorphy is restricted to inner affixes. Phonological processes apply differently for both affixes. A simple example for this is glottal stop deletion. After a fricative, a suffix-initial glottal stop is deleted (1-c), but this process only applies if the suffix is lexical (1-c). With a grammatical suffix, the glottal stop is retained (1-d). After other consonants, both suffixes show up in their underlying forms without ʔ-deletion (1-a,b):

(1) *ʔ-Deletion after fricatives (Stonham 2007:110+111)*

	Inner affixes: deletion		Outer affixes: no deletion
a.	ʔapʔaqsuɬ	b.	hiniːpʔaːqtɬqa
	/ʔap-ʔaqsuɬ/		/hina-iːj'ip=ʔaːqtɬ=qaˑ/
	LOC-at.the.mouth		LOC-obtain=INTENT=3.SUB
	'mouth'		'that they find…'
c.	ħasØaqsuɬ	d.	ciʕasʔaːqtɬqa
	/ħas-ʔaqsuɬ/		/ciʕas=ʔaːqtɬ=qaˑ/
	loud-at.the.mouth		woo=INTENT=3.SUB
	'loud voice'		'he was going to talk marriage'

Stratal theories entertain the hypothesis that much of the structure of Nuuchahnulth described so far is not a specific feature of this language, but a general design feature of human languages – strata (or levels) which differ both in their morphosyntactic and phonological properties and which are derivationally or recursively ordered such that the output of a lower stratum feeds into the input of the next higher stratum. Strata are in effect ordered 'minigrammars' with potentially different morphological and phonological operations. Thus in Stonham's analysis the first stratum, the Stem-Level stratum, corresponds to the lexical domain and the second domain to the Word Level Stratum. This is schematically shown in Table 1.

The role of serial order in Nuuchahnulth is also evident from the distribution of a second process, delabialization, which apparently has the opposite distribution, it happens with Word-Level suffixes, but not with Stem-Level suffixes. In fact, a stratal account of delabialization is even simpler than the one for ʔ-deletion since it can be captured by assuming that Stem Level and Word Level apply the same phonological processes. Generally, there is transparent delabialization at the end of words and more generally in syllable codas (2-a), whereas underlying labialized consonants surface faithfully in onset position (2-b):

(2) *Word-/syllable-final delabialization (Kim 2003:96)*

a.	/nuːk^{w}/	→	nuːk	b.	/nuːk^{w}-iːɬ/	→	nuː.k^{w}iːɬ
	song		'song'		song-make		'make a song'

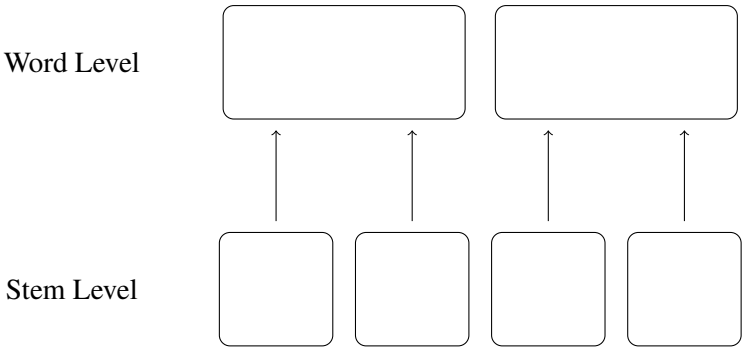


Table 1: Ordered 'mini-grammars' in Stratal Phonology

Crucially for stratal organization, labialization is kept at boundaries of vowel-initial lexical suffixes, but erased before phonologically similar grammatical affixes:

(3) *Labial consonants before vowel-initial suffixes (Stonham 2007:112)*

	Inner affixes: no delabialization		Outer affixes: delabialization
a.	jaːsiːk'^{w}as	b.	hisiːk'Øatweʔin
	/jaɬ-iˑk^{w}-'as/		/his(t)-iˑk^{w}='at=weˑʔin/
	there-go.along-outside		LOC-go.along=SW=3SG.QUOT
	'someone going along…'		'they passed by'

This follows if final delabialization applies first over a domain only comprising lexical suffixes. If a labialized obstruent happens to be final, it will undergo delabialization. Thus opacity in delabialization follows from cyclic application of a general process where the first cyclic domain is formed by the root + all lexical suffixes (if any) and the second cycle by the complete morphosyntactic word. Table 2 illustrates this notion of cyclicity – the application of morphological and phonological operations alternates – which is pervasive in Stratal Phonology. It is not only inherent in the notion of recursively applied mini-grammars with increasing domains; but it is also often assumed that at least some strata show internal cycles of this type (phonological evaluation applies after every morphological operation).

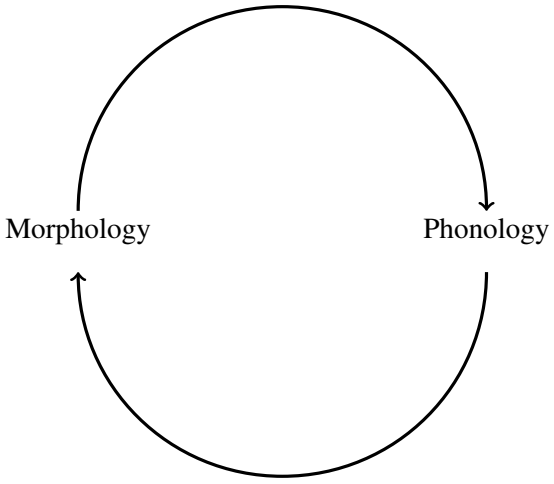


Table 2: Cyclicity in Stratal Phonology

The area where a distinction between stratal domains is assumed most widely and is maybe the default assumption in the theoretical literature on phonology is the distinction between Word-Level and a following stratum applying to entire utterances, the Phrase Level or postlexical Level. Thus the Bantu language Kinande (Jones 2014) has a process which shifts all underlying H tones one syllable to their left. This can be seen with a minimal pair of apparently homophonous verbs which both appear as low

toned on the surface. However, in contrast to 'peel' (4-a), 'precede' (4-b) imposes a H tone on the Low-toned infinitive prefix. As shown by Jones, this instantiates a general process of H-.tone shift. The H on the first vowel of 'precede' (/táng/) is shifted one mora to the left. Crucially, tone shift not only applies inside of words, but also across word boundaries as shown in (4-c).

(4) *Kinande H-tone shift (Jones 2014:16+37)*

a. /e-ri-taŋa/ → [e-ri-taŋa] 'to peel' b. /e-ri-táŋa/ → [e-rí-taŋa] 'to precede'
AUG-NCL.5A-peel-FV AUG-NCL.5A-precede-FV

c. /e-ri-hum-a ŋkóko/ →' [e-ri-hum-á ŋkoko]/ 'to hit a *chicken* (and not, e.g. a *goat*)'
AUG-NCL.5A-hit NCL.9-chicken

In stratal terms, this means that it is a process applying at the Phrase Level after all morphology and phonology of the Stem and Word Level.[1] Striking confirmation for this assumption comes from the interaction of H-tone shift and a word-internal reduplication process which copies noun stems including their tone to express intensification as in the examples in (5) (note that in (5-b) the H has shifted from the second stem syllable to the first one in both copies):

(5) *Kinande noun reduplication (Jones 2014:15)*

a. /o-ku-gulu.RED/ → [o-ku-gulu-gulu] 'a real leg' (AUG-NCL.15-leg-RED)
b. /o-mu-gongó.RED/ → [o-mu-góngo-góngo] 'a real back' (AUG-NCL.3-leg-RED)

Crucially, if the reduplicated noun has an initial H as in (6-c), the tonal parallelism seen in (5) breaks down. The H in the first copy of [lume] appears on the noun class prefix preceding it. On the other hand, the H of the second copy surfaces on the final syllable of the first copy:

(6) *Kinande noun reduplication (Jones 2014:15)*

a. /o-mu-lúme.RED/ → [o-mú-lumé-lume] 'a real man' (AUG-NCL.1-man-RED)
b. /a-ka-húká.RED/ → [a-ká-húká-húka] 'a real insect' (AUG-NCL.12-insect-RED)

This shows that reduplicative copying cannot apply after tone shift (mu-lúme → mú-lume → *mú-lume-lume) or enforce tone copying by completely parallel (non-stratal) constraint evaluation on outputs requiring base-reduplicant identity (McCarthy & Prince 1999). Conversely, the divergence in tone placement follows naturally if reduplication applies first, creating perfect tonal identity which is then made opaque by later tone shift:

(7) *Kinande noun reduplication (Jones 2014:16)*

	Underlying		Word-Level Reduplication		Phrasal Leftward shift
a.	/o-ku-gulu.RED/	→	o-ku-gulu-gulu	→	[o-ku-gulu-gulu]
b.	/o-mu-gongó.RED/	→	o-mu-gongó-gongó	→	[o-mu-góngo-góngo]
c.	/o-mu-lúme.RED/	→	o-mu-lúme-lúme	→	[o-mú-lumé-lume] '
d.	/a-ka-húká.RED/	→	a-ka-húká-húká	→	[a-ká-húká-húka]

This example nicely illustrates the explanatory power of stratal models. It does not just make it possible to order tone shift after reduplication. In contrast to accounts which make it possible to arbitrarily impose the relative order of processes, the stratal approach actually *predicts* that this is the only possible order of processes: Word-Level phonology can feed Phrase-Level phonology, but Phrase Level phonology cannot feed Word-Level phonology. This largely seems to be born out. Another well-known instance of the same ordering is the interaction of Canadian vowel raising and flapping (Bermúdez-Otero

[1]The 'Phrase Level' is also often simply referred to as 'Postlexical Phonology'. A more adequate name than 'Phrase Level' might be 'Utterance Level' since the domain in question is not single phonological phrases in the sense of Prosodic Phonology but complete utterances.

2003, 2019). The same point can also be made with the interaction of (Word-Level) final obstruent deletion and (Phrase-Level) apocope in Gran Canarian Spanish (Broś & Nazarov 2023, Gleim 2024), and the interplay of tone shifting and dissimilation in another Bantu language, Jita, discussed further below (section 1.5.2).

Taken together, we arrive at what might be called the minimum Standard model of Stratal Phonology shown in Table 3. Much of this chapter will be dedicated to an investigation of whether this model is sufficient or needs systematic add-ons such as additional strata, or loops between single strata (see especially section 2).

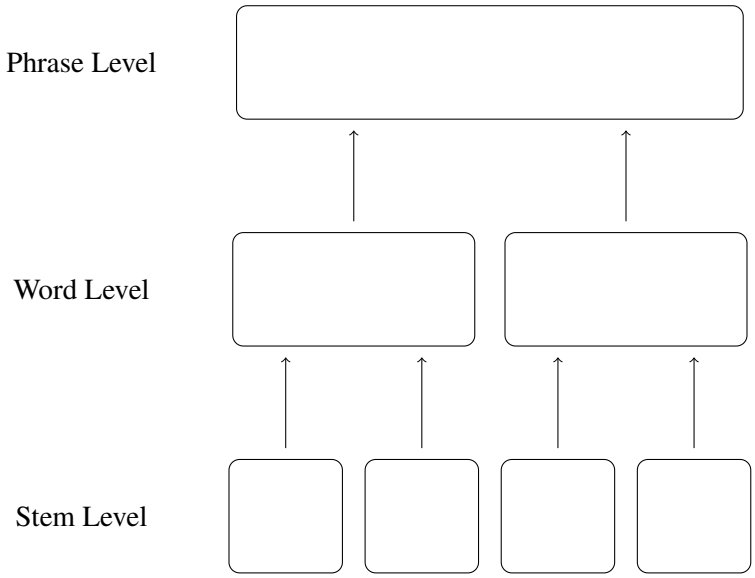


Table 3: Minimum Standard model of Stratal Phonology

Roadmap: In the remainder of this introductory section, I will work out the characteristics of stratal phonology in more detail, first by identifying central properties of the framework (section 1.1). Building on this, section 1.2 shows how stratal phonology is typically integrated with other theoretical mechanisms of formal grammar such as rules, constraints and representations. Section 1.3 provides a short sketch on the history of Stratal grammars. In section 1.4, I present a handful of additional empirical case studies which show the working of Stratal Phonology, and section 1.5 compares stratal phonology with similar competing frameworks. The central part of this chapter is section 2 which discusses controversial specific design features of Stratal grammars, such as the number and nature of strata. Section 3 addresses potential problems of Stratal Phonology which have been raised in the literature.

1.1 Central Properties of Stratal Models

In this section, I highlight what I consider to be the most essential properties of Stratal phonology. On the one hand, this spells out the basic ideas introduced above as more specific assumptions on grammatical architecture. On the other hand, this provides the necessary background for the comparison of Stratal Phonology with alternative approaches in section 1.5.

- Modular Separation of Morphology and Syntax ("Strong Lexicalism")

  How stratal models integrate Phonology into grammar crucially depends on specific assumptions about the nature of morphosyntax. In particular, stratal models embrace a modular architecture of the grammar where morphology (conceived of as the construction of words) precedes and feeds syntax (the construction of phrases and sentences from words), in a way such that both are blind to the internal working of the other module. Morphology generates words which are the atoms of Syntax. This model has been dubbed 'Strong Lexicalism'.[2]

- Cyclic Interleaving of Morphosyntax and Phonology

  Phonology is integrated into the lexicalist model via cyclic interleaving. Stem-Level morphology feeds Stem-Level phonology which forms the input for Word-Level morphology. Post-morphological ("Word-Level") Phonology processes the output of the Morphology module for every word. The operations of the Syntax module concatenate the resulting phonological representations which are in turn processed by postsyntactic ("Phrase Level") phonology. As a consequence, Word-Level phonology cannot be sensitive to syntactic context, Phrase-level phonology necessarily follows Word-Level phonology, and their rules or constraints do not directly interact (apart from the general feeding of Phrase-Level Phonology by Word-Level Phonology). In addition to the cyclicity generated by the cyclic interaction of strata, most versions of Stratal Phonology also assume inner-stratal cyclicity in one or more strata of the word-internal phonology such that every morphological operation triggers a cycle of phonological evaluation (see section 2.3 for detailed discussion).

- Backwards Myopia and Bracket Erasure

  By Cyclic Interleaving, the phonology (and morphology) at a given level is inherently myopic to phonological material and processes at later strata. However, most work in Stratal Phonology agrees that stratal myopia also extends to earlier strata. The operation which achieves this is usually called Bracket Erasure since it deletes morphological boundaries (e.g. between stems and affixes), but it also makes other information inaccessible to following levels.[3] Thus, if a morpheme *M* induces exceptions to phonological rules or shows some other form of morpheme-specific phonology due to morphological or diacritic features, these features will only be accessible at the level where *M* is concatenated (see Mohanan 1986 for extensive discussion). Similarly, suppletive allomorphy and evaluation of the subcategorization features of an affix can only be evaluated at the stratum introducing this affix (Kiparsky 2021).

- Modular Integration of Word-Level Morphophonology and the Lexicon

  A further central assumption of stratal models is that presyntactic morphology and phonology tightly interact with lexical storage of words in a qualitatively different way from syntax. Words formed by morphological operations and processed by post-morphological phonology are stored

[2] See Odden (1993) for an approach where a Lexical Phonology approach is assumed to be postsyntactic, and thus Stem-Level and Word-Level rules can access information about syntactic context. In the framework of Pranka (1983), the output of Lexical Phonology is inserted into the output of a GB-style syntax. This approach predicts that syntax cannot access phonological information, and allows for an interesting alternative account of cliticization and related phenomena.

[3] In contrast, the version of Bracket Erasure employed in SPE (Chomsky & Halle 1968) strictly deleted brackets, and served not so much as a locality device, but as a way to implement cyclic phonology. Bracket Erasure would iteratively delete innermost morphosyntactic brackets. After every round of Bracket Erasure, Phonological rules would apply to all stretches without internal brackets.

in the same way as simplex words, and may – once stored – undergo changes over time. Thus the word *break-fast*, originally a compound of *break* and *fast* has now an idiosyncratic meaning and pronunciation which makes its origin opaque to most native speakers. Conversely, lexically stored forms, whether simplex or derived, may block productive application of the rules of morphological structure building and of Word-Level phonology. A well-known morphological example is the blocking of the derivation *?gloriosity* from *glorious* by the independent simplex noun *glory*. A classical phonological example is the simplex noun *nightingale*. Thus Kiparsky (1982b) argues that the rule of trisyllabic laxing which changes the diphthong of *divine* to [ɪ] in *divinity* is blocked in *nightingale* since this is stored in the lexicon. The name "Lexical Phonology and Morphology" for the stratal model developed by Kiparsky Kiparsky (1982b) strikingly highlights the integration of lexicon, morphology and word-internal phonology.

- Cophonologies

  Stratal models share the assumption that languages have separate co-existing phonologies which descriptively involve different alternations (or their absence) and theoretically different rule inventories and constraint rankings. This holds most uncontroversially for phrasal phonology and lexical phonology, as they often differ drastically. But stratal models also assume that the lexical phonology itself is not homogeneous, but constituted of different separate phonological grammars, minimally a "Stem-Level" phonology and a Word-Level phonology.

- Layering

  By the lexicalist architecture and cyclic interleaving, it follows that all structure-building and phonology at the Word-Level Phonology strictly precedes all corresponding operations at the Phrase Level. Adopting a parallel notion for the structure of prosodic constituents (Selkirk 1995), I will call this property *Layering*. In many versions of Stratal Phonology it is assumed that Layering also extends to the different Cophonologies. Thus, all Stem-Level morphology and phonology strictly precedes all Word-Level Phonology. Layering is one of the more controversial assumptions.

- Level Uniformity

  is the requirement that all phonological material introduced at a given Level n is evaluated in all following levels $n+x$. Mohanan (1986:4) expresses this idea with the metaphor of a factory where morphemes are transported by a belt uniformly through all the rooms from the entry gate to the exit gate no matter whether they undergo specific operations or not. The most explicit challenge of Level Uniformity is due to Inkelas & Orgun (1995) who argue that only forms morphologically derived at a given level undergo the phonological processes and constraints of this level. Inkelas & Orgun call this *Level Economy*.

1.2 Integrating Strata with other Grammatical Mechanisms

No grammatical primitive is an island. The analytic potential of Stratal Phonology can only be evaluated in integration with orthogonal assumptions about phonological computation (section 1.2.1), representations (section 1.2.2 on prosodic, and section 1.2.3 on autosegmental representations), and the interaction with morphology (section 1.2.4) and syntax (section 1.2.5). Here I discuss standard assumptions in these areas with crucial consequences for later sections.

1.2.1 Phonological Computation

The constitutive difference between the original model of Stratal Phonology – Lexical Phonology (LP) – and its successor Stratal OT is the approach to phonological computation inside a given cycle in a

stratum. In LP, this was usually achieved by ordered rules as in SPE (Chomsky & Halle 1968).[4] In Stratal OT, each cycle consists of an OT-evaluation. A major consequence of this choice is the amount of innerstratal opacity predicted: basically no upper limit in LP, relatively limited opacity in Stratal OT (see Kiparsky 2000, 2023, 2015, Jaker & Kiparsky 2020 for discussion). Consider, for example, the hypothetical case of a language with two Word-level processes: Nasals assimilate to following adjacent stops in place of articulation (e.g., /np/ → [mp], but /nəp/ → [nəp]), syllable-final sonorants optionally allow the epenthesis of a following [ə] (e.g., /bin/ → [bin] ~ [bin◌ə]), and the second process counterbleeds the first one (e.g., /bin.pa/ → [bim.pa] ~ [bim◌ə.pa]). In LP, this can simply be captured by ordering the assimilation before the epenthesis rule in the Word-Level phonology. In standard Stratal OT, both processes would have to be derived in the same constraint evaluation triggered by markedness constraints applying to output forms. However the markedness constraint requiring adjacent vowels to share place of articulation should then be ineffective since in the output nasal and stop are not adjacent in the case of epenthesis.

Note however that the claim in Kiparsky 2000, Jaker & Kiparsky 2020 that reranking across strata is the *only* source of opacity in Stratal OT is obviously too strong. As is acknowledged in Kiparsky (2015), there are also cases of counterfeeding which can be captured by parallel constraint evaluation,[5] and specific cases of counterbleeding which follow from stratum-internal cyclicity (see e.g. Hargus 1985:390 on Sekani nasalization).

However, there are more fine-grained differences between specific models suggested in the literature. Thus Clark (1987) shows for her detailed account of Igbo tone that all ordering relations between phonological rule applications follow from the stratal affiliation of rules and independent principles such as the Elsewhere Principle (Kiparsky 1973) which gives precedence to more specific rules. Thus extrinsic ordering of rules is obviated (on the other hand, establishing rule ordering is one reason which necessitates the assumption of additional strata in Clark's Igbo analysis, see section 2.2 for discussion).

Whereas the version of OT advocated by Kiparsky (2000, 2003, 2015, 2023) still embraces stratum-internal cyclicity, Bermúdez-Otero completely abandons this apart from a version of extragrammatical pseudo-cyclicity (see section 2.3 for more discussion).

Trommer (2011) assumes a version of Stratal OT where phonological computation is based on Colored Containment theory instead of the version of Correspondence Theory which has become the de facto standard in research on OT. Since in Colored Containment Theory, inputs are never literally deleted, but only marked as phonetically unrealized, underlying phonology can still have an impact on constraint violation even if it is removed. This allows us to capture cases of innerstratal opacity which refer to the input, somewhat in-between what is possible in Correspondence Theory and what rule ordering can do. I will illustrate this with Hellendoorn Dutch where a nasal suffix generally assimilates in place to a preceding obstruent (e.g., /wɛrk-n/ work-INF → [wɛrkn̩] 'to work'). The past tense suffix -[t] blocks this assimilation process even where it is deleted in a consonant cluster (e.g., /wɛrk-t-n/ → [wɛrkn̩] work-PAST-1PL 'we worked', van Oostendorp 2004:2-3). Assuming that nasal assimilation is triggered by a constraint which requires that nasals are associated to the same place features as phonetically left-adjacent stops, labeled here simply as PLACEASS(IMILATION)), the contrast between [wɛrkn̩] and [wɛrkn̩] follows from higher ranked NOSKIP(PING) as shown in (8). Crucially, NOSKIP(PING) penalizes association of a feature across an intervening segment even if this segment is not phonetically realized. Phonetic invisibility is marked by shading of [t]. The brackets in (i-b) and (ii-b) indicate that the included segments are linked to the same place feature.

[4]Note that the adoption of a cyclic or stratal model provides a solution to a problem for strictly ordered rules with data where the application of a process P_1 seems to precede *and* follow the application of an independent process P_2. A famous example for this is Catalan place assimilation of coronal nasals, which seems to apply both before and after a process of cluster simplification, which deletes word-final stops after nasals, as in /bɛnk bint pan-s/ (Place Assimilation) → bɛŋk bint pan-s cluster simplification → bɛŋØ binØ panØ (Place Assimilation) → [bɛŋ bim pan]. Kiparsky (1985) shows based on Mascaró (1976) that assigning Place Assimilation both to the Word Level and the Phrase Level (and ordering its application before Cluster Simplification at both strata) captures not only the sandwiching application of both processes but also subtle differences in the application of Place Assimilation at different strata.

[5]See e.g. McCarthy (2007:sect.2.3.3) on the a → i → Ø chain shift in open syllables of Bedouin Arabic. As McCarthy shows, the fact that /i/ is deleted, but /a/ is not can simply be captured by a faithfulness blocking the latter, MAX a

(8) *Opaque place assimilation in Containment Theory*

(i) [wɛrkŋ] 'to work'

Input: a	NoSkip	PlaceAss
a. wɛrk-n		*!
☞ b. wɛr(k-ŋ)		

(ii) [wɛrkn] work-PAST-1PL 'we worked'

Input: a	NoSkip	PlaceAss
☞ a.wɛrkt-n		*
b. wɛr(kt-ŋ)	*!	

Note that Colored Containment still cannot derive all cases of opacity which can be achieved by arbitrary ordering of rules — constraints can refer in a limited way to underlying forms, but not to any kind of intermediate representations. See, for example, Zimmermann & Trommer (2024) for a demonstration that it cannot derive the kind of nonlocal assimilation under epenthesis discussed above.

On the other hand, Colored Containment alone cannot capture all cases of opacity which fall out naturally from strata. For example, Containment can account for phonological differences between underlying and epenthetic segments. This is achieved by another component of the theory, Coloring. Coloring assigns abstract colors to underlying segments according to their morphemic affiliation such that every underlying phonological element has a specific color, but epenthetic (non-underlying) segments are colorless. Since phonoogical constraints in Colored Containment have access to color, they can distinguish between epenthetic and underlying segments. But if Colored Containment is used in a fully parallel non-stratal architecture, it cannot account for differences between epenthetic vowels inserted in different levels which should all be uniformly colorless (see the discussion of Palestinian Arabic vowel epenthesis in section 1.4.2 below for an illustration of this point).[6] It might hence be argued that both strata and Containment together are indispensable to account for the full amount of opacity encountered in natural languages. Sporadically, other variants of constraint-based phonology have been explored in a stratal architecture. Calamaro (2017) proposes a combination of Stratal OT with Harmonic Serialism (McCarthy 2010, 2016). Nazarov & Pater (2017) investigate computational learning for a stratal model employing Maximum Entropy Grammar.

1.2.2 Prosody

In early work on strata and prosodic domains, the predominant idea was that strata provide a complete theory of word-internal phonological domains, whereas prosodic categories like the prosodic word are restricted to postlexical/phrasal phonology. See Nespor & Vogel (1986) for this view from a Prosodic Phonology perspective, and Mohanan (1986) for a classical formulation in Lexical Phonology. In contrast, most subsequent work in Stratal Phonology has adopted the view that at least prosodic words are already present in Lexical Phonology, and lead to further differentiation in word-sized domains.

[6] See also Idsardi (2000) for a similar argument in a demonstration that the Turbidity version of Containment cannot capture Tiberian Hebrew.

(9)

Booij & Rubach (1984), Bermúdez-Otero (2018b)	Prosody throughout the grammar Prosody + strata in parallel independence
Inkelas (1990, 1993)	Prosody throughout the grammar Fusion of prosody and strata
Mohanan (1986)	No prosody in the Lexical Phonology

Allowing for P(rosodic) Words in the lexical phonology seems to be inevitable in theories where word stress is defined in a relational way over prosodic words, and also for accounts where compound stress is related to recursive prosodic words (Ito & Mester 2021,) specific cases of Word-level prosodic morphology involving the PWord as a target (e.g. full-word reduplication in Diyari, see Kager (1999):§5.3.2).

Importantly, there are two very different ways found in the literature of integrating strata and prosodic domains. The first approach is found in Inkelas (1990, 1993). Inkelas essentially proposes to fuse the concepts of word-internal prosodic domain and stratum. These domains have derivational ordering (like strata), but, as prosodic units may diverge from the morphological constituency.

Whereas the fusion approach has been one of the sources for the development of Construction Phonology (see section 1.3), the standard way of integrating prosodic and stratal domains is parallel interaction, as proposed in work by Booij, Rubach, and Lieber (Booij & Rubach 1984, Booij & Lieber 1993, Bermúdez-Otero 2011, 2018b). Prosodic words are built at the Stem and/or Word Level, but may be smaller than the stratal domains, and may be modified at later strata. This allows for capturing standard cases of mismatches, i.e. phonological domains that do not correspond to morphosyntactic domains. A case in point are data where roots and suffixes form independent prosodic words excluding prefixes. Thus Nespor & Vogel argue for the Italian example in (10) that intervocalic voicing of [s] applies inside of prosodic words

(10) *(Nespor & Vogel 1986:126)*

Morphological structure:	[[ri-suddivis]-ione]	'resubdivision'
Phonological structure:	[[ri-]suddivis-ione]	
	re- subdivide -ion	

Booij & Lieber (1993) argue that also several other cases of bracketing paradoxes can be resolved using the PWord, as in the case of the comparative form *unhappier*. From a semantic point of view the bracketing should be as in (11-a) since the form means 'more unhappy' not 'not happier'. On the other hand, comparative *-er* selects for 'small' bases which are either monosyllabic or bisyllabic with a 'light' second syllable (e.g. *wis-er*, *merrie-er*, happy-*er*, but: *more content*, *more sporadic*). Thus prosodic subcategorization suggests the bracketing in (11-b):

(11) a. Semantically motivated structure: [[un happy] er]
b. Phonologically motivated structure: [[un[happy er]

Booij & Lieber (1993:34) suggest that the morphological structure of *unhappy* is indeed (11-a), but the prosodic representation at the point where -er is attached is a recursive prosodic word $(\text{un}(\text{happy})_{\omega})_{\omega}$. As a result the prosodic subcategorization of -er (for a light Pword on its left) is satisfied by this structure.

A final consequence of prosodic domains in the Lexicon is that it mitigates the effects of Bracket Erasure. For example, under Nespor and Vogel's analysis of Italian prefixation, it is a natural assumption that the lexical PWords are carried over to the postlexical phonology. Thus in principle phrase-level processes may be sensitive to the prefix-root boundary. In section 3.2, we will see that this allows for a simple account of apparently anti-stratal processes.

A basic question raised by the integration of prosody into a stratal architecture is how to distinguish prosodic and stratal domains. Bermúdez-Otero (2011) lists three major criteria: *First*, prosodic

domains such as feet and prosodic words are usually marked by subphonemic phonetic effects such as final lengthening, whereas stratal domains are not. *Second*, prosodic structure might not be able to distinguish word-internal and phrasal structures which have prosodically identical structure (see Bermúdez-Otero 2011 on the case of function words and affixes in English *l*-darkening as a case in point). This requires that there must be some further distinction by strata. *Third*, prosodic domains often diverge from morphological domains (see the discussion of *risudivisione* and *unhappier* above), whereas stratal domains by assumption do not.

I will assume here a further heuristics, based on central assumptions on possible crosslinguistic parametrization in Prosodic Phonology (Nespor & Vogel 1986).

(12) *PWord Heuristics:*
Phonological domains specific to prefixation and compounding are prosodic (correspond to a PWord), not stratal

(12) reflects the observation that prefixation and compounding are the best-attested sources for word-sized domains not corresponding to full grammatical words (see Hyman 2008, Downing & Kadenge 2020 on prefix-suffix asymmetries and Ito & Mester (2021,) on compounding). Formally, both preferences can be understood as the tendency that the left edge of a lexical root should coincide with the left edge of a PWord (see Peperkamp 1997 for an implementation of this idea). This would mean that true stratal compounding would be restricted to cases where one member of a stem compound is formed by a defective affixoid root.

1.2.3 Autosegmental Representations

One immediate consequence of Autosegmental representations for lexical morphology is that they make it much more feasible to adopt a piece-based approach to morphological exponence. Thus Pulleyblank (1986b:82+83) shows that the most elegant account of Tiv inflectional verb tone is as prefixation, suffixation, or circumfixation to bases which have underlying High or Low tones, illustrated for the Recent Past High-suffix in (13) (with the L-tone verb [vèndé] 'refuse' and H-tone [óngó] 'hear'):

(13) *Tiv Recent Past forms*

a. L + H → L H
vèn de → vèn dé

b. H + H → H H
ón go → ón gó

Autosegmental analyses have also been successfully applied to many other cases of non-concatenative processes such as consonant mutation, vowel changes (e.g. umlaut), lengthening, shortening and length polarity (see Lieber 1992, Wolf 2007, Bye & Svenonius 2012, Zimmermann & Trommer 2015 for comprehensive views on the vast literature to this effect).

But autosegmental phonology also has important consequences for the strictly phonological side of stratal models since a major motivation for lexical strata is to model morpheme-specific phonology. Autosegmental phonology is complementary to this in that it provides an alternative for many cases of what is prima facie morpheme-specific phonology. For example if the Tiv verb forms in (13) verbs are preceded by a H-toned element at the Phrase Level H-tone roots remain unchanged (/vé + óngó/ → [vé óngó], but L-tone roots undergo a general process of H-spreading (/vé + vèndé/ → [vé vén$^{\downarrow}$de] 'they refused (recently)' (Pulleyblank, 1986b:36)) with concomitant downstep of the verb-final H. Two prima facie cases of morpheme-specific phonology are found in another Tense, the Habitual 1 of Tiv, which has the same suffixal -H as the Recent Past. First, H-toned verbs show a downstep after H-toned words /vé + úngwá/ → [vé $^{\downarrow}$úngwá]. Whereas downstep insertion between two H-tones is a productive phonological process in a number of tone languages (e.g. Kishambaa, Odden 1982 and Igbo, Clark 1990), this obviously isn't the case in Tiv as shown by the Recent Past [vé óngó]. On the other hand, the Habitual 1 fails to undergo what is otherwise a general alternation in Tiv, H-tone spreading ([vé vèndé

'they are used to refuse', [vé vén$^{\downarrow}$de] is only possible as the Recent Past. Taken together, the Habitual 1 apparently shows both morphologically conditioning of an exceptional process and suppression of another otherwise general process. However, in Pulleyblank's classical analysis of these data these facts again follow simply from tone affixation. Note first that downstep in Tiv as in many other African languages is clearly related to underlying L tones. Thus words with a Falling contour (i.e. HL) tone trigger downstep on following H-tones phrase-internally where Falling tones are generally disallowed in the language. The same correlation also emerges in H-tone spreading as in the Recent Past That this triggers downstep on the second stem syllable follows naturally if downstep is simply the phonetic implementation of a floating (unassociated H) before a H tone, as shown in (14):

(14) *Tiv Recent Past forms with preceding H-tone word*

Pulleyblank's analysis is now purely morphological. He assumes that the Habitual$_1$ in addition to the H-suffix also employs a L-prefix – it is a tonal circumfix. This immediately accounts for the downstep in H-toned roots (15-b), but also captures naturally the fact that H-tone-spreading is blocked with L-toned roots. Under the assumption that phonological processes typically apply under strict adjacency of trigger and target, the floating L intervenes:

(15) *Tiv Habitual$_1$ forms with preceding H-tone word*

Autosegmental phonology also accounts for some cases of opacity. Consider for example, the famous example of Hijazi Bedouin Arabic, where the high front vowel [i] palatalizes preceding velars (16-b) ((16-a) shows the root-medial [k] is not palatalized underlyingly), and [i] is deleted in open medial syllables (16-c) (syncope). Apparently syncope counterbleeds palatalization as in (16-c):

(16) *Opacity in Hijazi Bedouin Arabic* (Al-Mozainy 1981, McCarthy 2007:11)

a. /t-ħaːkum/	→	[t-ħaːkum]	'you (masc.sg) rule'
b. /ħaːkim/	→	[ħaːk^{j}im]	'ruling (masc.sg)'
c. /ʃarib-at/	→	[ʃarbat]	'she drank'
b. /ħaːkim-iːn/	→	[ħaːk^{j}m-iːn]	'ruling (masc.sg)'

However, autosegmental representations offer a different account as phonological compensation. Under the natural assumption that palatalization is the association of an autosegmental Coronal feature to an appropriate node in the feature geometry of a consonant, the pattern in (16-c) might be attributed not to an assimilation process but to the fact that the Coronal feature of [i] is not deleted along with the segment, but survives by reassociation to the preceding consonant. This would be in parallel to the well-known patterns of compensatorf lengthening (Hayes 1989, Kiparsky 2011) and tone stability under vowel deletion (Yip 2002) (see also Zaleska 2020 on a compensatory interpretation of vowel coalescence).

Finally, autosegmental representations have another important consequence for Stratal Phonology. To see this, consider again the standard assumption that downstep between two H-tones is simply the phonetic implementation of a floating L between two H-tones. In the architecture of Stratal Phonology this implies that the L-tones triggering downstep must be floating at the Phrase Level since only the Phrase Level feeds phonetic implementation. However, in many cases the process which generates the

floating L is clearly Word Level such as in the Tiv Habitual$_1$. Thus floating autosegmental material from one Level can in principle be inherited to the next stratum. In section 3.2 we will see that this goes a long way in accounting for apparently anti-stratal process interaction.

1.2.4 The Nature of Lexical Morphology

Although the seminal stratal model developed in Kiparsky (1982b) is dubbed *Lexical Morphology and Phonology*, the morphological part of this (and subsequent stratal) models has been worked out to a much lesser degree than its phonological aspects.

Theories of morphology differ among two main dimensions:

First, on the morphophonological side, morphological theories are either piece-based or process-based. In piece-based approaches morphological primitives are basically pieces of phonological structure (e.g. a string of segments, or an autosegmental or prosodic unit such as a tone or a foot node). In process-based approaches, morphological primitives are rules (Anderson 1992, Stump 2001) constraints (Hammond 1995, Russel 1995) or more abstract units (e.g. constraint violations, Golston (1996) or feature cooccurrence restrictions, Müller 2013)

This has important repercussions for phonological theory since at least since the development of Autosegmental Phonology, theoretical phonologists have claimed a prerogative to explain a substantial part of the area which is traditionally called nonconcatenative morphology (see section 1.2.3).

The standard though not the only possible position in stratal models seems to be that phonology is in principle concatenative.[7] The most explicit statement of this approach for Stratal Phonology is by Bermúdez-Otero (2012) who derives it from the more general modularity assumption in (17):

(17) *Morph Integrity Hypothesis (Bermúdez-Otero 2012:50)*

Morphological operations do not alter the syntactic specifications or phonological content of morphs.

Second, on the semantic side, words might be built in a compositional-incremental or in a realizational way. Under the first approach, the overall meaning and morphosyntactic features of a word are computed by combining morphological primitives, where each of these primitives contributes some of these features. In contrast under a realizational theory the overall meaning of a word is given in advance and constructing a word means computing a morphophonological realization for this meaning. Most current theories of morphology have a strong Realizational component since this type of approach provides a natural explanation for the fact that word forms often very incompletely reflect their morphosyntactic content.

As argued by Kiparsky (2020, 2021), an incremental account naturally derives general locality and compositionality restrictions

Allomorphy of affixes cannot be sensitive to properties of more outwards affixes because these are only added to the derivation after the selection of a given allomorph. See Paster (2006) for a general typological argument for this asymmetry in allomorphy, Kiparsky (2021) for a Stratal-OT reanalysis of Nez Perce data which according to Deal & Wolf (2017) provide evidence for outward-looking allomorphy, and Kalin (2020) for another potential violation of this constraint.

[7] In the history of stratal models, both word formation rules and a word syntax approach have been advocated, which is nicely illustrated by two conflicting statements from the work of Kiparsky:

Kiparsky (1982a:134): "Affixes will then not be lexical entries and will not have lexical features… Each affix is introduced by a rule…". Kiparsky (1982d:15): "there are no word-formation rules and affixes are just lexical entries which differ from stems in being obligatorily subcategorized"

An incremental approach to morphology also predicts that in the default case affix order seems to reflect semantic compositionality as shown by the minimal pairs in (18):

(18) *Affix order and meaning*

a.	jug-par-cuar person-big-little 'little giant'	b.	jug-cuar-par person-little-big 'big midget'	(Yup'ik) (Mithun 2000)
c.	re-mis-interpret co-pre-production anti-neo-fascism	d.	mis-re-interpret pre-co-production neo-anti-fascism	

This generalization broadly related to the **Mirror Principle**, which according to Baker (1985, 1988) governs the relation between affix order and syntactic operations falls out from incremental structure building under the assumption that this applies to the phonological as well as to the semantic side of the process.

On the other hand, a realizational approach potentially solves some classical problems for Stratal Phonology, such as specific types of bracketing paradoxes. Consider for example the well-known case of *ungrammaticality*. Semantically we expect the morphological structure in (19-a) since *ungrammaticality* is the property of being *ungrammatical*. However, [un]- is arguably a Word-Level prefix (thus in contrast to Stem-Level [in]- it doesn't undergo place assimilation) whereas -[-ity] is a classical case of a stress-shifting Stem-Level suffix. Thus by Layering (see section 1.1), we expect that [un-] is attached outside of -[ity] as in (19-b):

(19) a. [[un [grammatical]]ity]
b. [un[[grammatical]ity]

However, the semantic argument for (19-a) crucially presupposes an incremental compositional approach. Under a realizational take the meaning of *ungrammaticality* is already given before concatenation happens by something like [being [not [grammatical]]]. The ordering of affixes then follows from independent morphological mechanisms. Thus Xu & Aronoff (2011) posit the violable OT-constraint in (20) to account for Mirror-Principle effects as the ones in (19):

(20) Scope: Given two scope-bearing features f1 and f2, if f1 scopes over f2,
then I2, an exponent of f2 cannot be farther away from the same stem than I1,
an exponent of f1. (Xu & Aronoff 2011:389)

(20) requires for example that [un[inter[active]] could not be realized as *[inter[un[active]] where un has scope over inter, but is farther away from the stem. However *ungrammaticality* would not violate the constraint because both affixes are adjacent, i.e. equidistant to the root. An approach of this type thus would provide a principled account for the observation by Strauss (1982) that Bracketing paradoxes typically involve the composition of prefixes and suffixes.

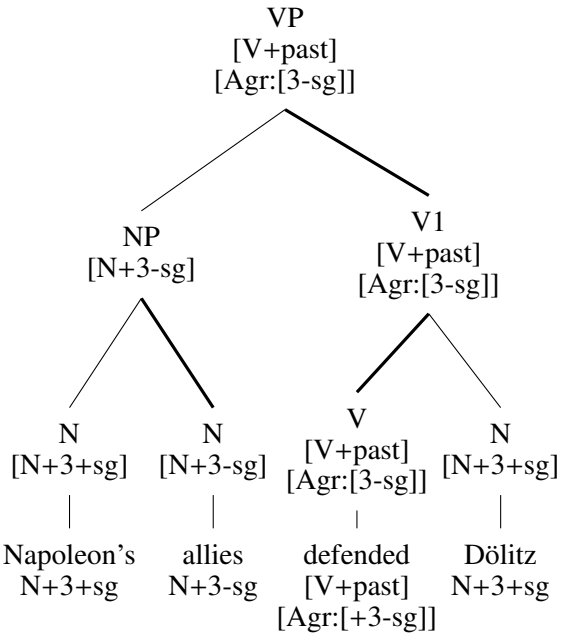
1.2.5 The Division of Labor between Morphology and Syntax in Strong Lexicalism

Strong lexicalism means a complete reversal of perspective compared to the basic approach of early transformational grammar (SPE, Syntactic structure), actively retained in the Minimalist Program. Consider simple verb inflection like subject agreement and Tense marking in English which clearly has the morphological properties of word-level morphology (e.g., fixed linear ordering, and suppletive allomorphy involving roots and affixes, as in *drank* instead of **drink-ed*). However, from a non-lexicalist perspective, it is clear that Tense and agreement directly interact with the broader syntactic context. Tense in a sentence like *Napoleon captured Liebertwolkwitz* has not only scope over the verb, but over

the entire event including *Napoleon* and *Liebertwolkwitz*. This is one of the motives for treating Tense as an independent head which is only lowered and attached to verbs postsyntactically in many syntactic analyses. Even more dramatically, subject agreement is not a feature of a verb (or a verbal event) at all, but apparently simply a reflex of the inherent features of the subject noun. In a DM-style architecture of the grammar, this can be captured simply by copying phi-features from the subject to the verb node. Thus from the non-lexicalist perspective, the existence of Tense and agreement in English is a strong argument for post-syntactic morphology.

An important achievement of lexicalist work in the 80s was to show that this conclusion is by no means necessary, and phenomena of this type can be captured succinctly in a bottom up fashion by the use of feature sharing and percolation. This is illustrated in (21) for the sentence *Napoleon's allies defended Dölitz.* in a notation loosely based on GPSG. Nodes contain complex feature specifications, every local tree (i.e. any subtree consisting of a node and all its daughter nodes) has a head node (indicated here by boldface edges), and a sentence is interpreted as a maximal (saturated projection) of a lexical verb (Pollard & Sag 1994).

(21)



Crucially, morphology generates verb forms with specific values for Tense and subject agreement. Thus the past tense 3sg of defend might carry the feature specification [V+past,Agr:[3+sg]]. Assuming that these features are head features, the Head Feature Convention of Gazdar et al. (1985) will require that their values are shared between a mother node and its head node in a local tree. The effect of this is that the [+past] specification of the verb *defended* is inherited to its maximal projection the VP/sentence, where it can be appropriately interpreted semantically. Similarly, the NP *Napoleon's allies* will carry the specification [-sg] inherited from its head *allies*, not the [+sg] of *Napoleon's*. Subject-verb agreement can then be captured by a coindexation condition on the rule licensing the combination of subjects and verb phrases into sentences as in (22):

(22) VP → NP [α3 αsg] V1 [Agr:[α3 αsg]]

Similar techniques have been applied successfully for capturing the behavior of special clitics such as the English Possessive-*s*. Descriptively, this appears at the right edge of a possessor phrase of any complexity:

(23) *English Possessive -s on complex phrases (Lowe 2016:160)*

a. [Richard and David**'s**] car
b. [the Queen of England**'s**] hat
c. [someone I know**s**] brother
d. [the boy opposite me**'s**] sister
e. [the man I live with**'s**] girlfriend

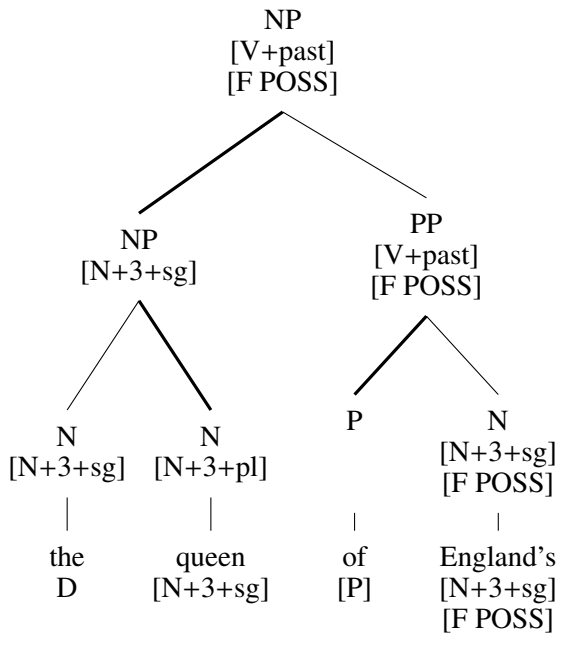
However, morphophonologically, the *s*-formative interacts tightly with the word on its left As observed by Zwicky (1987) it appears as [ɪz] after uninflected words ending in a sibilant (e.g. in *the sphinx's*), suppressed (or fused with) after the regular plural-s (*the ducks' feathers*, /dʌks/ not /dʌksɪz/), but retained after irregular plurals which happen to end in sibilants (*the geese's feathers*, /gi:sɪz/ not /gi:s/, examples following Payne 2009). In a number of pronouns pronouns there is partial or complete suppletion (compare e.g. *it* ~ *its*, *he* ~ *his*, and *we* ~ *our*)

These data seem to be prima facie direct counterevidence to lexicalism: A formative which seems to have the syntactic properties of a preposition and combines with complex noun phrases, behaves morphophonologically like an affix. However, again these facts can be captured naturally by syntactic feature percolation, as proposed by Zwicky (1987) following an approach to clitics developed by Nevis (1985) (see Payne (2009), Bermúdez-Otero & Payne (2011) for similar analyses). In parallel to head features, Zwicky assumes a class of edge or LAST features which are subject to the following conditions:

(24) a. An L-feature appears on the mother node of a local tree if and only if it appears on a daughter node
b. A node with an L-feature specification follows all other nodes in a local tree

In effect, the POSS feature is the effect of word internal morphology, which is inherited to the top of a possessor phrase such as *the queen of England's* which can then be combined locally with a head noun as in *the queen of England's head*. -s is rightmost in the noun phrase not because it is merged in syntax with the NP, but because positing an NP specified as [POSS] in a position which is non-final in an NP, would necessarily violate at least one of the conditions in (23).

(25)



Technically, possessive-*s* and similar elements might be called *edge affixes* to distinguish them from inflectional affixes like English tense and agreement which appear on lexical syntactic heads and would correspondingly be categorized as *head affixes*. The percolation approach to head-marking and edge-marking will play an important role in our discussion of antistratal effects in section 3.2.

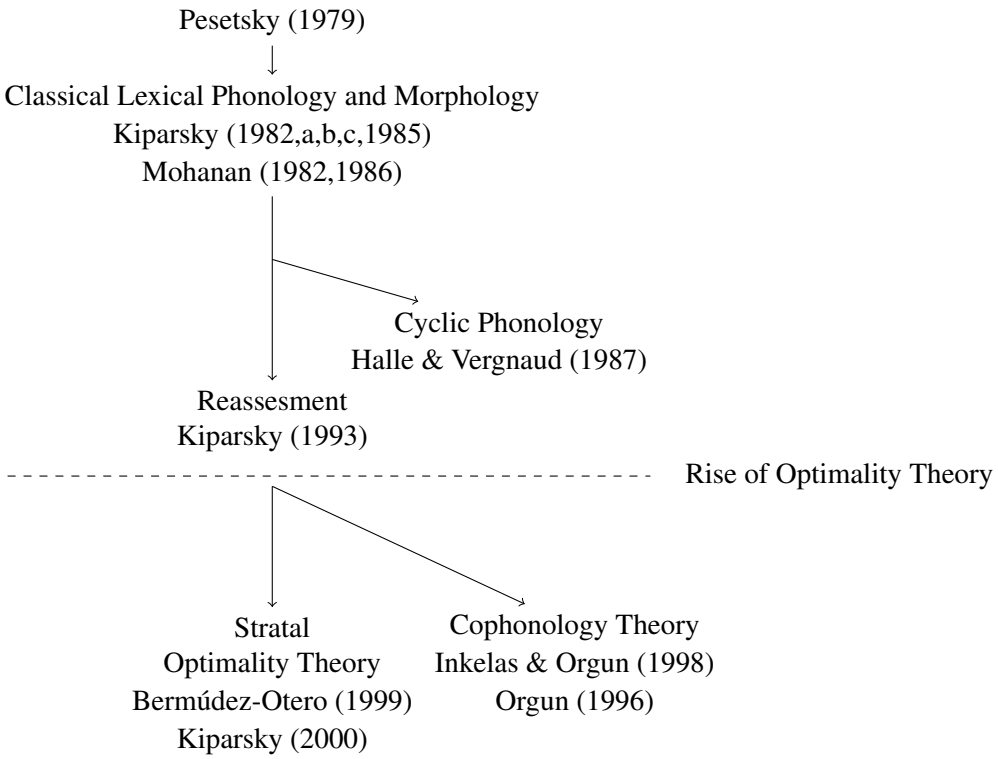
The interpretation of particular clitics such as the English possessive of course leaves open the option that there is an additional class of syntactic clitics which are formatives only introduc ed by morphosyntactic operations at the Phrase Level, *phrasal affixes*. See Anderson (2005) for a general analysis of clitics along these lines. Bermúdez-Otero & Payne (2011) argue that many prominent examples of clitizization (besides the Possessive-s, the Bulgarian definite marker and pronominal clitics in Catalan) must be edge affixes, not phrasal affixes, but see Iosad (2014), Gjersøe (2019), Gleim & Rasin (2024) for analyses assuming phrasal affixes in Stratal Phonology.

1.3 History

The seminal paper in the development of stratal theories was an unpublished term paper, Pesetsky (1979), which started Lexical Phonology and Morphology — one of the many reactions to the lexicalist turn in theoretical linguistics era heralded by Chomsky's *Remarks on Nominalizations* (Chomsky 1970).

Building directly on Pesetsky's proposals, Kiparsky developed the theory in a number of papers at the beginning of the 80's (Kiparsky 1982d,b,a, 1985). While this series of papers directly reflects slightly different possible versions in a continuous flux, the significance of Mohanan (1982) is that it provides a coherent model applied in a comprehensive case study to a single language (Malayalam). At the end of the 80's Lexical Phonology was the uncontested standard approach to the phonology-morphology interface in theoretical linguistics.

(26) *History of stratal frameworks*



However, in the early 90's Lexical Phonology seemed to be in utter crisis. Theory-internally because it become more and more undeniable that central assumptions of the theory such as Structure Preservation and the Strict Cycle Condition were empirically untenable (see section 4 for discussion). The splitting off of Halle & Vergnaud's theory of Cyclic Phonology was also mainly due to to the believe that another central dogma, the Affix ordering generalization had to be abandoned. Externally derivational models

seemed to face a more general crisis with the advent of Optimality Theory which promised to make sequential ordering in derivations superfluous.

At this point, Stratal Phonology seemed obsolete to many observers. Its resurrection was due to the fact that fully parallel OT was profoundly struggling with the problem of opacity (see the contributions in Roca 1997 and Hermans & van Oostendorp 1999). Whereas mainstream proponents of OT came up with interesting new approaches to the problem such as Sympathy Theory (McCarthy 1999), a growing minority of phonologists felt that Stratal Phonology and OT were not alternative, but complementary components of phonological theory. At this point, a number of researchers developed frameworks which substantially borrow from Stratal Phonology, but have a distinct overall architecture. Thus the output-output approach developed by Benua (1997) reconstructs many features of Stratal Phonology in a recursive paradigmatic framework. Cophonology Theory (Orgun 1996, Inkelas & Orgun 1998) continues the tradition of Lexical Phonology analyses with fine-grained stratal structure such as Hargus (1985) and Inkelas & Orgun (1995) with a new research program to unify morphologically conditioned phonology and nonconcatenative morphology. The more conservative fusion of Stratal Phonology and OT was initially called 'OT-based Lexical Phonology and Morphology', 'OT with Interleaving' or Derivational OT, but was soon commonly referred to as 'Stratal OT' Seminal work of this new framework are Rubach (1997), (Bermúdez-Otero 1999) and Kiparsky (2000).

1.4 More Representative Case Studies

In this section, I collect a few additional case studies from the literature which have been of particular importance to the development of Stratal Phonology and/or illustrate its basic mechanisms in an especially clear way. Moreover they will illustrate the application of Stratal Phonology to a variety of phonological phenomena (lexical accent, epenthesis and deletion, tone and vowel harmony) and play a crucial role in comparing Stratal Phonology with alternative theoretical approaches in section 1.5.

1.4.1 Vedic Sanskrit

Vedic accent is maybe the classical case for strata in lexical accent systems, and there are numerous analyses building on the original generalizations in unpublished work by Kiparsky. Here I present an analysis in Stratal OT based on the Lexical-Phonology account of Halle & Mohanan (1985), which demonstrates how the interaction of heterogeneous, but simple phonological grammars at different strata derives a complex pattern. The case study is also instructive in showing how morpheme-specific phonology is typically addressed in stratal analyses, partially by underlying representations (here: underlying presence or absence of accent in the lexical entry of a morpheme), and partially by the distinctive stratal affiliation of affixes. Thus 'dominant' (stress-erasing) suffixes are analyzed here as Stem-Level and 'recessive' (stress-neutral) suffixes as Word-Level affixes.

Roots in Vedic are either underlyingly unaccented (27-a) or accented on one of their vowels (marked in the following by underlining) (27-b,c). Suffixes also may be accented or unaccented but also fall in two independent orthogonal classes which I will characterize here in stratal terms as Stem Level and Word Level. This distinction largely coincides with the distinction between derivation and inflection: derivational affixes are Stem Level and all inflectional suffixes except the Vocative are Word Level. Crucially, Word-Level affixes always occur outside of Stem-Level affixes as expected by stratal Layering. I will start my discussion with Word-Level suffixation illustrated in (27) and (28): In combination with Word-Level suffixes, surface accent corresponds to the leftmost underlying accent, the root accent in (27-b,c), and the suffix accent in (27-a):

(27) *Vedic: Accented Word-Level suffixes (Halle & Mohanan 1985:68)*

a. /duhitar-e̲/ → [duhitré] 'to the daughter (dat.)'
daughter-DAT

b. /bhra:̲tar-e̲/ → [bráthre] 'to the brother (dat.)'
brother-DAT

c. /maru̲t-e̲/ → [marúte] 'to the wind (dat.)'
wind-DAT

That lexical accent is phonologically unpredictable can be seen especially clearly in examples where accented and unaccented suffixes are otherwise homophonous as with the masculine nominative ending -[as] and the genitive singular ending -[a̲s]. (28-a) also shows what happens if all involved morphemes are underlyingly unaccented: accent falls on the initial syllable of the word:

(28) *Vedic: Accented Word-Level suffixes (Yates 2020:68)*

a. /juɟ-as/ → [júɟas] 'yokes'
yoke-MASC.NOM

b. /juɟ-a̲s/ → [juɟás] 'of the yoke'
yoke-GEN.SG

c. /na̲r-as/ → [náras] 'men'
yoke-MASC.NOM

d. /na̲r-as/ → [náras] 'of the man'
man-GEN.SG

This can be captured by the interaction of three constraints, 1∗ ('Assign ∗ to every PWord which doesn't have exactly 1 accent'), Dep ∗, which penalizes the insertion of accents, and LeftMost ∗ ('Assign *n* violations to every accent which is separated by *n* syllables from the left edge of the closest PWord');[8]

(29) *Vedic Word-Level accent*

(i) No underlying accents

Input: = a.	1∗	Dep ∗	LeftMost ∗
a. juɟ-as	*!		
b. j̊uɟ-ås	*!*	**	*
c. juɟ-ås			*!
☞ d. j̊uɟ-as		*	

(ii) Two underlying accents

Input: = a.	1∗	Dep ∗	LeftMost ∗
a. maru̇t-e̊	*!		*,**
b. marut-e̊			**!
c. m̊arut-e		*!	
☞ d. maru̇t-e			*

Inner – Stem-Level – affixes also may be accented or unaccented, but the effect of accentedness is considerably different. Stem-Level affixes are always accented in the context of accented roots and or accented outer (Word-Level) suffixes:

(30) *Vedic: Accented Stem-Level suffixes (Halle & Mohanan 1985:68)*

a. /ra̲th-i̲n-e̲/ → [rathíne] 'to the charioteer'
chariot-NOM-DAT

b. /mitr-i̲n-e̲/ → [mitríne] 'to the befriended'
friend-NOM-DAT

[8] 1∗ is a shortcut for two independent constraints, requiring maximally (Culminativity 'Assign *n* violations to every PWord with *n* + 1 accents'), and minimally Obligatoriness 'Assign *n* violations to every PWord which lacks an accent') 1 accent.

Accentless Stem-Level suffixes have the effect that any base accent is deleted and accent appears on the default position in the first syllable of the word:

(31) *Accentless Stem-Level suffix (Perry & Vaux 2018:286)*

a. /prati-cjav-/ → [praticjáv] 'moving towards'
   towards-move-

b. /prati-cjav-ijaṃs/ → [práticjavijaṃs] 'moving more [ardently] towards'
   towards-move-CMP

If accented and unaccented Stem-Level affixes cooccur the outermost determines the accent pattern of the word:

(32) *Vedic: Accented + Unaccented Stem-Level suffix (Halle & Mohanan 1985:69)*

a. /kar-a:j-itum/ → [kárajitum] 'in order to cause to make'
   make-CAUS-PURP

The behavior of Stem-Level affixes can be captured by a general economy constraint favoring lack of accent (NoAccent) dominated by a positional faithfulness constraint protecting accent of the last morpheme of a word (Max $*$-$\square_\omega$) which dominates NoAccent. For an accented Stem-Level affix, the effect is simply that only the affix accent survives (33-i). The accent on the Stem-Level suffix then survives at the Word Level due to high-ranked LeftMost (33-ii) (note that (33-ii) is structurally identical to (29)):

(33) *Vedic Stem-Level accent (accented suffix)*

(i) Stem level

Input: = a.	Max $*$-$\square_\omega$	NoAccent
a. ráth-ín		**!
b. ráth-in	*!	*
c. rath-in	*!	
☞ d. rath-ín		*

(ii) Word Level

Input: = a.	1$*$	Dep $*$	LeftMost $*$
a. rathín-e	*!		*,**
b. rathin-é			**!
c. ráthin-e		*!	
☞ d. rathín-e			*

Also with an accentless Stem-Level suffix all accents on preceding morphemes are deleted. Since the suffix itself has no accent (which would be protected by Max, $*$-$\square_\omega$), the stem becomes completely unaccented (34-i), and gets initial default accent or the accent of an accented suffix at the Word Level (34-ii):

(34) *Vedic Stem-Level accent (unaccented suffix)*

(i) Stem level

Input: = a.	Max $*$-$\square_\omega$	NoAccent
a. prati-cjáv-ijaṃs		*!
b. práti-cjav-ijaṃs		*!
☞ c. prati-cjav-ijaṃs		*

(ii) Word Level

Input: = a.	1$*$	Dep $*$	LeftMost $*$
a. prati-cjav-ijaṃs	*!		
b. jprati-cjáv-ijaṃs		*	*!
☞ c. práti-cjav-ijaṃs		*	

(35) shows the derivation of an unaccented Stem Level suffix following an accented one, which is essentially identical:

(35) *Vedic Stem-Level accent (accented + unaccented suffix)*

(i) Stem level

Input: = a.	MAX *-$\square_\omega$	NOACCENT
a. kar-á:j-itum		*!
b. kár-a:j-itum		*!
☞ c. kar-a:j-itum		*

(ii) Word Level

Input: = a.	1*	DEP *	LEFTMOST *
a. kar-a:j-itum	*!		
b. kar-á:j-itum		*	*!
☞ c. kár-a:j-itum		*	

1.4.2 Palestinian Arabic: Syncope, Epenthesis and Stress

Syncope, epenthesis and Stress in Palestinian Arabic in the analysis of Brame (1974) have been the classical and most time-resistant argument for some form of cyclicity. This data set forms the empirical basis for prominent claims that OT can obviate traditional cyclicity (Kager 1999, Steriade 2000). However, in his seminal paper, Kiparsky (2000) conclusively shows that these reanalyses have serious flaws and that a Stratal OT account not only solves them, but also improves in several ways on the original analysis of Brame (see section 1.5.4 for detailed discussion).

(36) *Palestinian Arabic: Syncope in /fihim/ 'understood' (Kiparsky 2000:352)*

(i)	fíhim il-wálad	'he understood the boy'
(ii)	fíhim	'he understood'
(iii)	f**hím**-na	'we understood'
(iv)	fi**hím**-na	'he understood us'

(37) *Palestinian Arabic: Epenthesis in /fihm/ 'understanding' (Kiparsky 2000:352)*

(i)	**fí**hm il-wálad	'the boy's understanding'
(ii)	**fí**h(i)m	'understanding'
(iii)	**fí**h(i)m-na	'our understanding'

(38) *Palestinian Arabic: epenthesis in /katab/ 'wrote' (Kiparsky 2000:353))*

a. /katab/	[kátab]	'he wrote'
b. /katab-it/	[kátab-it]	'she wrote'
c. /katab-t/	[katáb-(i)t]	'I wrote'

The first challenge posited by the Arabic data is the distinctive behavior between f**hím**-na 'we understood' and fi**hím**-na 'he understood us', where the first undergoes the general syncope process for i in non-final open syllables, but the latter does not. In Kiparsky's account this follows from the fact that -na as a subject marker is added at the Stem Level, but at the Word Level as an object marker, as shown in (39). As a consequence, the [i] in the initial syllable is stressed in (39-b) in contrast to (39-c) which accounts for the fact that it is not deleted:

(39) *(Kiparsky 2000:359)*

	a.	b.	c.
Stem Level	**fí**him	**fí**him	fi**hím**-na
Word Level	**fí**him	fi**hím**-na	f**hím**-na
	'he understood'	'he understood us'	'we understood'

(40) shows how this is derived by OT-evaluations. I use (A)PENULT as a shorthand for several high-ranked constraints which ensure that modulo stratal effects stress is on a superheavy final syllable, otherwise on the penultimate syllable if it this is heavy (e.g. fihímna), and otherwise on the antepenultimate syllable (e.g. kátabat). No [i] is the trigger of i-syncope, which is however blocked by MAX V́ in (40-ii)

(40) *Palestinian Arabic syncope: fi**hím**-na 'he understood us' (Kiparsky 2000:360)*

(i) *Stem Level*

Input: = a.	(A)PENULT	MAX V	MAX V́	No [i]
a. fihim	*!			**
b. fi**him**	*!			**
c. f**hím**		*!		*
☞ d. **fí**him				**

(ii) *Word Level*

Input: = a.	(A)PENULT	MAX V́	No [i]	MAX V
a. **fí**him-na	*!		**	
b. fihim-**ná**	*!		**	
c. f**hím**-na		*!	*	*
☞ d. fi**hím**-na			**	

In f**hím**-na 'we understood' the vowel of the first syllable never has stress and is therefore freely deleted:

(41) *Palestinian Arabic syncope: f**hím**-na 'we understood' (Kiparsky 2000:360)*

(i) *Stem Level*

Input: = a.	(A)PENULT	MAX V	MAX V́	No [i]
a. fihim-na	*!			**
b. **fí**him-na	*!			**
c. f**hím**-na		*!		*
☞ d. fi**hím**-na				**

(ii) *Word Level*

Input: = a.	(A)PENULT	MAX V́	No [i]	MAX V
a. fi**hím**-na			**!	
b. **fí**him-na	*!		**	
c. fihim-**ná**	*!		**	
☞ d. f**hím**-na			*	*

A different type of opacity is found in **fí**him-na 'our understanding' where stress is on the antepenult although regular stress assignment predicts it on the penultimate. Kiparsky derives this from the fact that the vowel in the penultimate syllable is epenthetic, and arguably only inserted at the Phrase Level (this is shown by (36)-b-i where epenthesis is bled by a vowel-initial following word). Stress is computed at the Word Level (42-i) before epenthesis, and blocked by the high-ranked constraint H(EAD)M(ATCH) which penalizes stress shift at the Phrase Level (epenthesis is triggered by the constraint against complex syllable codas).

(42) *Palestinian Arabic epenthesis f**í**h(i)m-na 'our understanding' (Kiparsky 2000:355ff)*

(i) *Word Level*

Input: = a.	ASTR	MAX V́	DEP [i]	HM	*CC]$_\sigma$
☞ a. **fíh**m.na					*
b. **fíh**(i)m.na	*!		*		
c. fih(i)m.na			*!	*	
d. fh(i)m.na		*!	*		

(ii) *Phrase Level*

Input: = a.	HM	*CC]$_\sigma$	MAX V́	ASTR	DEP [i]
a. **fíh**m.na		*!			
☞ b. **fíh**(i)m.na				*	*
c. fih(i)m.na	*!				*
d. fh(i)m.na			*!	*	*

The same difference in ranking across strata derives the opaque final stress in [katáb-(i)t] 'I wrote'. Stress is assigned to the superheavy final syllable at the Word level and stays there by HM even when epenthesis breaks up the final syllable coda:

(43) *Palestinian Arabic epenthesis [katáb-ⓘt] 'I wrote' (Kiparsky 2000:355ff)*

(i) *Word Level*

Input: = a.	ASTR	MAX V́	DEP [i]	HM	*CC]$_\sigma$
☞ a. kat**ábt**					*
b. katáb(i)t	*!		*		
c. **ká**tab(i)t			*!	*	

(ii) *Phrase Level*

Input: = a.	HM	*CC]$_\sigma$	MAX V́	ASTR	DEP [i]
a. kat**ábt**		*!			
☞ b. katáb(i)t				*	*
c. **ká**tab(i)t	*!				*

1.4.3 OCP-resolution Strategies in Shona tone

Myers' (1997) paper on OCP resolution is probably the most influential classical OT paper on tone in the literature because it demonstrates stringently that the theory can capture a bewildering variety of strategies to avoid adjacent distinct H tones in adjacent syllable by a single constraint, the Obligatory Contour Principle (OCP) for H tones which bans just this configuration in outputs. Myer's Shona analysis uses strata to demonstrate different resolution strategies for the OCP in the same language. Further below, I will build on the discussion here to show that OCP-effects in Shona also have important repercussions fo specific design features of Stratal Phonology, the internal (non-)cyclicity of strata (section 2.3.2), and non-canonical cycles on affix clusters (section 2.3.7).

Crucially, Shona has a Word-Level process which deletes the second of two H-tones in adjacent syllables. Moreover, Myers (1997) shows that the same configuration is also repaired at the Stem Level, but in a different way by fusing the offending H-tones. tone is fused at level x, Fused tone is deleted at level x+1:

(44) *Shona H-dissimilation (Meeussen's Rule, Myers 1997:856,857,870)*

a. [í][banga] 'it is a knife'
COP-knife
cf. bángá 'knife'

b. [vá][sekuru] 'grandfather (honorific)'
2a-grandfather
cf. sékúru 'grandfather'

c. [v-á][tengesa] 'they sold'
3PL-PAST-buy-CAUS-FV
cf. [ku][téngésá] 'to sell'

The evidence for fusion is provided by the fact that sequences of Stem-Level H-tones behave as a single tone for Meeussen's Rule at the Word Level as shown by the data in (45). the Word-Level prefix [ti]- has an underlying H-tone and we have already seen that the root [téng] has a H-tone (44-c). Now if we add the word-level H-prefix [há]-, both tones are deleted.[9]

(45) *H-dissimilation (Meeussen's Rule) vs. H-Fusion (Myers 1997:870)*

a. [tí-téngésé] 'we should sell'
1PL.SBJ-buy-CAUS-FV

b. [há-ti-tengese] 'let us sell!'
HORT-1PL.SBJ-buy-CAUS-FV

(46) shows how this is derived in Myer's Stratal-OT analysis: At the Stem Level the OCP constraint is repaired by fusion since Uniformity ('Don't fuse tones') is ranked below MAX:

[9] In contrast in combinations of three independent Word-Level H-tones only the middle one is deleted. See section 2.3.2 below for data and discussion.

(46) *Shona — Fusion at the Stem Level*

Input: = a.	OCP	MAX	UNIFORMITY
a. H_1 H_2 | ti teng e se	*!		
b. H_1 | ti teng e se		*!	
☞ c. $H_{1,2}$ ti teng e se			*

At the word level, the fused tone is morphoogically combined with a further independent H. but at this level, Uniformity is ranked higher than MAX, and therefore deletion is chosen (LEFT arbitrates in favor of deleing the second not the first H-tone.)

(47) *Shona — Dissimilation at the Word Level*

Input: = a.	OCP	UNIFORMITY	MAX	LEFT
a. H_1 H_2 | ha ti teng e se	*!			*
b. $H_{1,2}$ ha ti teng e se		*!		
c. H_2 ha ti teng e se			*	*!
☞ d. H_1 | ha ti teng e se			*	

1.4.4 Karimojong Vowel harmony

Vowel harmony in Karimojong provides another nice illustration from segmental phonology that a language has similar phonologies at different word-internal levels which however differ in crucial details. My account here is a simplified version of the account in Lesley-Neuman (2012).[10] All data here and in the paper by Lesley-Neuman are from the comprehensive description of the language by Novelli (1985).

Karimojong has root-dominant ATR-harmony at the Stem Level (e.g. á-mɔ́kí-ʊ̀n 'to handle firmly here' vs. á-ólí-ùn 'to get lost here', Novelli 1985:269). In this process, [-ATR] [a] becomes [+ATR] [o] (e.g. á-kɪ-cɔ́m-ar 'to pierce there' vs. á-kì-lík-or 'to swallow there', Lesley-Neuman 2012:123).

At the Word Level, final suffixes trigger [+ATR] harmony on [-ATR] roots (e.g. dɔŋ 'pinch' → à-dóŋ-ì 'I am pinched' Novelli 1985:269). However, this harmony doesn't affect [a] even where it intervenes between the harmony-triggering root and the harmonizing root (e.g. á-dɔŋ-án-ákìn 'pinch frequently for' → à-dóŋ-án-ákìn-ì 'I am pinched frequently for' Novelli 1985:350). (48) an d (49) give further longer examples:

[10] Lesley-Neuman and Kiparsky (2023) assume that the language has a third word-internal stratum. See section 2.2.2 for critical discussion.

(48) *Word-Level [ATR] -armony triggered by the final suffix*

a. á-dɔ́ŋ-án-àr 'to pinch there for' (Novelli 1985:338)
INF-pinch-FREQU-IT

b. à-dɔ́ŋ-án-àr-ì 'I will pinch there for' (Novelli 1985:338)
1SG-pinch-FREQU-IT-FUT

(49) *Word-Level [ATR]-harmony triggered by the final suffix*

a. á-dɔ́ŋ-àr 'to pinch there' (Novelli 1985:291)
INF-pinch-FREQU

b. á-dɔ́ŋ-ár-ò 'to pinch there (impers.)' Novelli 1985:294)
INF-pinch-IT-IMPERS

With Lesley-Neuman, I will assume that /a/ in these cases becomes [+ATR] [a̟]. The difference between the Stem Level and the Word Level can now be captured by a simple reranking of the same constraints, where AGR [ATR] is the harmony-triggering constraint. Root-dominant harmony at the Stem Level emerges due to IDENT [ATR]$_{Rt}$ (protecting underlying ATR-values for vowels in lexical roots) over IDENT [ATR]$_{\omega}$ (which does the same for the vowel in the final syllable). That the [+ATR] suffix vowel will become [o] not [a̟] (50-c) is due to the ranking of *[a̟] over IDENT [rd]:

(50) *Karimojong — Root-dominant Harmony at the Stem Level*

Input: = a.	AGR [ATR]	IDENT [ATR]$_{Rt}$	*a̟	IDENT [rd]	IDENT [ATR]$_{\omega}$
a. lik$_{Rt}$-ar	*!				
b. lɪk$_{Rt}$-ar		*!			
c. lik$_{Rt}$-a̟r			*!		
☞ d. lik$_{Rt}$-or				*	

At the Word Level, both crucial rankings (IDENT [ATR]$_{Rt}$ ≫ IDENT [ATR]$_{\omega}$ and *a̟ ≫ IDENT [rd]) are simply reversed, resulting in suffix-governed ATR harmony without rounding of underlying /a/:

(51) *Karimojong — Suffix-dominant Harmony at the Word Level*

Input: = a.	AGR [ATR]	IDENT [ATR]$_{\omega}$	IDENT [rd]	*a̟	IDENT [ATR]$_{Rt}$
a. dɔ́ŋ$_{Rt}$-àr-ò	*!				
b. dɔ́ŋ$_{Rt}$-àr-ɔ̀		*!			
c. dóŋ$_{Rt}$òr-ò			*!		*
☞ d. dóŋ$_{Rt}$-à̟r-ò				*	*

1.5 Contrasting Stratal Phonology with Competing Frameworks

In this section, I will further clarify major features of Stratal Phonology by comparing it to closely related approaches to phonology.

1.5.1 Stratal Phonology vs. Halle & Vergnaud (1987a,b)'s Cyclic Phonology

Halle & Vergnaud (1987b,a) have developed a framework which has been influential in analyses of stress and accent systems, and which they call *Cyclic Phonology*. One way to understand the architecture of Cyclic Phonology is to interpret it as the Booij & Rubach (1987) version of Lexical Phonology modulo the affix ordering generalization. As in Booij & Rubach's approach, every cyclic (≈ Stem Level) affix triggers a cycle of cyclic (≈ Stem Level) phonology, and non-cyclic (≈ Word Level) phonology applies only once after all other lexical phonology. However, in contrast to Lexical Phonology, the order of attaching cyclic and non-cyclic (≈ Word Level) affixes is not universally fixed, but due to language-

and affix-specific morphological factors. See section 2.4 for discussion on the empirical motivation for and against the affix ordering generalization.

A second major departure from Lexical Phonology is the return to the position of SPE (Chomsky & Halle 1968) that cycles don't involve actual interaction (interleaving) of morphosyntax and phonology. Instead all morphological and syntactic structure building strictly precedes all phonological processes. In this system, the phonological cycle then is the result of **recapitulating** the original structure building process by the alternating application of phonological rules and the erasure of inner brackets that function as temporary traces of the applications of phrase structure rules. Thus, for [Elisabethan], the syntax would first generate [[Elisabeth] an] (still without any stress), then perform an initial cycle of stress assignment to the innermost bracket-less subconstituent Elisabeth, resulting in [[E.ˈli.sa.beth]an], followed by a first round of bracket erasure, leading to [E.ˈli.sa.be.than], which the second cycle of stress rules map to [E.ˌli.za.ˈbe.than] by reassigning a new primary stress, and preserving the stress of the first cycle as secondary stress.

The recapitulative approach to cycles is often called 'non-interactionist' in the literature contrasting it with the 'interactionist' architecture of standard Lexical Phonology.

In many cases, the 'non-interactionist' interpretation of cyclicity makes the same predictions as the interactionist approach. A major difference is in the consequences for morphological operations which are sensitive to derived phonological properties for example suppletion conditioned by stress of the base (Hargus 1993, Paster 2006, Booij & Rubach 1987). See Odden (1993) for the most detailed defense of the non-interactionist approach. Odden basically argues that cases of apparent phonologically conditioned suppletion actually follow from minor phonological rules limited to specific morphemes.

This illustrates also the conceptual tradeoff between both approaches in terms of modularity: In interactionism, phonology may be blind to morphological information. In non-interactionism morphology and phonology are uninterrupted blocks

For empirical arguments favoring an interactionist (non-recapitulative) interpretation of cyclicity, see Bresnan (1971), Legate (2003) on evidence from sentential stress, Dolatian (2020a) for phonologically conditioned suppletion, and Scheer (2011) on a more general discussion of interactionism.

1.5.2 Stratal Phonology vs. Parallel Constraint Domains (Kim & Pulleyblank 2009a, Buckley 1996)

Kim & Pulleyblank (2009a) propose an analysis of Nuuchahnulth lexical phonology which acknowledges two different domains corresponding to the Stem Level and Word Level of Stonham (2007), but interprets these domains in parallel. Thus ʔ-deletion works differently for Stem level affixes because faithfulness constraints for the Stem domain are ranked higher than those for the Word domain:

In (52) *sʔ$_{\text{Stem}}$ leads to deletion because the sequence [sʔ] is fully contained in the stem:

(52) *Stem-Level affix*

Input: = a.	*sʔ$_{\text{Stem}}$	Max	*sʔ$_{\text{Word}}$
a. [[ħas-ʔaqsuɬ]$_{\text{Stem}}$]$_{\text{Word}}$	*!		*
☞ b. [[ħas-ʔaqsuɬ]$_{\text{Stem}}$]$_{\text{Word}}$		*	

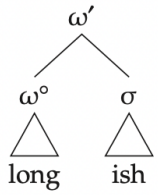
On the other hand, *sʔ$_{\text{Stem}}$ isn't violated in (53) because only [s] but not [ʔ] are part of the stem:

(53) *Word-Level affix*

Input: = a.	*sʔ$_{\text{Stem}}$	Max	*sʔ$_{\text{Word}}$
☞ a. [[ciʕas]$_{\text{Stem}}$=ʔaːqtɬ=qaˑ]$_{\text{Word}}$			*
b. [[ciʕas]$_{\text{Stem}}$=ʔaːqtɬ=qaˑ]$_{\text{Word}}$		*!	

A similar model is also advocated in Buckley (1996) for Kashaya, but with slightly different domain structures. In fact, one reading of work in prosodic phonology which eschews the use of strata (e.g.

Hammond 1999) is a model that is virtually indistinguishable from Parallel constraint domains. Consider for example the case of English syllable-final stop deletion after nasals (/lɑŋg/ → [lɑŋ] 'long'), as discusser in Bermúdez-Otero (2011). The stop resyllabifies into Stem-Level suffixes (['i:lɑŋ.gert] 'elongate'), but not into Word-Level suffixes such as -ish (/lɑŋgɪʃ/ → [lɑ.ŋɪʃ]/*[lɑŋ.gɪʃ]/ 'longish'). This can be derived in a stratal model by positing that the process applies at the Stem Level, but could also be captured by a prosodic structure as in (54) with recursive PWords. /g/ would be deleted because syllables cannot cross PWord boundaries. However, this analysis would requires a high-ranked constraint requiring that minimal Prosodic Words (and syllable boundaries) generally coincide with Stem boundaries. Thus the [t] before ish in a word such as *dilettantish* would also be predicted to be syllable-final, which is at odds with the standard assumption that its aspiration follows from a syllable-initial position. See Bermúdez-Otero (2011) for other problems with the structure in (53) based on l-darkening.



In general, parallel constraint domains can replace stratal accounts only for a very limited set of data, basically cases where the same process applies on some strings of a given phonological shape *S*, but not to other strings of the shape *S*, depending on the morphological affiliation of *S*

A tonal example is tone shift in Jita where an underlying H-tone shifts to a following syllable (54-e,f). Again, this must be a phrasal process because it applies across word boundaries (55-a,b,c) and is barred from applying to phrase-final positions (54-c). At the same time it can apply in single words (54-e,f):

(54) *Jita tone shift (Downing 2014:103)*

a. /oku-sja/	[oku-sja]	'to grind'
b. /oku-ljá/	[oku-ljá]	'to eat'
c. /oku-βóna/	[oku-βóna]	'to see'
d. /oku-βuma/	[oku-βuma]	'to hit'
e. /oku-βón-an-a/	[oku-βon-án-na]	'to see each other'
f. /oku-βón-er-an-a/	[oku-βon-ér-an-na]	'to get something for each other'

(55) *Jita Tone Shift (Downing 2014:103)*

a. [oku-βoná iiɲoɲi 'to see a bird'
(cf. [oku-βóna] 'to see'; iiɲoɲi 'bird'
b. [oku-lja múnó 'to eat a lot'
(cf. [oku-ljá] 'to eat'; munó 'a lot'
c. [oku-ɲa (a)má-puja 'to drink corn wine'
(cf. [oku-ɲwá] 'to drink'; ama-puja 'corn wine'

(56) demonstrates a second process in Jita, Meeussen's Rule which deletes the second of two H-tones in adjacent syllables. As (56-a) shows, the root ljá 'eat' has a H tone (which cannot shift because it is already phrase-final, and becomes falling in phrase-final position). In (56-b) the prefix βá- which is also H-toned triggers deletion of the H on ljá (again there is no H-tone shifting because this doesN't target phrase-final positions):

(56) *Jita: Meeussen's Rule (Downing 1996:58)*

	Underlying	Word Level	Phrase Level	
a.	/oku-ljá/	oku-ljá	[oku-ljâ]	'to eat'
b.	/oku-βá-ljá/	oku-βá-lja	[oku-βá-lja]	'to eat them'

In (57), Meeussen's Rule non-vacuously feeds tone shift: βá- triggers again deletion of the following root-initial H, which is then shifted to the following syllable:

(57) *Jita: Meeussen's Rule (Downing 1996:58)*

	Underlying	Word Level	Phrase Level	
a.	/oku-sí:ndika/	oku-sí:ndika	[oku-si:ndíka]	'to push'
b.	/oku-βá-sí:ndika/	oku-βási:ndika	[oku-βa-sí:ndika]	'to push them'

The most striking evidence for the stratal interaction between Meeussen's Rule and tone shift comes from cases where tone shift counterfeeds Meeussen's Rule as in (58-a): The H-tone of tá- shifts to the following syllable and becomes thus adjacent to the H of the verbal root (which cannot shift because it is already H). Meeussen's Rule doesn't have any effect because it only applies at the Word Level not the Phrase Level.

(58) *Jita Negative Present Continuous: Tone Shift counterfeeds Meeussen's Rule (Downing 1996:73)*

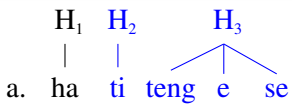
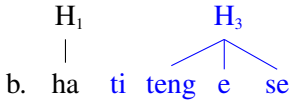
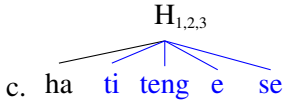
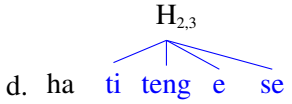
	Underlying	Word Level	Phrase Level	
a.	/a-tá-ku-ljá/	a-tá-ku-ljá	[a-ta-kú-ljâ]	'(s)he isn't eating'
b.	/a-tá-ku-bóna/	a-tá-ku-bóna	[a-ta-kú-bóna]	'(s)he doesn't see'
c.	/a-tá-ku-síndika/	a-tá-ku-bóna	[a-ta-kú-si:ndíka]	'(s)he isn't pushing'
	3SG.CL1-NEG-TNS-V			

It is hard to see how the Jita facts could be captured by parallel constraint domains. At the output level it is not true that the OCP consistently holds in the Word domain . Thus in (58-a) two H-tones originating from the same word can be adjacent whereas in (56)-b. /oku-βá-ljá/ → [oku-βá-lja] the second one is deleted. Crucially the OCP holds only at an intermediate stage.

Similar points can be made with Palestinian Arabic, Karimojong vowel harmony and tone dissimilation in Shona (see section 1.4). In all these cases, processes at later strata apply differently to the same morphemes and segments, andcannot be distinguished by different output positions.

(59) shows for example why a constraint-domain analysis of Shona using the same constraints as employed above fails. Applied in parallel a Max constraint relativized to the stem domain has not simply the effect of prioritizing fusion it also incorrectly blocks deletion of stem tones:

(59) *Shona — Failed Constraint Domain Analysis*

Input: = a.	OCP	MAX$_{Stem}$	UNIFORMITY	MAX	LEFT
a. 	*!				***
b. 		*!		*	**
☛ c. 			*(*!)		
(☛) d. 			*(*)	*!	*

1.5.3 Stratal Phonology vs. Cophonology Theory (Orgun 1996, Inkelas 1998)

Similarly to Stratal OT, in Cophonologies every affix (and more generally, every morphological construction) is associated to a specific constraint ranking, and constraint evaluation applies cyclically over morphologically defined domains. However, in contrast to most current versions of Stratal Phonology, Cophonology analyses typically assume that every morphological construction establishes a different cycle of phonological evaluation and is associated to a phonological grammar (a constraint ranking) which may arbitrarily differ from the grammars associated to all other constructions in a given language. Thus there is no boundary on the number of strata in a given language (see section 2.2 on this issue in Stratal Phonology proper). A related difference concerns what Inkelas & Orgun (1995) call Level Economy which one might contrast with the Level Uniformity assumption of Stratal models where lexical morphemes obligatorily pass through all strata. Take as simple example *absurdities* whose standard structure according to Stratal models is [[absurditi]$_{\text{Stratum 1}}$es]$_{\text{Stratum 2}}$. In both a cophonology and a stratal analysis, *absurdity* would run through grammar 1 feeding into the input for affixing -(e)s which would then run through grammar 2. However Level Uniformity implies that the same recursive evaluation would happen to an underived item such as in the utterance 'absurd!' Like absurdities this would pass through all strata (say Stem Level, Word Level and Phrase Level) even if there is no overt inflection or derivation. A further difference to most versions of Stratal Phonology is that Cophonology Theory explicitly abandons Layering. (60) summarizes the differences between Cophonology Theory and Stratal Phonology:

(60) *Stratal Phonology vs Cophonology Theory*

Stratal Phonology		*Cophonology Theory*
Scarce Cophonologies	↔	Maximal Cophonologies
Batch cyclicity	↔	Dense cyclicity
Level Uniformity	↔	Level Economy
Layering	↔	No Layering

Overall, Cophonology roughly amounts to a maximally permissive version of Stratal Phonology, which maximizes construction-specific phonologies and cycles, and minimizes general restrictions such as Level Uniformity and Layering (cf. section 1.1).[11] In section 2, I will argue that the more restrictive approach of Stratal Phonology can be generally maintained.

Note also that the notion that every morphological construction is a cyclic conflicts with the considerable evidence for non-cyclic word-internal processes (see section 2.3.2, and Orgun 1996 for an

[11] See, for example, Orgun (1996) who implements a specific form of Stratal grammar as a special case of Cophonoogy.

approach to parametrize cyclicity in a Cophonology approach).

1.5.4 Stratal Phonology vs. Output-output Correspondence (Benua 1995, Steriade 1999, 2008)

Benua (1995) proposes a model where apparently cyclic or stratal effects are reanalyzed via paradigmatic faithfulness to output forms. Thus the secondary stress in [E.ˌli.za.ˈbe.than] is not due to a previous cycle [E.ˈli.za.beth], but to faithfulness to the existing output of the same shape which forms its morphological base. The fact that English Stem-Level affixes trigger stress shift (e.g. *oríginal* → *originálity*), but Word-Level affixes don't (e.g. cléver → *cléverness*) is captured by the assumption that only the latter ones impose an output faithfulness constraint to the base word, whereas Stem-Level affixes undergo regular stress assignment.

As shown by Kager (1999) this approach also applies straightforwardly to Arabic syncope where High-vowel deletion in /fihim-na/ [fihím-na] 'he understood us' is blocked by faithfulness to the base form [fíhim] 'he understood'. On the other hand /fihim-na/ [fhim-na] 'we understood' undergoes regular syncope since it doesn't have a morphological base form as shown in (61):

(61) *Palestinian Arabic (Kager 1999:292)*

a. 'he understands'

Input: = a.	BSA	Max V_{Base}	No [i]	Max V
a. fihim	*!		**	
b. fi**him**	*!		**	
c. f**hím**	*!		*	*
☞ d. **fí**him			**	

Base ↓

a'. 'he understands us'

Input: = a.	BSA	Max V_{Base}	No [i]	Max V
a. **fí**him-na	*!		**	
b. fihim-**ná**	*!		**	
c. f**hím**-na		*!	*	*
☞ d. fi**hím**-na			**	

b. 'we understand'

Input: = a.	BSA	Max V_{Base}	No [i]	Max V
a. fi**hím**-na			**!	
b. **fí**him-na	*!		**	
c. fihim-**ná**	*!		**	
☞ d. f**hím**-na			*	*

A base according to Kager (1999) is defined as in (62).:

(62) *Definition of 'base' (Kager 1999:282)*

a. The base is a free-standing output form – a word.
b. The base contains a subset of the grammatical features of the derived form.

According to (62-b) [fíhim] 'he understands' is the base of 'he understands us', but not of 'we understand'. The latter doesn't have a base according to (62-a) because Arabic doesn't have finite verb forms without a specification for subject agreement. Crucially, this notion of bases and consequent recursive candidate evaluations for many cases emulates the recursive evaluation of stems and words in Stratal OT.[12]

A central difference consists however in the prediction that opacity should always be mediated by existing output forms. Trommer (2013b) shows in detail for several examples from Albanian stress

[12]There is very little literature on output-output correspondence addressing opacity effects involving postlexical phonology, but Storme (2023) proposes to capture this by constraints requiring faithfulness to Phrase-Level citation forms. A simple application would be syllable final devoicing of German (Bermúdez-Otero 2018b:11) under resyllabification. Devoicing applies regularly in the citation /leːg/ → [leːk], where the velar obstruent is in syllable-final position, but overapplies under resyllabification before enclitics ([leː.kəs.vɛk]) 'put it away'. The latter would reflect a faithfulness constraint for voicing requiring identity with [leːk].

that this prediction is wrong. In Albanian similarly to English, stress is predictable on stems. On final syllables if these are heavy as in <adˈet> 'habit' or <paˈtok> 'gander' or end in a peripheral vowel (e.g. <haˈta>, 'calamity', <qershi> 'cherry'), but penultimate if the final syllable is open and has a mid vowel as in <ˈba.bo> 'midwife'). However this generalization becomes opaque under affixation of word level affixes such as accusative -(i)n (<ˈbabo-n>) <aˈdetin>, where the final heavy syllable fails to attract stress. In these cases, this could be captured either by OO-faithfulness or a stratal analysis where ten word level phonology preserves the phonologically motivated stress assignment at the stem level. However, there are also nouns and verbs which lack the apparent base forms. Thus <pemurín-a> 'fruit' is formally plural – <it> triggers plural agreement and carries the regular plural suffix -a, but lacks corresponding singular form. In a stratal account it is natural to assume that stress is assigned to the stem <pemurin> and then transferred to <pemurina> just as in nouns with a full paradigm, OO incorrectly predicts that the final [a] should be stressed as in uninflected forms since there is no overt base.

Another case in point is Itelmen (see section 2.2.3 below for detailed discussion) where ə-epenthesis overapplies in verbs – which lack a free-standing base, but not in noun plurals which have have one, a twisted reversal of the predictions by OO-correspondence. Similar problems with lacking bases have been reported for Catalan (Mascaró 2016) and Breton (Iosad 2012a). A further potential case are identity effects in reduplicated roots in Chamorro (Klein 1997).

However OO-correspondence also runs into problems with opacity caused by phrasal phonology. Consider again the Jita data discussed in section, where Meussen's Rule deletes the second of two H-tones if these are underlyingly adjacent (63-b), but not if they only become adjacent at the Phrase Level through Tone shift of the first tone (63-c):

(63) *Jita: Meeussen's Rule (Downing 1996:58)*

	Underlying	Word Level	Phrase Level	
a.	/oku-ljá/	oku-ljá	[oku-ljâ]	'to eat'
b.	/oku-βá-ljá/	oku-βá-lja	[oku-βá-lja]	'to eat them'
c.	/a-tá-ku-ljá/	a-tá-ku-ljá	[a-ta-kú-ljâ]	'(s)he isn't eating' (Present Continuous)

OO-faithfulness per se doesn't explain why the base H is preserved in (63-c), but not in (63-b) since the transparent base of (63-b) has a H tone. One might posit that the negative prefix [tá]- imposes a special faithfulness constraint protecting the tone of its base. This would miss the generalization that application of Meeussen's rule correlates with the underlying position of tones, and appears also to be problematic empirically. Thus negative [tá]- also occurs in tenses where it actually triggers Meeussen's Rule such as in the Today Past (in (64-b), simultaneous coalescing with the adjacent tense prefix [a]-):

(64) *Jita: Affirmative and Negative Today Past (Downing 1996:69)*

	Underlying	Word Level	Phrase Level	
a.	/a-a-síriːsja/	aː-síriːsja	[aː-siríːsja]	'she burned'
b.	/a-tá-a-síriːsja/	a-táː-sirisja	[a-taː-sírisja]	'she didn't burn'

The actual (Affirmative) base forms for the Negative Present Continuous. form a highly irregular (in Downing's terms 'chaotic') paradigm for which Downing provides only little data. However from Downing's description it becomes clear that in simple Negative Present Continuous forms the underlying H of a word root is never deleted (as in (63-c)). On the other hand, in short Affirmative Present Continuous forms with H-toned prefixes, Meeussen's rule applies as expected (e.g. /e-ní-ljá/ → e-ní-lja TNS-2SG-eat'I am eating', Downing 2014:190).[13] Hence these forms couldn't serve as the output rationale for the corresponding forms in the negative which preserve their H.

[13] Affirmative Present Continuous forms are marked by a morphological H surfacing on most agreement prefixes and an underspecified vowel preceding subject agreement.

Phrase-Level processes also lead to fatal problems for an OO-correspondence approach in Palestinian Arabic as shown in detail by Kiparsky (2000) for epenthesis. Thus the Palestinian stress rule predicts penultimate stress on the heavy syllable in (65-b-iii) (epenthetic vowels are marked again by background shading). In Kiparsky's stratal analysis this is captured by locating epenthesis later (at the Phrase Level) than stress assignment (at the Word Level). I an OO-analysis, we might derive antepenultimate stress by faithfulness to the base form in (65-b-ii), however, this would incorrectly predict that the same opacity effect shows up in nouns without epenthesis (65-a-iii):

(65) *Epenthesis in Palestinian Arabic (Kiparsky 2000:??, Kager 1999:290)*

a. /bakar/ 'cattle'
   (i) **bá**kar il-wálad 'the boy's cattle'
   (ii) **bá**kar 'cattle'
   (iii) ba**kár**-na 'our cattle'

b. /fihm/ 'understanding'
   (i) **fí**hm il-wálad 'the boy's understanding'
   (ii) **fí**h(i)m 'understanding'
   (iii) fíh(i)m-na 'our understanding'

Kager (1999) tries to solve this problem by a constraint effectively banning stress on epenthetic vowels (HeadMax-BA), but as shown by Kiparsky this fails. First there seem to be other cases of epenthesis where the epenthetic vowel can be stressed, such as in quadriconsonantal clusters (/katab-t-l-ha/ → [katab-**t**(i)**-l**-ha] 'I wrote for her', Kager 1999:355). The OT-analysis can accommodate this difference by assuming that epenthesis in this context is already enforced at the Word Level and hence visible for stress, but in a strictly parallel system there seems to be no way to differentiate between different sources of epenthetic vowels. HeadMax-BA also fails to account for the opaque stress in cases such as (66-c), where the transparent stress would be on a non-epenthetic vowel (the antepenultimate). Again this pattern also defies an account in terms of OO-correspondence. The obvious morphological base for (66-c) has regular stress on the initial, not the second syllable, and c an hence not motivate its position in (66-c):

(66) *Palestinian Arabic epenthesis (Kiparsky 2000:353))*

a. /katab/	[kátab]	'he wrote'
b. /katab-at/	[kátab-at]	'she wrote'
c. /katab-t/	[katáb-(i)t]	'I wrote'

See Bermúdez-Otero (2011, 2018b) for two further case studies from Spanish and dialects of English which demonstrate the problems for OO-correspondence with Phrase-Level phonology.

The Benua-Kager model is asymmetric and thus closely emulates a stratal cyclic approach. However, in an output-output model it is also conceivable that there are paradigmatic influences between forms which are not in an inclusion relation.

The most detailed empirical argument to this effect is by Steriade (2008) that in Romanian palatalization is transferred from plural forms to derivational forms not containing the plurals.[14] However, Bermúdez-Otero (2018a) argues convincingly that the Romanian data should be captured morphologically: Roots which have palatalization have a floating Coronal feature as theme marker, which occurs in exactly the same contexts as segmental theme markers in inflection and derivation.[15]

[14] McCarthy (2005) argues that symmetric paradigmatic relations account for verb-noun asymmetries in the phonological templates of Classical Arabic, but Bobaljik (2008) shows that this assumption is by no means necessary, and doesn't account for similar noun-verb asymmetries in Itelmen.

[15] See the same paper on detailed arguments against extended output-output accounts of Latin rhotacism by Albright (2002) and French liaison by Steriade (1999).

2 Design Choices for Stratal Grammar: Extensions to the Basic Consensus Model

Stratal analyses differ in many respects in the details they assume for a stratal architecture. In this section, I investigate different design choices of this type from the perspective of a minimalist consensus architecture with the following properties:

- There are universally only three strata: Stem Level, Word Level and Phrase Level (section 2.2)
- Strata are internally non-cyclic (section 2.3)
- Strata are strictly layered: all Word-Level operations follow all Stem-Level operations, and all Phrase-Level operations follow all Word-Level operations (section 2.4)
- Bracket Erasure is unexceptional (section 2.5)

I will argue that most extensions to this minimal model proposed in the literature. The apparent evidence folr extensions can be captured in a natural way by representational means such as autosegmental representations or prosodic representations in line with the PWord Heuristics set above up in (12).

Note also that these design choices, especiallly the number of strata asumed, are not completely independent from each other. Additional strata potentially obviate inner-stratal cycles (see the discussion of Itelmen ə-epenthesis below for a concrete example). On the other hand, additional strata often implies problems for Layering and Bracket Erasure. For example, Mohanan (1986) subdivides the Stem Level in three separate strata for derivational morphology, coordinative compounding, and subordinative compounding. However coordinative compounds can be freely embedded in subordinative compounds and vice versa, undermining strict Layering. Both problems are avoided if the special properties of compounding are captured by prosodic representations instead. Similarly, as discussed in detail below, Hargus' (1985) subdivision of the Stem Level in 3 strata leads to problems because the morpheme boundaries of the first and second Stem-Level stratum must still be visible to account for processes also including material of the third Stem-Level stratum. This forces Hargus to substantially weaken the formulation of Bracket Erasure. In contrast, Bracket Erasure is not an issue if all these levels are collapsed into a single Stem Level stratum.

As a necessary background to the following discussions, I start this section with a short consideration of the nature and substance of strata in section 2.1.

2.1 The nature and substance of strata

2.1.1 Non-phonological Motivation for strata

In most languages, the strata posited for phonological reasons seem to be at least partially non-arbitrary from a morphological point of view. Thus in many stratal analyses of Indoeuropean languages, the Stem Level roughly coincides with derivational morphology (see Halle & Mohanan (1985) on Vedic, Trommer 2013b on Albanian), whereas inflection is part of the Word Level. The same is true for the analysis of Malayalam in Mohanan (1986). Nuuchahnulth (Stonham 2007) is a similar case with more derivational ('lexical') suffixes at the Stem Level, whereas valency-changing and inflectional affixes are at the Word Level.

These cases of morphologically grounded strata are in stark contrast to languages where stratal organization seems to be largely orthogonal to morphosyntactic categories. Thus Level-1 and Level-2 derivation in English achieves in principle the same grammatical functions (for example *-ity* and *-ness* both derive nouns from adjectives). Both negative *un-* (as in *un-happy*) and *in-* (as in *in-competent*) express negation and attach to adjectives, but there is broad evidence that *in-* is a Stem-Level and *un-* a Word-Level affix. Similarly Kiparsky (2020) argues that English irregular verb inflection is Stem Level whereas regular inflection is Word Level.

Evidence for a similar stratal split in is provided by Wiese (1988) for plural marking in German and by Trommer (2013b) for Albanian. Paster (2007) shows that plural in Lower Jubba May is expressed

either by a (Word-Level) affix, or a (Phrase Level) clitic. See Zwicky & Pullum (1983), Bresnan (2001) for arguments that a similar stratal split holds for full vs. contracted negation in English. Caballero (2008) argues that allomorphs of Applicative and Causative in Raramuri are located at different lexical strata. (see also Inkelas & Caballero 2013). In fact, most authors in the stratal literature concede that even the very same affix might be attached at different levels (see Halle & Mohanan 1985, Mohanan 1986, Giegerich 1999) resulting in 'dual-level' affixes or 'chameleon' affixes such as English adjectivizing -[able] (Kiparsky 2005, Bermúdez-Otero 2018b). Kiparsky (2020) makes the same claim for English Past Tense *-d* which is affixed as Stem-Level affix in strong verbs (such as *sell ~sol-d*), but as a Word-Level affix in regular verbs (as in *yell ~ yell-ed*). Bermúdez-Otero & Luís (2009) provide exhaustive evidence that object markers in European Portuguese are Word-Level affixes if they follow the verb (in Imperatives and infinite paradigms), but Phrase-Level clitics when they precede it. Hargus (1985) argues that a specific class of pronominal prefixes in Sekani is at Level 1 if used to mark possessor on noun stems, but at Level 3 when they mark object agreement in verbs.

The crosslinguistic diversity of strata seems to imply that there is no invariant grammatical substance to notions like Stem Level and Word Level. In contrast, (Bermúdez-Otero 2012) proposes a grounding of lexical strata in broader cognitive terms, where Stem Level and Word Level of correspond to different modes of lexical storage: the Stem Level to non-analytic listing (stems are stored without internal morphological structure), and the Word Level to analytic listing (words are stored without internal morphological structure). Under this approach, only Word-Level morphology is the result of productive rules, Stem-Level morphology is an epiphenomenon of fully stored lexical items connected by redundancy rules, which are only exceptionally used to produce novel word (form)s.

Under the assumption that these types (analytic vs. non-analytic) are the two only types of lexical storage provided by human cognition, strata should be uniform across languages, and languages should have a maximum of two word-internal strata. I will call this hypothesis *the Non-Arbitrariness of Word-Internal Strata Hypothesis:*

(67) *The Non-Arbitrariness of Word-Internal Strata Hypothesis*
Languages have a maximum of two word-internal strata
strictly corresponding to basic cognitive categories of memory

However, even for Bermúdez-Otero, the difference between Phrase-Level and Word-Level phonology seems not to be motivated by a difference in memory organization (presumably also the storage of syntactic units in idioms is analytic just as storage of entire words). This leaves room for other structurally defined word-internal level. A natural candidate for such a level is the morpheme (or specific morphemes such as roots). I will discuss this possibility in detail in section 2.2.3.

Let me finally address an open question which is hardly addressed at all in the stratal literature. Is there a way to capture low-level generalizations on stratal structure? For example Kiparsky in his Palestinian Arabic analysis (see section 1.4.2) assumes that all subject markers are Stem-Level, whereas all object markers are Word-Level. Similarly, Inkelas & Orgun (1995) assign all possessive suffixes to a specific stratum. The standard assumption in the literature seems to be that Stem-Level or Word-Level affiliation is an idiosyncratic subcategorization property of affixes (Kiparsky 2003) or of corresponding word-formation rules (Bermúdez-Otero 2012). Under this view, generalizations on morpheme classes are essentially accidental in synchronic grammar.

2.2 The Number of strata

In this section, I will argue that the basic standard model of strata comprising two (or maximally three) lexical and one postlexical strata doeesn't have to be extended. Concretely, I will argue that most languages which have been argued to provide evidence for additional language-specific strata can be reanalyzed by making use of prosodic structure and autosegmental representations. I will start with the issue of multiple strata in postlexical Phonology (section 2.2.1), turn then to word-internal strata (section2.2.2), and finally discuss the possibilty that there is a further general stratal level for roots (section 2.2.3).

2.2.1 Multiple Strata in Phrasal Phonology

Proposals for strata in phrasal phonology are of three different types. In the model of **Jones (2014)**, there is an additional stratum which evaluates prosodic phrases (corresponding roughly to NP's, VP's etc.) before the final stratum evaluates the complete utterance as in standard approaches. The same approach is proposed by **Koontz-Garboden (2001)** for Tiberian Hebrew based on earlier work by Dresher (1983).[16] **Rubach (2011)** posits an additional stratum for words including clitics before a general postlexical/phrasal stratum. In both approaches the additional strata maintain the basic intuition behind Cyclic Interleaving: each stratum evaluates bigger morphosyntactic domains than the preceding stratum. The motivation for two phrasal strata in **Clark's (1990)** analysis of Igbo is also the special behavior of clitics, but in a rather different, indirect way. Both of Clark's postlexical strata apply to entire utterances, but they differ qualitatively in the fact that the first postlexical stratum obeys the Strict Cycle Condition (its rules cannot apply if both trigger and target are part of the same morphosyntactic word). The major effect of this assumption is that clitics, although added by assumption in phrasal syntax behave differently from full words, and actually in a way more similar to lexical affixes. Thus it appears that positing two phrasal strata would become obsolete if clitics would be analyzed as edge affixes as discussed in section 1.2.5. Note that Clark's system in effect runs directly counter to a main intuition behind stratal models: Rules apply first to bigger domains and subsequently to smaller domains.

The bistratal model of postlexical phonology proposed by **Kaisse (1985)** is based on the assumption that phrasal phonology mirrors the distinction between Stem-Level and Word Level. Thus the first postlexical level ("P1") is assumed to be cyclic and directly sensitive to morphology, whereas the second postlexical level ("P2") is non-cyclic and blind to lexical storage and category-specific effects. This follows in Kaisse's model from the natural assumption of Bracket Erasure after P1. Whereas Kaisse's model is conceptually appealing, there seems to be little evidence from process ordering for the proposed system. See Seidl (2001:ch.7) for critical discussion.

(68) *Proposals for additional phrasal strata*

Jones (2014)	Kinande
Rubach (2011)	Macedonian
Clark (1990)	Igbo
Kaisse (1985)	

[16] The same architecture is used in Gjersøe (2017) to capture the fact that in Kikuyu a process called *Downstep Displacement* by Clements (1984) precedes other Phrase-Level tone alternations. In Clement's original analysis, *Downstep Displacement* is an unusual process which moves a floating tone that is the exponent of TAM and suffixed to the verb to the end of its phonological phrase. However Clements (1984:328) also suggests that the location of this tone might be better capture by treating it as a kind of tonal clitic attached to the first syntactic phrase after the verb. Under this interpretation, there is no phonological process of *Downstep Displacement* and no motivation to derive its ordering by positing innerphrasal strata.

The argument by Rubach 2011 for an additional clitic stratum in **Macedonian** seem to be rather analysis-specific. Rubach analyzes the distinctive behavior of sonorant consonants in the absence of an adjacent vocalic syllable nucleus. Root-initially, these sonorants triggers [ə]-epenthesis (69-b), root-finally [a]-epenthesis (69-f,i), and root-internally they become syllabic consonants (69-a). The intuitive appeal of a clitic stratum lies in the fact that vowel-initial enclitics such as definite -[ɔt] behave partially differently wrt epenthesis than vowel-initial suffixes (compare for example (69-g) and (69-h)). However, looking at prefixal and suffixal formatives separately, each of them fall into two arbitrary classes. Perfective [s]- bleeds ə-epenthesis (69-e) while the other prefixal elements counterbleed it (69-d,f). Similarly the plural suffix -[i] bleeds a-epenthesis, whereas the clitic -[ɔt] counterbleeds it. Crucially, this is perfectly consistent with assigning the enclitics (and most prefixes) to the Word-Level stratum and the suffixes proper to the Stem Level since there seems to be no additional arbitrary division among the suffixes. In fact, Rubach admits that such an analysis is in principle viable if slightly more specific constraints on syllabification and epenthesis are assumed. Thus the argument for a clitic stratum seems to be rather inconclusive.

(69) *Syllable structure repairs in Macedonian (Rubach 2011:246)*

a.	.bɽ̩.dɔ	‘hill’	b.	.ⓐr.ti	‘bud’
c.	za-.ⓐr.ti.	‘bud’ (perfective)	d.	.i.z-ⓐr.ti.	‘bud’ (perfective)
e.	.sɽ̩.ʒi	‘growl’ (perfective)	f.	.vⓐr.bɛt.	‘in (the) spine’
f.	.ti.gⓐr.	‘tiger’	g.	.ti.gⓐ.-rɔt.	‘the tiger’
h.	.tig.ri.	‘tigers’	i.	.o.gⓐn.	‘fire’
j.	.og.nɔ.vi.	‘fires’	k.	.og.n-ɔt	‘the fire’

Jones’ evidence for strata in **Kinande** is based on the assumption that there is no stratum-internal opacity (see section 3.4). In Kinande lexically associated L-tones block the association of boundary tones for phonological phrases (which is uniformly H) but not for intonational phrases (utterance-finally: H for questions, L for statements). The boundary tones are fully realized with toneless words as in (70):

(70) *Phrasal variants of a noun with a toneless final vowel [o-ku-gulu] ‘leg’*

a.	b.	c.
H_{φ}	H_{φ} L_{ι}	H_{φ} H_{ι}
|	| |	| |
o ku gu lú $)_{\varphi}\ldots)_{\iota}$	o ku gú lù $)_{\varphi})_{\iota\text{-D}}$	o ku gú lú $)_{\varphi})_{\iota\text{-I}}$

(71) *Phrasal variants of a noun with a final L-tone [e-ki-hekà] ‘truck’*

a.	b.	c.
L	L_{ι}	H_{ι}
|	|	|
e ki he kà $)_{\varphi}\ldots)_{\iota}$	e ki he kà $)_{\varphi})_{\iota\text{-D}}$	e ki he kà $)_{\varphi})_{\iota\text{-I}}$

The opaque case is (71-c). Since the i-H overwrites the lexical L there seems to be no reason why not also the φ-H could associate resulting in two final H-syllables just as in (70-c). In Jones’ analysis this follows from assigning phrases and in phrases to different strata. At the Phrase stratum φ-H cannot overwrite. At the ι-stratum, the final L is overwritten by the ι-H, but it is to late for the φ-H to associate because it has been already deleted in the – earlier – φ-stratum.

However, there is a simple way to exclude association of both tones under Containment in a parallel way. Under the containment assumption, tones and association lines are not literally deleted, but only marked as phonetically uninterpretable. This means that associating both ι-H and φ-H would lead to crossing association lines as in (72-b) which can be avoided by associating only one H:

(72) a. ki he ká b. ki hé ká

The evidence for two phrasal strata provided by Koontz-Garboden (2001) centers around a process which spirantizes stops after vowels. As shown by Dresher (1994) this process applies across word boundaries, as shown by /təʊ/ → [ɬəʊ] in (73), but not across prosodic phrase boundaries (indicated here by vertical lines), as shown by the failure of spirantization in [toːraθ] :

(73) *Tiberian Hebrew spirantization bounded by phonological phrases (Koontz-Garboden 2001:13, Dresher 1994:4)*

ʃimʕuː	ɬəʊ ar-yhwh	qəṣiːneː	səɬoːm
hear	word-(of)Yhwh	chieftains	(of)Sodom

haʔaziːnuː	toːraθ	ʔeloːheːnuː	ʕam	ʕamoːraː
give.ear.to	instruction	(of)our.God	folk	(of)Gomorrah

‘Hear the word of the lord, you chieftains of Sodom;
give ear to our god’s instruction you folk of Gomorrah’ (Isa. 1.10)

Koontz-Garboden argues that there are two syncope processes which delete vowels in medial open syllables following another open syllable. One applies at the Stem Level (74-a) (where ja-, na- li- are analyzed as Stem Level affixes), and one which applies at the Utterance Level (74-b) (-u and bi- in Koontz-Garboden’ analysis are Word-Level affixes, thus katab and katob don’t undergo Stem-Level Syncope in their absence). Since spirantization is sandwiched between both instances of Syncope (at the Phrase Level), it is bled by Stem Level syncope, but counterbled by Utterance-Level syncope:

(74) *Tiberian Hebrew spirantization interacting with vowel deletion (Koontz-Garboden 2001:6)*

a. Vowel deletion triggered by Stem-Level affixes bleeds spirantization

(i) /ja-katob/ → [jixtóːv]/*[jixθóːv] ‘write 3MSG IMPF’
(ii) /li-katob/ → [lixtóːv]/*[lixθóːv] ‘write 3MSG INF CONSTRUCT’

b. Vowel deletion triggered by Word-Level affixes counter-bleeds spirantization

(ii) /bi-katob/ → [bixθoːv]/*[bixtoːv] ‘when writing INF CONSTRUCT’
(ii) /katab-u/ → [kaθvúː]/*[kaθbúː] ‘when writing INF CONSTRUCT’

A similar analysis is given for the interaction of spirantization with vowel epenthesis in coda clusters. In the Koontz-Garboden analysis there is epenthesis at the Stem Level (as in the bare root /malk/ in (75-a)) and at the Utterance Level (for clusters emerging due to Word-Level affixation as in (75-b), I will abstract away here from the fact that both instances of epenthesis follow slightly different conditions, see Koontz-Garboden for details). Again, spirantization is sandwiched between the two instances of epenthesis, and thus fed by Stem-Level epenthesis (75-a), and counterfed by Utterance-Level epenthesis (75-b):

(75) *Tiberian Hebrew spirantization interacting with vowel epenthesis (Koontz-Garboden 2001:6*

a. Vowel insertion triggered by bare stem feeds spirantization

/malk/ → [mélex]/*[mélek] 'king'

b. Vowel insertion triggered by Word-Level affixation counterfeeds spirantization

/ʃamaʕ-t/ → [ʃamaʕ-át]/*[ʃamaʕ-áθ] 'hear 2SG.FEM.PRF'

Tiberian Hebrew would be amenable to a Containment analysis. This is easy to see for the phrasal syncope process. If syncope is sensitive to underlying and surface vowel, this would directly explain counterbleeding if syncope happens at the same postlexical stratum as late spirantization. On the other hand, underlying vowels deleted by syncope would not be visible for spirantization if Containment doesn't hold across strata. The more difficult problem is the postlexical interaction of spirantization with epenthesis. This would have to be solved by representational means, e.g. by positing that vowels inserted by postlexical phonology lack moras and mora-less vowels fail to trigger spirantization.[17] An account of Tiberian Hebrew without multiple postlexical levels thus seems to be viable, but is clearly more complex than KoontzGarboden's analysis.

2.2.2 Multiple Strata in Lexical Phonology

Recall that the grounding of lexical strata by Bermúdez-Otero (2012) connects the nature of specific strata to general cognitive modi of storage. Under the assumption that the human cognitive architecture has only a limited number of storage types, a corollary of this approach is that there should also be a small crosslinguistically uniform number of lexical strata.

This contrasts with the fact that there is a considerable number of proposals for multiple lexical strata.[18] However, it is important to see these in the context of other theoretical assumptions. Thus a number of authors advocating more than two lexical levels, explicitly or implicitly reject the assumption of Prosodic Words in the Lexical Phonology. For example, Mohanan (1986) captures the special phonological properties of the two compound types in **Malayalam** by two dedicated extra strata. In an approach where these are captured by prosodic means (see Sproat 1985), suggested by the PWord Heuristic stated in section 1.2.2, the number of strata shrinks to 2. The same seems to hold for the claim by Halle & Mohanan (1985) that **English** has 4 lexical strata, which is also mainly based on the special behavior of segments in compound boundaries. See Inkelas (1990) for a reanalysis of Malayalam without dedicated compound strata, and Booij & Rubach (1987) on a reanalysis of English. Whereas in Malayalam and English compounds seem to behave as Word-Level construction with special prosodic properties, Clark (1990) posits a third lexical stratum ('Root Stratum') for **Igbo** mainly consisting of root compounds. Shaw (1985) splits the Stem Level in Dakota into two separate strata based on the dif-

[17] Conversely Stem-Level spirantization would have to be qualitatively different and lack this restriction, and not be sensitive to underlying vowels. However, the latter is in principle unproblematic under the assumption that sensitivity to underlying structure in Containment is due to constraint cloning and contingent on ranking. Similarly if the restriction that epenthetic vowels are non-moraic could be related to a specific constraint which is highly ranked at the Phrase Level, but ineffective due to low ranking at the Stem Level.

[18] I ignore here proposals for multiple lexical strata which are based exclusively on restrictions on morpheme ordering (see Packard 1990 on Mandarin, Wiese 1996 for German, and Scalise (1984) for Italian)

ference between phonological differences between Stem-Level compounds and reduplication.[19] PWord Heuristics stated in (12) in section 1.2.2 leads us to expect that not additional strata, but complex PWords at the Stem Level or the Word Level are at stake.

The PWord Heuristics might also obviate strata posited for prefixes. Thus the main motivation for Lesley-Neuman (2012) to posit an additional 3rd stratum for **Karimojong** is to capture the behaviour of a class of pronominal prefixes which fail to undergo the ATR harmony processes applying to Stem-Level affixes and Word-Level suffixes. However, if these prefixes are taken to be outside the innermost prosodic word, they can be simply analyzed as Word-Level prefixes. The harmony process is then restricted to the minimal PWord much as in the classical arguments for prosodic domainhood in the vowel harmony processes of Turkish and Hungarian (Nespor & Vogel 1986).

A similar point can be made for analyses of **Bantu languages** which interpret the widespread notions of stem, macro-stem and word domain in the Bantulogical literature as strata. The most explicit analysis of this type is Jones (2014) on **Kinande**, who explicitly rejects word-internal prosodic domains on the grounds of theoretical parsimonity. Jones (2014) assumes that Kinande verbs not only contain a Stem stratum (roughly the verb roots + suffixes) and a Word stratum comprising the complete morphosyntactic word, but also an intermediate macrostem stratum which contains the stem and object prefixes, but excludes other prefixes as in (76-a).[20] However, in a theory with prosodic words, it is possible to reinterpret this structure as in (75-b). the stem plus he object prefixes constitute the stratal Stem domain. That the complex of root and suffixes behaves apart from the object prefixes could then be ascribed to the fact that it forms a separate prosodic word inside this domain, again as predicted by the PWord heuristic in (12).

(76) a. *Bantu Word Structure in Jones (2014):*

[Word]
[Stem]
Prefixes Object Prefixes [Root + Suffixes]
[Macro-Stem]

b. *Reanalysis with Stem-internal Prosodic Words:*

[Word Level]
[Prosodic Word]
Prefixes Object Prefixes [Root + Suffixes]
[Stem Level]

Jones' domain argument is that stems are the domain for positioning tonal morphemes. The opacity argument is based on the fact that under his analysis the second of two affixal H's is deleted due to the OCP at the Stem Level (the root + the suffixes).

[19] In her summary of strata (p.175) Shaw also assigns different sets of suffixes to these two initial lexical strata, but she doesn't provide any discussion to back up this choice. See also Paschen (2021) for an analysis of closely related Lakota with only two word-internal strata.

[20] In the phonological literature on Bantu, it is often not clear whether these domains are intended as purely prosodic domains, stratal/cyclic domains or in a theory which fuses both hierarchies as in Inkelas (1990). As shown by Hyman (2008) in a comparison of Shona, Luganda and Central Bantu varieties the domain structure of different Bantu languages can be dramatically different from each other. Myers (1987) assumes for Shona a structure more akin to what is proposed here for Karimojong, a stratally defined Stem Level, and a Word level plus proclitics and enclitics which form a prosodic Word together with Grammatical Words at the Phrase Level.

(77) *Complex Tone and the OCP (Jones 2014:18)*

Toneless stems

a. humana + H H	→	humánà	'hit each other'
b. humirana + H H	→	humíranà	'hit for each other'
c. humanirira + H H	→	humánirirà	'hit each other on purpose'

H-toned stems

d. túmana + H H	→	túmàná	'send each other'
e. túmirana + H H	→	túmìraná	'send for each other'
f. túmanirira + H H	→	túmànirirá	'send each other on purpose'

On the other hand, there is a process of binary H-spreading which extends throughout the Macrostem Domain (the Stem + preceding object prefixes). Obviously spreading is oblivious about the OCP, in fact creates OCP violations as in (78-b):

(78) *OCP + Binary H-Spread (Jones 2014:19)*

Toneless stems

a. humánà	→	húmánà	'hit each other'
b. humíranà	→	húmíranà	'hit for each other'
c. humánirirà	→	húmánirirà	'hit each other on purpose'

H-toned stems

d. túmàná	→	túmáná	'send each other'
e. túmìraná	→	túmìráná	'send for each other'
f. túmànirirá	→	túmànirírá	'send each other on purpose'

This according to Jones is the central argument for having two stratal domains: The OCP is high-ranked at the Stem Level where it effects H-deletion, but ranked low at the Macrostem Level where its violations are tolerated. However, a simple alternative is to posit that the version of the OCP at work in Kinande does not block all adjacent H-tones, but only adjacent tautomorphemic H's.

Igbo: Let us also shortly discuss the evidence for an additional Root Stratum by Clark (1990) which is due to differences between suffixes and hence not amenable to a solution in line with the PWord Heuristics.[21] Apart from root compounding, Clark assigns only two affixes to the Root Level stratum, collective suffix -[kɔ] and the directional suffix -[ta]. The main reason for this assignment is the fact that in contrast to other Stem-Level affixes they can appear inside of root compounds. (79) shows data with -[ta] between the members of a compound. (79) shows cases where -[ta] is inside of -[kɔ]:

(79) *Root-Level suffix -ta in compounds (Clark 1990:76)*

a. í-↓lɔ́-tá-dú 'to come along back'
INF-return-DIR-accompany

b. í-↓fé-tà-bà 'to cross over into'
INF-cross-DIR-enter

[21] Note that the Root Stratum proposed by Clark witz inrternal morphologicl complexity is substantially different from the Root stratum approach discussed in section 2.2.3, which strictly operates on single morphemes.

(80) *Root-Level -ta (Clark 1990:77)*

a. í-ˡbí-kɔ́-tá 'to live together'
INF-live-COLL-DIR

b. í-ˡgú-kɔ́-tá 'to add together'
INF-count-COLL-DIR

c. í-zù-kɔ̀-tà 'to assemble'
INF-meet-COLL-DIR

The phonological reason for this assignment is the behavior of the affixes in ATR-harmony. However, this concerns only directional -[ta]. -[kɔ] behaves just like all other opaque Stem-Level suffixes in failing to undergo any ATR-harmony. The special behavior of -[ta] is that it in principle undergoes ATR-harmony (81-a,b), but not with the vowel [e] (81-c):

(81) *Root-Level -ta in Clark (1990) (Clark 1990:78+79)*

a. (i) bù-té 'catch' (ii) gwù-té 'dig up'
(iii) lì-té 'get up' (iv) ʒì-té 'demonstrate' (v) gò-té 'buy'

b. (i) gʊ̀-tá 'read' (ii) zʊ̀-tá 'buy'
(iii) cì-tá 'bring' (iv) cɔ̀-tá 'look for'

c. (i) chè-tá 'remember' (ii) wè-tá 'bring' (iii) kè-tá 'share out'

The possibility of a representational account becomes clear from the overall distribution of harmony in Igbo's suffixes (82). Whereas for all non-low vowels there are affixes which don't undergo harmony. [a] only appears in alternating affixes.

(82) *Igbo Suffixes* (Clark 1990:78)

Harmonizing		Non-harmonizing	
-lá/-lé	perfective	-bè or -bò	'ever, yet'
-lá/-lé	neg.imperative	-mò	'lest
-ɣá/-ɣé	continuative	-kɔ́	collective
-wá/-wé	incipient	-sí	distributive
-tá/-té	directional	-dí	emphatic
-chá/-ché	'thoroughness'	-gíðɛ́	continuative
-ɣí/-ɣí	neg.non-imperative	-tʊ́	diminutive

Under the assumption that all fully harmonizing affixes are underspecified underlyingly for [ATR], there is an apparent gap: Non-low vowels may be underlyingly specified for ATR or not, whereas all low voweled affixes alternate. My suggestion is that the difference between -[ta] and the other [a]-affixes is in parallel to the contrast among non-low voweled affixes. Most of them are underspecified, but -[ta] is underlyingly [-ATR] which explains that it remains [-ATR] even in a specific [+ATR] context

(83) *Suggested [ATR]-specifications of vowels in Igbo suffixes*

a. Specified non-low vowel	No harmony	-di
b. Underspecified non-low vowel	Full harmony	-ɣi/-ɣɪ
c. Underspecified low vowel	Full harmony	-la/-le
d. Specified low vowel	Partial harmony	-ta

The special behavior of -ta can then be captured purely phonologically. Assume that harmony is triggered by the constraint SHARE [ATR] ('Assign $*$ to every pair of vowels in adjacent syllables which are not associated to the same instance of feature [±ATR]'), and that the impossibility of -te after stems with [e] is due to a higher-ranked constraint against adjacent syllables with [e]. As a consequence we

get harmony (-te) if -ta is added to a base with any other vowel (84), but lack of harmony if attached to a base with a final [e]-syllable (85). IDENT [ATR]$_{[-low]}$ (Assign $*$ to every underlyingly [-low] vowel which is specified as [αATR] in the input and [-αATR] in the output') is not violated in (84) and (85) (and the following two tableaux) since -ta and -la have [+low] vowels.

(84) *Igbo*

Input: = a.	IDENT [ATR]$_{[-low]}$	DEP [ATR]	*ee	SHARE [ATR]
a. li-ta				*!
☞ b. li-te				

(85) *Igbo*

Input: = a.	IDENT [ATR]$_{[-low]}$	DEP [ATR]	*ee	SHARE [ATR]
☞ a. we-ta				*
b. we-te			*!	

Other suffixes with a low vowel such as n e.imperative -la are by assumption underspecified for [ATR]. This is where DEP [ATR] comes into play. After a base with a final [e]-syllable the violation of *ee is tolerated since this is the only possibility to avoid insertion a [±ATR] feature (86):

(86) *Igbo*

Input: = we-lA	IDENT [ATR]$_{[-low]}$	DEP [ATR]	*ee	SHARE [ATR]
a. we-la		*!		*
☞ b. we-le			*	

With different base vowels, *ee is irrelevant and sharing of the [ATR]-feature of the base is again the prefered option (87):

(87) *Igbo*

Input: = li-lA	IDENT [ATR]$_{[-low]}$	DEP [ATR]	*ee	SHARE [ATR]
a. li-la		*!		
☞ b. li-le				

Due to the inertness of IDENT [ATR]$_{[-low]}$ (which only assigns violation marks for underlyingly specified vowels) and the high ranking of DEP [ATR], underspecified non-low vowels ((83)- b) will show the same general harmony as in (87) and (86). Finally suffixes with a npon-low vowel that is underlyingly speified for ATR ((83)-a), will be protected by the highest-ranked constraint IDENT [ATR]$_{[-low]}$, and therefore not show an y alternation.

There are also claims on multiple strata in word-internal morphophonology which are not strictly compatible with a standard stratal model. Thus Dolatian (2020b) posits an additional word-internal stratum for **Armenian** which doesn't coincide with morphological constituency and seems thus rather prosodic in nature. Another case is Caballero (2008) on **Rarámuri** rounding harmony according to Caballero is restricted to a stratum which she calls Aspectual Stem. Whereas all examples cited by Caballero for exhibiting rounding harmony target affixes inside this verbal constituent. Interestingly rounding harmony appears to be blocked if a potential target inside the Aspectual Stem is followed by a more peripheral target outside of the Aspectual Stem. However, in a stratal architecture material in an outer stratum should never have an effect on processes in an inner stratum (by the myopia property introduced in section 1.1). Crucially, the data in Caballero (2008) also seem to follow from an alternative interpretation. Rounding harmony is blocked in cases where one or more of the target vowels is in the word-final syllable in accordance with the fact that the final vowel in the language is systematically immune to otherwise applicable changes such as reduction or deletion.

The most thorough and convincing arguments for multiple lexical strata have been developed for polysynthetic American Indian languages, by Hargus (1985, 1988) on **Sekani** and by Jaker & Kiparsky (2020), Jaker (2022) for **Tetsǫ́t'iné** (both Athabaskan languages), and for the Pomoan language **Kashaya** by Buckley (1994a). However, in all three languages, it is also apparent that some of the posited strata only differ in minor ways, and that the major dichotomy is between just two word-internal domains (see Buckley on Kashaya and Hargus on Sekani, see also Trommer 2023b on the same point in a two-stratum reanalysis of **Turkish**). In the two Athabaskan languages this distinction corresponds to the well-known difference between conjunct and disjunct affixes. In fact, Buckley (2017) comes to the conclusion that the 4 levels of his original analysis might be streamlined to an analysis restricted to a Stem and Word Level once strictly morphologically conditioned processes and processes not applicable to affixes of specific phonological shapes are factored out. It remains a major challenge for the Nonarbitrarity hypothesis to show that the same conclusion can be extended to Athabaskan. See section 2.4.1 on some first steps into this direction for the analysis of Sekani.

2.2.3 The Root Stratum and the Status of Morpheme Structure constraints

Trommer (2011) proposes that in addition to Stem Level and Word Level stratal grammars also comprise a Root stratum. In tandem with the assumption that Word-Level affixes go independently through the Stem Level before concatenation, this effectively emulates the traditional notion of morpheme structure constraints in stratal terms.[22] A simple example for the application of this idea is H-tone in many Bantoid languages such as Tiv (Pulleyblank 1986b) and Kinande (Jones 2014) which have a restriction that single verb roots have maximally 1 H-tone. However on a stem more than one H tones can be realized. For example, the Tiv verb /óngo/ according to Pulleyblank has a single initial H, but hosts an additional suffix H in the Recent Past (óngó) '(s)he heard'. Similarly, Jones argues that specific morphological patterns at the Stem Level create stems with two H-tones (e.g. (túmìrá:), p.185).[23] If Jones' analysis is correct, the restriction to 1 tone cannot be a general property of stems. It would however follow from a stratum preceding the Stem Level which imposes this restriction. The fact that the 1H-restriction is sensitive to part of speech (noun roots in Tiv and Kinande can have more than one underlying H) is also consistent with an additional claim in Trommer (2011) that sensitivity of phonological constraints to extraphonological properties of a single morpheme *M* is limited to the stratum where *M* is introduced, hence in case of roots at the Root Level.[24]

One central objection against MSC's (and implicitly against a root or morpheme stratum) both in the Lexical Phonology literature (Kiparsky 1982b) and the OT-literature is the claim that they simply reflect more general phonological regularities in a given language. Thus in Yawelmani roots cannot have CCC clusters underlyingly, but there are also several phonological processes such as V-epenthesis which repair CCC-clusters created by affixation (Kisseberth 1970). Stating the same restriction twice for roots and larger forms would result in the 'Duplication Problem'. However, as shown by Albright (2004) and Tebay (2022), phonotactic constraints on roots and other morphemes are often phonetically 'unnatural' in contrast to constraints imposed on bigger morphophonological domains (both authors hypothesize that the functional reason for this is that marked structure enhances the recoverability of root morphemes in speech. Thus in several languages such as Fe'Fe'-Bamileke (Atlantic- Congo; Cameroon), lexical roots can end in voiced plosives, but not in voiceless ones reversing the crosslinguistic preference for voiceless obstruents in syllable- and word-final position. In fact, Fe'Fe'-Bamileke has word-final devoicing (Tebay, 2022:43).[25]

A second objection militating against a root stratum is the generalization based mainly on English that bound roots are not cyclic domains for phonological processes (the stem is the smallest domain). But there seem to be numerous counterexamples. A well-known case is the restriction against two identical non-final consonants in Arabic roots. Thus there are stems like [katab] 'write' and [samam] 'poison', but no roots such as *[sasam] (McCarthy 1986:209). However this configuration can be created by the reflexive binyanim, which prefixes [i]- and infixes [t] after the first root consonant (e.g. [kataba] 'he wrote' → [ʔi-k-t-ataba] 'he copied', McCarthy 1979:209). Under the standard assumption that the binyanim are Stem-Level morphology, this means that the constraint against identical consonants holds in bound roots but not in stems. See also Tebay (2022) on a detailed argument for tonal MSCs on bound roots in Chungli Ao. Another potential counterexample to the claim that MSCs are coextensive with Stem-Level phonotactics is Dahl's Law which holds in roots and in prefixes, but not in suffixation (see section 2.3.2 for detailed discussion). But since virtually all analyses of Bantu agree that suffixes are

[22] A root stratum is also assumed in Inkelas & Orgun (1995) on Turkish. Benz (2017) and Clark (1990): root strata with limited internal morphology, reduplication in Washo, root compounding and two irregular suffixes in Igbo, as discussed in section 2.2.2.

[23] [túmìrá:] is a morphologically complex stem, but Kinande has monomorphemic roots with two or three syllables, e.g. [lender] 'to walk' or [birikir] 'to call' (Downing, 2000:11). Whereas Jones doesn't discuss the relevant tonal patterns for these roots, his description implies that

[24] Another potential case: place restrictions in English "In consonant clusters, consonants may have at most one other articulator feature than Coronal. If we come across such clusters in words (as in zipcode and backpack),they must be compounds" Booij (2011)2055. Also in derived stems such as wakeful, worshipful' with the Stem-Level suffix -ful (Kiparsky, 2020:15-16)

[25] 'Unnatural' MSC's are also posited as the general source of Non-Derived Environment Blocking effects by Rasin (2023) (see section 4.2). See also Rasin & Katzir (2020) for an argument for MSCs based on computational learnability.

part of the Stem domain the constraint cannot be a general property of stems.

Another possible counterexample is found in Itelmen (Bobaljik 2008), which has [ə]-epenthesis to satisfy a constraint which requires that voiced consonants are adjacent to a vowel. Thus no [ə] is inserted in noun roots before vowel-initial suffixes, but bare singulars exhibit epenthesis:

(88) *Itelmen ə-epenthesis in nouns (Bobaljik 2008:44)*

a. ɬxəm	~	ɬxm-ɐn	'sable' sg. ~ pl.
b. spəl	~	spl-ank	'wind' direct ~ locative
c. ʷtχəz-xʔal	~	ʷtχz-enk	'road' ablative ~ locative

A ə/Ø-alternation is also found in verbs with the present tense suffix -[z]. However in forms like in (89), [z] is actually adjacent to the vowel of the following suffix:

(89) *Itelmen ə-epenthesis in verbs (Bobaljik 2008:44*

a.	ɬeru-z-in	'she gripes'	gripe-PRES-3SG
b.	ilə-z-in	'he drinks'	drink-PRES-3SG

A simple way to make sense of this pattern in stratal terms is to assume that [ə]-epenthesis, -[z] and the nominal suffixes are Stem-Level, but the agreement suffixes are Word-Level:

(90) *Stratal analysis of Itelmen ə-epenthesis*

		Stem Level				Word Level		
		Morphology		Phonology		Morphology		Phonology
ɬxm	→	—-	→	ɬxəm	→	——	→	——
ɬxm	→	ɬxm-ɐn	→	—-	→	——	→	——
ɬeru	→	ɬeru-z	→	—-	→	ɬeru-z-in	→	——
il	→	il-z	→	ilə-z	→	ilə-z-in	→	——

Crucially [ə]-epenthesis also overapplies with vowel-initial suffixes in verb roots: Interestingly in (91-f), it applies twice:

(91) *Itelmen ə-epenthesis in verb roots (Bobaljik 2008:44+45)*

a.	t-zəl-cen	'I gave it'	
	1SG-give-1SG>3SG		
b.	zəl-en	'you gave it'	*zlen
	give-2SG>3SG		
c.	t-ɬəm-cenʔ	'I killed them'	
	1SG-kill-1SG>3PL		
d.	q-ɬəm-in	'kill it!'	*q-ɬmin
	2IMP-kill-1SG>3PL		
e.	spəl-qzu-in	'it was windy'	
	windy-ASP-3SG		
f.	spəl-in	'it was windy'	*splin
	windy-3SG		
g.	spələz-in	'it is windy'	
	windy-3SG		

The crucial problem is the question why epenthesis applies twice in (91-f) because [spləzin] would also be fine phonotactically (both z and l are adjacent to a vowel). Moreover paradoxically [ə]-epenthesis appears to happen cyclically in bound verb roots (verbs in Itelmen never appear without affixes) whereas it doesn't in nouns which are generally free morphemes. Positing a Root Level would immediately solve these problems: It would provide a further source of cyclicity without positing any innerstratal cyclicity (see section 2.3 for discussion). It also would naturally account for the fact that [ə]-epenthesis for roots is sensitive to the noun-verb distinction, a typical property of morpheme-structure constraints (see Tebay 2022) also found in Kinande and Tiv

(92) *Stratal analysis of Itelmen* ə*-epenthesis employing a Root Stratum*

		Root Level			Stem Level			Word Level		
		Phonology		Morphology		Phonology		Morphology		Phonology
ɬxm	→	—-	→	—-	→	ɬxəm	→	——	→	——
ɬxm	→	—-	→	ɬxm-ɐn	→	—-	→	——	→	——
ɬeru	→	—-	→	ɬeru-z	→	—-	→	ɬeru-z-in	→	——
il	→	—-	→	il-z	→	ilə-z	→	ilə-z-in	→	——
zl	→	zəl	→	—-	→	—-	→	zəl-en	→	——
spl	→	spəl	→	spəl-z	→	spəl-əz	→	spəl-əz-in	→	——

Note also that the notion of MSC's underlies one possible solution to the phnenomenon of Non-derived Environment Blocking by Rasin (2023) discussed in section 4.2.

Generally, the status of MSC's and potential evidence for a Root stratum are in need of more systematic crosslinguistic evaluation. Thus in most existing surveys, the status of a phonological generalization as a MSC is ascertained by identifying any counterexamples against the generalization in complex words, disregarding any further word-internal structure. Thus Booij (2011:2052) claims that there is a MSC in English against voiced obstruent clusters ruling out morphemes such as *[lʌvd] or *[dʌbd], whereas these are attested as inflected words (*loved* and *dubbed*). However, Past tense -[d] is arguably a Word-Level affix (Kiparsky 2020), thus this constraint could still be a property of stems, not of isolated morphemes.

2.3 Innerstratal Cycles

An original claim of Lexical Phonology was that the Strata of Lexical Phonology are cyclic whereas phrasal phonology is non-cyclic. Thus in the word-internal phonology, phonological evaluation happens after every application of a morphological rule such as affixation or compounding. On the other hand, all syntactic structure building would happen as a block preceding a single phonological evaluation by the phrasal phonology.

(93)

Pesetsky (1979), Kiparsky (1982b)	Lexical Phonology: cyclic Phrasal Phonology: non-cyclic
Mohanan (1986)	Cyclicity is a parametric property of strata
Booij & Rubach (1987), Borowsky (1986),	Stem Level: cyclic Word Level and Phrasal Phonology: non-cyclic
Bermúdez-Otero (2012)	All strata non-cyclic (but fake cyclicity at the Stem Level)

Various departures from this picture have been proposed. Maybe most crucially, there is by now a broad consensus that at least some lexical strata might be non-cyclic. This has been argued for the Word Level in English by Borowsky (1986) and Halle & Mohanan (1985) (who make the same claim for Sanskrit), and by Booij & Rubach (1987) for Dutch and Polish. Mohanan (1986) argues that in Malayalam all lexical strata are non-cyclic, a position generalized by Bermúdez-Otero (2012) in Stratal OT. Bermúdez-Otero argues for a model where every stratum consists of a battery of morphological operations followed by a single application of phonological optimization. The evidence for cyclicity at the Stem Level is reinterpreted as the effect of a special type of lexical listing only available at the Stem Level. These listed forms compete morphologically with transparent derivations.[26]. On the other hand, Mohanan (1986) assumes that cyclicity is simply subject to free crosslinguistic parametrization. Every lexical stratum can in principle be cyclic or non-cyclic.

2.3.1 Models of Stratum-Internal Cyclicity in Word-internal Phonology

(94) *stratum-internal cyclicity in word-internal phonology in different analyses*

Pulleyblank (1986b)	Tiv	1 cyclic level
Pulleyblank (1986b)	Margi	1 cyclic level
Clark (1990)	Igbo	3 cyclic levels
Jones (2014)	Kinande	3 cyclic levels
Mohanan (1986)	Malayalam	4 non-cyclic levels
Buckley (1994a)	Kashaya	4 cyclic levels and 1 non-cyclic level
Buckley (1994a)	Kashaya	4 cyclic levels and 1 non-cyclic level
Hargus (1985)	Sekani	3 cyclic levels and 1 non-cyclic level

2.3.2 Non-Cyclicity in Word-internal Phonology

Evidence for word-internal processes which apply non-cyclically comes mainly from three types of processes: Edge effects, iterative processes, and paradigmatic faithfulness to remote bases.

The classical effect for a non-cyclic edge effect is syllable-final devoicing in Dutch and German.

Thus in German (Wiese 1996, Bermúdez-Otero 2018b) devoicing applies regularly in the imperative form /leːg/ → [leːk] ‘put’, (cf. [leː.g-ən] ‘to put’) where the velar obstruent is in syllable-final position, but overapplies under resyllabification before enclitics ([leː.kəs.vɛk]) ‘put it away’. Devoicing also applies to the Word-Level adjectivizing suffix /-ig/ if it is word-final (/fɛ.t-ig/ → [fɛ.tiç] ‘fat-y’), but not if it is followed by another Word-Level suffix such as plural -ə ((/fɛt-ig-ə/ → [fɛ.ti.gə] ‘fat-y’ (pl.)))

[26]Note that Kiparsky (2000) still embraces true stratum-internal cyclicity. See e.g. the discussion of the Warlpiri analysis from Kiparsky (2023) below.

(95)

a. Non-cyclic derivation

/fɛt-iɡ-ə/

↓

[fɛ.ti.gə]

Cyclic derivation

Morphology:	/fɛt-iɡ-ə/	Cycle 1
Phonology:	fɛt.iç	
Morphology:	fɛt.iç-ə	Cycle 2
Phonology:	*[fɛt.i.çə]	

Another case of a non-cyclic edge effect is word-final vowel raising in Ondarroa Basque (Hualde 1989) discussed more in detail in section 2.4.1. Final /a/ in a suffix raises to [e] if the last stem vowel is high (96), but not if the suffix is followed by a further suffix:

(96) *No vowel raising on suffixes if [a] is non-final (Hualde 1989:677)*

a.	/mutil-a/	[mutiʎe]	'the boy'
	/mutil-a-k/	[mutiʎak]	'the boys'
b.	/ondaru-ɾa/	[ondaruɾe]	'to Ondarroa'
	/ondaru-ɾa-ko/	[ondaruɾako]	'bound for Ondarroa'
c.	/bin-a/	[biɲe]	'two for each'
	/bin-a-ka/	[biɲaka]	'two by two'
d.	/ari-ka/	[arike]	'throwing stones'
	/ari-ka-da/	[arikaɾa]	'throwing of a stone'

If raising would apply cyclically we would expect that it also applies in these cases (/bi-na → |bin-e| → *[bine-ka])

A further similar case is reported for Spanish dialects by Bermúdez-Otero (2007): Underlying /n/ becomes a placeless nasal – and ultimately – velar [ŋ] if it appears in coda position and is not left-adjacent to a consonant which may trigger place assimilation (97-a). Debuccalization is arguably a Word-Level process because it is bled by adding a vowel-initial Word-Level suffix such as augmentative /-azo/ (see Bermúdez-Otero 2007 for arguments that /-on/ and /-azo/ are Word-Level affixes) (97-b), but not by resyllabification triggered by following vowel-initial independent words (97-c):

(97) *Coda debuccalization of coda /n/ in dialects of Spanish*

a.	we.ˈβoŋ	huevón
b.	we.βo.ˈna.θo	huevonazo
c.	we.ˈβo.ŋim.ˈbe.θil	huevon imbécil

If debuccalization would apply cyclically after every affixation step, this would result in /weβ-on/ → we.ˈβoŋ → *[we.βo.ˈŋa.θo]. See Booij (1994:531) for English l-darkening and Icelandic vowel lengthening as two other edge effects with roughly the same consequences for stratal structure.

See also the short discussion on Pesetsky's (1979) rule of yer deletion in Russian in section 2.3.3 below for a very special type of non-cyclic edge effect.

A classical case for iterativity which is incompatible with cyclic application is Dahl's Law in Kikuyu as discussed by Pulleyblank (1986a). Dahl's Law is a dissimilatory process which voices /k/ before voiceless obstruents across intervening vowels (98) (independently, [g] whether underlying or derived is spirantized to [ɣ] in Kikuyu in most contexts):

(98) *Dahl's Law in Kikuyu: Voicing before voiceless obstruent (Pulleyblank 1986a:575)*

a. /ko-θɛk-a/	→	[ɣoθɛka]	'laughing'
b. /ka-tɛgwa/	→	[ɣatɛgwa]	'small ox'
c. /ka-cera/	→	[ɣacera]	'small path'
d. /ko-ku-a/	→	[ɣokua]	'dying'

(99) *Dahl's Law in Kikuyu: **No** voicing before voiced obstruent (Pulleyblank 1986a:575)*

a. /ka-βori/	→	[ka-βori]	'small goat'
b. /ko-ɦia:nd-a/	→	[ko-ɦia:nd-a]	'planting'
c. /ko-gat-a/	→	[koɣata]	'cutting'
d. /ko-git-a/	→	[koɣita]	'thatching a house'

With multiple /k/-initial prefixes Dahl's Law applies iteratively to all of them (except the last one):

(100) *Iterative application of Dahl's Law in Kikuyu (Pulleyblank 1986a:575)*

a. /a-ka:-ke-ikia/	→	[aɣa:ɣi:kia]	'he (cl.1) will throw it'
b. /ka-ka:-ke-ikia/	→	[ɣaɣa:ɣi:kia]	'he (cl.12) will throw it'
c. /a-ke-ko-eta/	→	[aɣeɣwe:ta]	'he called you'
d. /ke-ke-ke-θoka/	→	[ɣeɣeɣeθoka]	'and thus it was spoiled'

If Dahl's Law would apply cyclically, it would be incorrectly predicted that application of the process would alternate if multiple morphemes with underlying /k/ are concatenated:[27]

(101) *Hypothetical cyclic application of Dahl's Law (Pulleyblank 1986a:576)*

Root cycle:			θok		—-
Affix cycle 1:			θok	a	—-
Affix cycle 2:		ke	θok	a	—-
		↓			Dahl's Law
		g			
Affix cycle 3:	ke	ke	θok	a	—-
	↓				Dahl's Law
	g				
	*ɣekeθoka				

[27]Note that Dahl's Law cannot apply long-distance across another obstruents. Otherwise we would expect voicing of the initial /k/ in forms like [koɣita] triggered by root-final /t/.

Across-the-board dissimilation in (101) is correctly derived if Dahl's Law applies simultaneously to all instances of /k/ as shown in (102):[28] However, simultaneity implies that the process doesn't apply cyclically.

(102) *Simultaneous application of Dahl's Law (Pulleyblank 1986a:576)*

ke	ke	ke	θok	a
↓	↓	↓		Dahl's Law
g	g	g		
ɣeɣeɣeθoka				Output

Dahl's Law also appears to be a Word-Level process — it doesn't extend to verbal suffixes which apparently in most Bantu languages are part of the Stem Level:[29]

(103) *No application of Dahl's Law to suffixes (Pulleyblank 1986a:576)*

a. ɲ + cɔk + eːt + ɛ	→	[ɲɟɔkɛːtɛ]	'I had come back'
a. ko + hiŋ + ok + ek + ek	→	[kohiŋokeka]	'to be openable'

A close tonal counterpart to the Kikuyu pattern is found in another Bantu language, Rimi. Rimi has a dissimilation process where a H-toned syllable becomes L if it precedes another H-toned syllable. In the case of multiple H-toned syllables in a row, all H-tones except the last one are lowered (underlining shows the position of underlying H-tones, the surfacing final H is shifted from [te] to [ghe] by a general H-tone shifting process at the Phrase Level):

(104) *Rimi H-tone disimilation (Myers 1997:878 based on Olson 1964:190)*

n-a-va-teghéey-a . . . (Olson 1964, p. 190)
1stsg-past-them-look for-term
I looked for them (the people) . . .

[28]Note that, as shown by Johnson (1972), simultaneous application of a process which like Dahl's Law applies from right to left (i.e. the target is on the left of the trigger) can be always equivalently captured by iterative application of the rule from left to right, e.g. ke-ke-ke-θok-a → ge-ke-ke-θok-a → ge-ge-ke-θok-a → ge-ge-ge-θok-a, (where underlining indicates the left-to-right window of iteration. Note that iterative dissimilation is problematic in Stratal OT if Correspondence Theory is assumed because the iterative applications are opaque on the surface. However sensitivity of dissimilation to input values is in principle unproblematic in Containment Theory.

[29]At the same time, Pulleyblank argues that Dahl's Law functions as a morpheme-structure constraint in cases such as
a. gɛk 'condemn'
b. git 'thatch a house'
c. gɔc 'bend sharply'
d. gɔθ 'beer flask'

This could be captured by positing that the Stem Level in Kikuyu has a version of Dahl's Law which applies only morpheme-internally. A further complication of this analysis is that the Word-Level application of Dahl's Law would also have to be blocked for Stem-Level suffixes as in (103). It is thus a further case of Non-Derived Environment Blocking.

Another case of an iterative process which provides evidence for non-cyclicity is the Word-Level H-tone dissimilation process in Shona discussed in section 1.4.3 (Meeussen's Rule) which also extends to proclitics and enclitics (recall from section 1.2.5 that a standard lexicalist interpretation of clitics is as edge affixes). Recall that Meeussen's Rule deletes a H-tone on a syllable (becoming phonetically Low) immediately preceded by another H-tone syllable. If there are more than two adjacent H-tones the first H is preserved followed by alternating L and H tones. (105) shows this for multiple enclitics, (106) for multiple proclitics and (107) for an example with a pro- and an enclitic sandwhiching a stem:

(105) *Shona enclitics (Odden 1981:48+49)*

a. /ákábíke-í-wó/	[ákábíke-í-wo]	'what did he cook (polite)?'
b. /ákapé-i-zvé/	[ákapé-i-zvé]	'what did he give again?'
c. /bwe-í-zvé-wó/	[bwe-í-zve-wó]	'what kind of rock again (polite)?'
d. /mudíki-sá-wó-zvé/	[mudíki-sá-wo-zvé-wó]	'too small again (polite)'
e. /murefú-sá-wó-zvé/	[murefú-sa-wó-zve]	'too long also again'
f. /murefú-sá-wó-zvé-ká/	[murefú-sa-wó-zve-ká]	'really too long again also'

(106) *Shona proclitics (Odden 1981:85+90)*

a. /hóvé/	[hóvé]	'fish'
b. /mbúndúdzí/	[mbúndúdzí]	'army worm'
c. /né-hóvé/	[né-hove]	'with the fish'
d. /sé-hóvé/	[sé-hove]	'like the fish'
e. /é-hóvé/	[é-hove]	'of the fish'
f. /é-mbúndúdzí/	[é-mbundudzi]	'of the army worm'
g. /né-é-hóvé/	[né-e-hóvé]	'with (the thing) of the fish'
h. /sé-é-hóvé/	[sé-e-hóvé]	'like (the thing) of the fish'
i. /sé-né-mbúndúdzí/	[sé-ne-mbúndúdzí]	'like by army worms'

(107) *Shona proclitic + stem + enclitic (Myers 1997:872)*

/í-mbwá-wó/	[í-mbwa-wó]	'it is a dog also'
COP-dog-also		
(cf. i-mbwá) 'dog'		

(108) and (109) show how this iterativity is derived in the analysis of Myers (1997):

(108) *Shona — Iterative H-dissimilation (3 underlying H-tones)*

Input: = a.	OCP	MAX H	← H
a. ne e ho ve (H1 H2 H3)	*!*		*,**
b. ne e ho ve (H1 H2)	*!	*	
c. ne e ho ve (H2)		**!	*
☞ d. ne e ho ve (H1 H3)		*	**

(109) *Shona — Iterative H-dissimilation (4 underlying H-tones)*

Input: = a.	OCP	MAX H	← H
a. fu za wo dzwe (H1 H2 H3 H3)	*!*		
b. fu za wo dzwe (H1 H3)		**	***!
b. fu za wo dzwe (H2 H3)		**	*,**!*
☞ c. fu za wo dzwe (H1 H3)		**	**

To be sure, a pattern with enclitics as in (109) could also be derived cyclically as in (110):

(110) *Cyclic derivation of muzefu za ho dzwe*

Cycle 1	H H fu za	→	H fu za
Cycle 2	H H fu za wo		——
Cycle 3	H H H fu za wo dzwe	→	H H fu za wo dzwe

However iterative left-to-right application is anticyclic for multiple proclitics. Thus for /né é hóvé/ it is incorrectly predicted that only the first H survives:

(111) *Failure of cyclic approach to ne e hove*

Cycle 1	H H | ⟋⟍ e ho ve →	H | e ho ve
Cycle 2	H H | | ne e ho ve →	H | * ne e ho ve

The third type of evidence for non-cyclic application is faithfulness to remote bases and insensitivity to local base. A detailed argument to this effect is made by Bermúdez-Otero (2018b) for Indonesian stress where regular main stress is on the penultimate syllable (e.g., [dúduk] and [bicára]). If this doesn't lead to clash with main stress there is secondary stress on the word-initial syllable (e.g., [màʃarákat] vs. [bicára]/*[bìcára]). Additional secondary stresses appear alternating before the main-stressed penultimate if not clashing with the word-initial stress ([èrodìnamíka] vs. [xàtulistíwa]/*[xàtùlistíwa]).

The base faithfulness effect emerges in morphologically complex forms as in (112) where word-initial suppression of secondary stress in [bicará-kan] is inherited from the base [bicára] (*[bìcára]). This follows without stratum-internal cyclicity if -[kan] as argued by Bermúdez-Otero is a word-level affix, and [bicára] the output from stem-level optimization.

(112) *Indonesian stress (Bermúdez-Otero 2018b:106)*

$(\text{bicára})_{\omega}$		'speak'
$(\text{məm-}(\text{bicará-kan}))_{\omega\omega}$	$*(\text{məm-}(\text{bìcará-kan}))_{\omega\omega}$	'speak about'

The argument for remote bases and insensitivity to the local base comes from forms as in (113) with two Word-Level suffixes. Here the lack of root-initial stress is motivated neither by the surface form ([bìcarakána] in analogy to monomorphemic [xàtulistíwa]) nor to the main stress of the local base [bicarákan], but only wrt to the stem [bicára]

(113) *Indonesian stress (Bermúdez-Otero 2018b:106)*

$(\text{bicára})_{\omega}$		'speak'
$(\text{məm-}(\text{bicará-kan}))_{\omega\omega}$		'speak about'
$(\text{məm-}(\text{bicàra-kán-ɲa}))_{\omega\omega}$	$\left\{\begin{array}{l}*(\text{məm-}(\text{bìcara-kán-ɲa}))_{\omega\omega}\\ *(\text{məm-}(\text{bicara-kán-ɲa}))_{\omega\omega}\end{array}\right\}$	'speak about it'

This follows if cyclic effects are stratal and do not exhibit stratum internal cyclicity. /-kan/ and /-na/ are both added to [bicára] (at the Word Level) before phonological optimization applies.

Another case of insensitivity to local bases in varieties of Turkish is discussed by Orgun (1996:23). The claim is that morphologically complex stems must be at least bisyllabic, explaining the ungrammaticality of (114-a). However if this constraint was enforced cyclically, the forms in (114-b-e) should also be ungrammatical.[30] On the other hand this distribution is expected if phonological evaluation is only carried out once non-cyclically over complete stems:

[30]This argument is complicated by the independent problems of implementing ineffability of a given input by OT-evaluations or derivational rules. See Orgun (1996) for detailed discussion and an OT-analysis invoking the Null-parse

(114) *Prosodic minimality in Turkish (Orgun 1996:23)*

a. *je-n	eat-PASS
b. je-n-ir	eat-PASS-IMPERF
c. je-n-di	eat-PASS-PAST
d. je-n-me-miʃ	eat-PASS-NEG-EVID

2.3.3 Cyclicity in Word-internal Phonology

There are several methodological problems for systematically evaluating the evidence for innerstratal cycles in lexical phonology.

First, word-internal cycles can also in principle be the effect of stratification. Thus if the Stem Level and the Word Level have the same ranking, a single word-internal cycle would follow either from stratification or running sequentially through the two strata. A number of classical cyclic analyses do not assume word-internal stratification (e.g. Brame 1974, Chung 1983, Pulleyblank 1986b). A concrete reanalysis of this type can be observed in Kiparsky's (2000) Stratal-OT reanalysis of Brame's cyclic account of Palestinian Arabic syncope, introduced in section 1.4.2. Although Kiparsky still assumes stem-internal cycles, all crucial cycles in the actual account of the data follow directly from stratification. Consequently, arguments on stratum-internal cycles also depend on the number and types of strata assumed. Consider for example Pulleyblank (1986b)'s argument for cyclic tone association in Tiv. in Tiv, different forms such as the General Past are morphologically marked by a L-tone prefix which is phonetically detectable by a downstep on H-tone verbs as in ˡúngwà '(s)he heard' (there is also independent evidence for the L-prefix - in L-initial roots where it blocks phrasal H-spreading of preceding words, see section 1.2.3). Pulleyblank assumes that this L remains floating in the output of phonology and that the predictable final L is due to postlexical default epenthesis of tone. Cyclic application has the surprising effect that one-by-one left-to right association of two underlying tones to two syllables still results in a tone which remains floating and a syllable that must be associated to an epenthetic tone, as shown in (115). This emerges since the first cycle of left-to right association applies before the L-prefix is attached. In the second cycle the L-prefix cannot associate to the initial syllable since the association conventions only target toneless TBU's and neither to the second one because this would involve illicit line crossing.

(115) *Cyclic tone association in Tiv (Pulleyblank 1986b:68)*

	Morphology		Phonology	
Cycle 1	(H)		H	
	ung	wa	ung	wa
Cycle 2	(L) H		——	
	ung	wa		
Postlexical Phonology	——		(L) H	(L)
			ung	wa

(116) shows that a non-cyclic derivation results in the incorrect output *ùngwá.

	(L)	(H)		L	H
(116)	ung	wa	→	ung	wa

Under the assumption that the L-tone prefix in (116) is a Stem-Level affix, this implies that the

Stem level must exhibit an internal cycle to reach the cyclic depth of 3. On the other hand, positing an additional root or morpheme stratum the initial cycle in Tiv could be simply derived by the fact that this has the same phonology as Stem and Word Level, and hence tones are already associated before the Stem Level.[31]

Second, evidence for word-internal cyclicity might be indistinguishable from directional (often iterative) application of a process. Thus Rubach (2008) cites the Slovak Rhythmic Law as bona fide evidence for cyclicity. Here suffixes with long vowels are shortened if attached to a base ending in a long vowel (117-a,b). With multiple long vowel suffixes, an alternating pattern results (117-c):[32]

(117) *Slovak Rhythmic Law (Rubach 2008:463)*

a.	mal-iː	a'.	tʃiːr-i
	small-NOM.SG		clear-NOM.SG
b.	rol'-ɲiːk	b'.	puːt-ɲik
	field-AG		pilgrimage-AG
	'farmer'		'pilgrim'
c.	rol'-ɲiːtʃ-k-i	c'.	puːt-ɲitʃ-k-iː
	field-AG-ADJ.NOM.SG		pilgrimage-AG-ADJ.NOM.SG
	'farmer' (adj.nom.sg)		'pilgrim' (adj.nom.sg)

Clearly, the Slovak pattern can be elegantly captured by a cyclic derivation, as in (118):

[31]Note that the two other data sets from Margi and Tonga Pulleyblank discusses, also involve association of root tones to root TBU's hence morpheme-internal phonology.

[32]The same ambiguity between directionality and cyclicity is typical of stem-controlled vowel harmony systems in predominantly suffixing languages. Interestingly, Baković (2000, 2001) makes an argument for cyclic computation of partially harmony in dominant-recessive systems such as Maasai where (with some systematic exceptions) all vowels in a word become [+ATR] if it contains at least one [+ATR] vowel:

Maasai (Baković 2001:3 based on Tucker & Mpaayei 1955, Archangeli & Pulleyblank 1994)

a. /kɪ-norr-ʊ/ → [ki-norr-u] 'we shall love'
1PL-love-EF

b. /ɪsʊɟ-ɪʃɔ-re/ → [isuɟ-iʃo-re] 'wash with something!'
1PL-love-EF

The argument for cyclicity comes from the complex behavior of the low vowel [ɑ] in suffixes. If this is preceded by a [+ATR] root, it becomes mid [o] (Maasai lacks a low [+ATR] vowel), however if it is followed by a [+ATR] suffix it (and other preceding [-ATR] vowels) is opaque and remains [ɑ]:

Maasai (Baković 2001:6)

a. /ɪm-mudoŋ-a/ → [imudoŋo] 'kinship'
FEM.PL-N-PL

b. /ɛ-ɪpʊt-a-rɪ-ie/ → [ɛɪpʊtarijie] 'it will get filled up'
3SG-fill-MA-N-APPL

Baković captures this in a cyclic OT-analysis where [ATR]-harmony is generally enforced by symmetric AGR-constraints on vowels in adjacent syllables, but overwritten by a higher-ranked faithfulness constraint for the feature [+low] in the base of affixation. Thus at the point where -ie is affixed to the base pʊtarɪ in (116), the stem [ɑ] cannot be raised to [o] (note also that this is not root faithfulness, but faithfulness in a complex stem) since the [ɑ] is a suffix vowel). However, Maasai *can* in principle be captured by pure directionality as in the analysis of Archangeli & Pulleyblank (1994) with two separate harmony rules, one left to right with repairing of [a], and one right-to left involving opacity. This also has the empirical advantage that it extends to [a] in prefixes which is also opaque to [ATR]-harmony:

Maasai (Baković 2001:12)

a. /a-rɔk-u/ → [aroku] 'I become black'
1SG-black-INCEP

b. /a-duŋ-akɪm-ie/ → [aduŋokinie] 'I cut for s.o. with s.t.'
1SG-cut-DAT-APPL

Evidence for true (non-cyclic) harmony can also be found in other languages such as Punu (Hyman 2002b), where suffixes trigger harmony to the left

(118) *Slovak Rhythmic Law - cyclic derivation of (117-c/c') (Rubach 2008:463)*

Cycle 1	Morphology	puːt-ɲiːk	rol'-ɲiːk
	Phonology	puːt-ɲik	—-
Cycle 2	Morphology	puːt-ɲik-k	rol'-ɲiːk-k
	Phonology	puːt-ɲitʃ-k	rol'-ɲiːtʃ-k
Cycle 3	Morphology	puːt-ɲitʃ-k-iː	rol'-ɲiːtʃ-k-iː
	Phonology	—-	rol'-ɲiːtʃ-k-i

However, Slovak length dissimilation is also in principle isomorphic to the tone dissimilation pattern in Shona discussed above when we restrict our attention to Shona enclitics. Obviously Myer's Shona non-cyclic analysis could be transferred to Slovak, but, as we have seen, cyclicity doesn't account for the Shona case. Thus Slovak and similar cases don't provide unequivocal evidence for stratum-internal cyclicity.

Clark (1990) provides a detailed tonal argument for innerstratal cyclicity in Igbo which also has the same problem. She argues that L-dissimilation at the Stem Level has to apply cyclically in a form with three underlying L-tones like [è-wé-fʊ̀] AFF.NON.FAC-pick.up-go.out 'taking out' (p.69ff): /wè-fʊ̀/ → |wé-fʊ̀| → [è-wé-fʊ̀] because otherwise her rule system predicts dissimilation of both the first and the second L. However for the data she gives this could also be captured by iterative right-to-left application of dissimilation.

Directionality of a slightly different type is relevant for the claim by Inkelas (2014) that the scope of reduplication as evidence for cyclicity. Thus in Tagalog the CV:-reduplicant expressing Contemplated Aspect may appear in variable positions wrt other segmental prefixes. However, the part of the word from which it copies is always the following combination of affixes and root

(119) *Tagalog Contemplated Aspect Reduplication (Ryan 2010:762-63)*

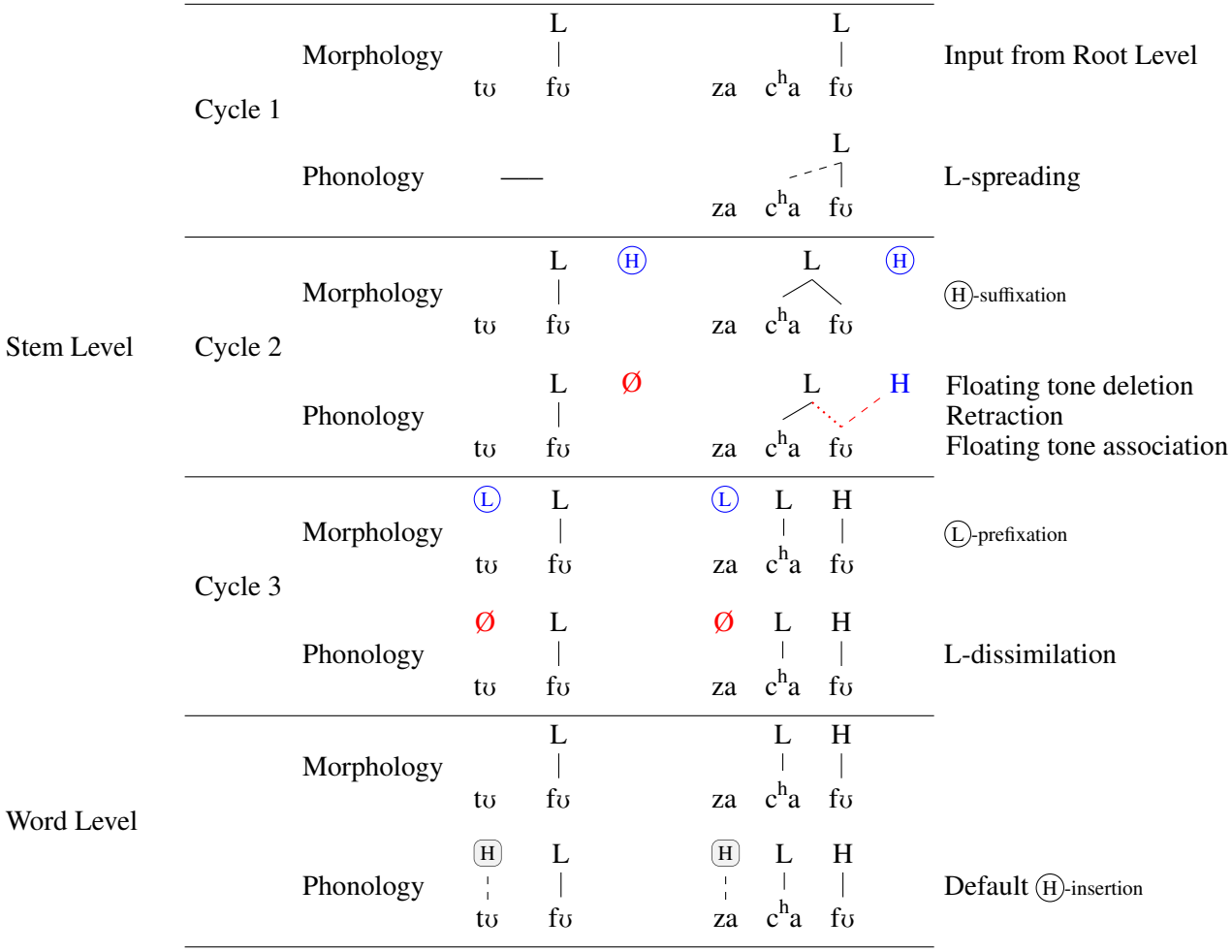
a.	[pà:]-pa-buks-án RED-CAUS-open-LT	
a'.	pa-[bù:]-buks-án CAUS-RED-open-LT	'will cause to open'
b.	ma-[kà:]-ka-pag-pa-sajá ABIL-RED-TEL-TRANS-CAUS-be.happy	
b'.	ma-ka-pag-[pà:]-pa-sajá ABIL-TEL-TRANS-RED-CAUS-be.happy	'will be able to make happy'
b''.	?ma-ka-pag-pa-[sà:]-sajá ABIL-TEL-TRANS-CAUS-RED--be.happy	

Narrow cyclicity naturally predicts this: it implies that at the point where phonological copying happens more outermost prefixes are not part of the representation and can hence not become part of the reduplicant. However, the same result could also be achieved by a purely directional constraint requiring that in phonological copying copied segments should be on the left of the copied material.[33]

Third, in rule-based analyses cyclicity is often used as a means to predict rule ordering, an argument which may be obviated in a constraint-based analysis. Consider for example a major argument by Clark (1990) for stratum-internal cyclicity at the Stem Level in Igbo. This is illustrated by bisyllabic and trisyllabic main clause imperative forms in (120). These forms are characterized by a H tone suffix and a L-tone prefix. The central involved processes are left-ward spreading of tones to non-initial toneless syllables and deletion of floating tones if there is no adjacent free TBU, and Retraction (deletion of the final association line) of a multiply associated tone before a floating tone. Cyclicity in Clark's analysis allows for deriving the fact that spreading applies before Retraction and Floating Tone Deletion, and thus partially accounts for the difference between bisyllabic and trisyllabic forms. If floating feature deletion would apply before the other processes the suffix H should be lost with both bi- and tri-syllabic bases:

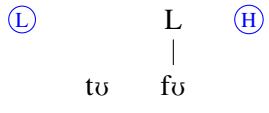
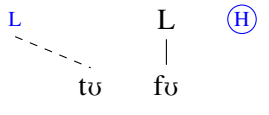
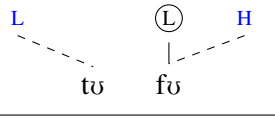
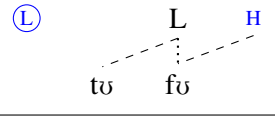
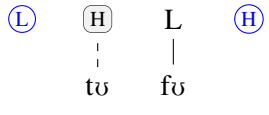
[33]This constraint might be related to the fact that reduplicative affixes in contrast to strictly segmental ones show a strong tendency for prefixing (Nelson 2003). Only prefixes can reliably copy material from the right. An interesting point of comparison between a cyclic and a directional approach to bases of reduplication are cases where the morphosyntactic base seems to be contingent on phonological properties. Thus in Ndebele reduplication, object prefixes are typically not in the domain of foot-sized reduplication, but they may be included for bases which are smaller than a minimal foot. (Hyman et al. 2008). A similar case in Kihehe is shortly discussed in section 3.3.

(120) *Igbo rule ordering by cyclicity (Clark 1990:88)*



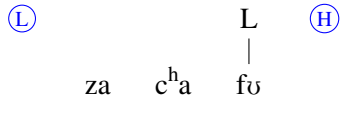
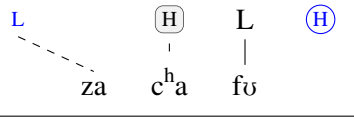
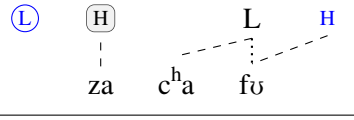
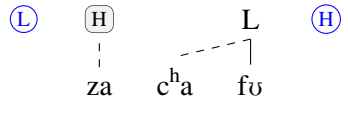
Here is a simple reanalysis of this pattern in OT. OCP blocks association of two tones on adjacent syllables as in (121-b). As a consequence the L-prefix remains unassociated. σ ▷ τ requires that every syllable is associated to a tone. H ▷ σ demands association of H-tones to syllables, MAX [τ] protects underlyingly associated tones, and *SPR-[σ penalizes spreading to the initial syllable of a PWord (I assume that this is also violated if the spreading tone is simultaneously deassociated from its original syllable). Thus in a bisyllabic word, the stem-L cannot spread to the initial syllable as in (121-d). Hence the only way to associate the H-suffix would be to completely disassociate the stem-L as in (121-c) which is blocked by MAX [τ]:

(121) *Igbo tone association in a parallel OT-analysis: 2-syllabic base*

Input: = a.	σ ▷ τ	*SPR-[σ	OCP L	MAX [τ]	H ▷ σ
a. 	*!				*
b. 			*!		*
c. 				*!	
d. 		*!			
☞ e. 		**	**		*

In contrast, in a trisyllabic base, the L can spread/shift to its left as in (122-c) without violating *SPR-[σ since the penultimate syllable is not initial

(122) *Igbo tone association in a parallel OT-analysis: 3-syllabic base*

Input: = a.	σ ▷ τ	*SPR-[σ	OCP L	MAX [τ]	H ▷ σ
a. 	*!				**
b. 					*!
☞ c. 					
d. 					*!

The OT-reanalysis here naturally obviates the use for cyclicity.

Fourth, on the background of Bermúdez-Otero's claim that Stem-Level cyclicity is not synchronic cyclic derivation, but results from non-analytic full-form listing ('fake cyclicity or pseudo-cyclicity', see section 1.2.1), this is also an alternative option which must be considered. The signature feature of pseudo-cyclicity is that it derives not from online computation but from lexical storage, which predicts that cyclic effects should correlate with frequency. Consider for example the textbook example for English Stem-level cyclicity *origìnálity* where the secondary stress on the second syllable is attributed to the intermediate cycle triggered by the affixation of *-al*: /origin+al/ → orígіnal → orígínal+ity → [orìgínálity] Simplifying somewhat, in a pseudocyclicity account, the second-syllable stress of *orígin-al* will only have an effect on orìgin-ál-ity for a speaker who has stored the word *orígіnal* and has fast access to this lexeme. Otherwise, she will produce *originality* on the basis of the three independent morphemes origin, *-al* and *-ity* without secondary stress on the second syllable. Since it is well known that storage and speed of lexical access correlate with frequency, this can be taken as a litmus test for pseudo-cyclicity. Collie (2007) and Bermúdez-Otero (2012) show in detail that this prediction is correct for English Stem-level derivation, but we lack relevant evidence for the other languages discussed here – a major empirical challenge for future research

After considering the methodological problems, let us now turn to a short survey of the potential evidence for innerstratal cyclicity in the literature which I summarize in (123):

(123) *Evidence for word-internal cyclicity*

Domain	Language	phonological processes	source
generic word-internal	Russian	yer lowering	Pesetsky (1979)
generic word-internal	Chamorro	preservation of primary as secondary stress	Chung (1983)
generic word-internal	Chamorro	umlaut of stressed syllable	Chung (1983)
generic word-internal	Itelmen	schwa epenthesis	Bobaljik (2008)
generic word-internal	Tiv	initial tone association (General Past)	Pulleyblank (1986b)
generic word-internal	Tiv	Interaction of L-raising and association (Past Habitual)	Pulleyblank (1986b)
generic word-internal	Tiv	Interaction of H-spreading and L-raising (Habitual 3)	Pulleyblank (1986b)
generic word-internal	Slovak	Directionality of length dissimilation	Rubach (2008)
generic word-internal	Tagalog	Scope of reduplication	Inkelas (2014)
generic word-internal	Turkish	vowel epenthesis	Inkelas (2014)
generic word-internal	Saami	footing and allomorph selection	Dolbey (1997)
generic word-internal	Bemba, Nyamwezi	Interaction of interfixation and spirantization	Hyman (2002a)
generic word-internal	Huave	affix order	Kim (2010)
generic word-internal	Sundanese	Interaction of infixation and nasal spreading	Cohn (1990)
generic word-internal	Turkana, Maasai	directional asymmetries in vowel harmony	Baković (2000, 2001)
Stem Level	Igbo	directionality of L-tone dissimilation	Clark (1990)
Stem Level	Igbo	ordering of spreading and floating tone deletion	Clark (1990)
Stem Level	English	preservation of primary as secondary stress	Collie (2007)
Stem Level	Lakota	interaction of Reduplication with palatalization	Paschen (2017)
Stem Level	German	syllabification and final devoicing	Rubach (1990)
Stem Level	Huave	preservation of primary as secondary stress	Noyer (2013)
Stem Level	Huave	vowel raising in primary stressed syllables	Noyer (2013)
Stem Level	Huave	vowel lengthening in primary stressed syllables	Noyer (2013)
Stem Level	Sekani	syllabification and V+N coalescence	Hargus (1985)
Stem Level	Finnish	Interaction of vowel coalescence + t-deletion	Kiparsky (1993)
Stem Level	Warlpiri	directionality of vowel harmony	Kiparsky (2023)
Stem Level	Telugu	directionality of vowel harmony	Kiparsky (2023)
Stem Level	Kinande	realization of tonal affixes	Jones (2014)

I include here analyses which do not invoke word-internal stratification at all (labeled here: 'generic

word-internal') since the depth of cyclicity or other analytic considerations may reveal that stratum-internal is necessary even in addition to stratification.

A case in point is ə-epenthesis in Itelmen as in the form spələz-in (windy-PRES-3SG) 'it is windy'. Even though there are only two epenthetic vowels, this requires 3 cycles under the assumption that epenthesis is driven by an OT constraint which requires that voiced consonants must be adjacent to a vowel This is shown in (124-a). If there are only two cycles as in (124-a,b) or only one, one epenthetic vowel and the [i] provided by the suffix -in will be sufficient to satisfy the constraint on sonorant-vowel adjacency.[34]

[34]The assumption in (124) is that every phonological cycle inserts the minimal number of ə's so that every voiced consonant is adjacent to at least one vowel. Moreover ə-epenthesis is as leftwards as possible, hence spl becomes spəl not splə in (124)-a,b

(124) *ə-epenthes in Itelmen*

		a.	b.	c.	d.
Cycle 1	Morphology	spl	spl	spl-z	spl-z-in
	Phonology	sp◎l	sp◎l	spl◎-z	sp◎l-z-in
Cycle 2	Morphology	sp◎l-z	sp◎l-z-in	spl◎-z-in	
	Phonology	sp◎l◎-z	—-	—-	
Cycle 3	Morphology	sp◎l◎-z-in			
	Phonology	—-			

Huave affix order – according to Kim (2010) computed cyclically in the generic word domain – implies a more indirect argument for innerstratal cyclicity.

Monoconsonantal suffixes like [t] (completive) and [r] (second person intransitive) move to a pre-vocalic prefix position if concatenated after consonants to avoid consonant clusters: In examples like (125-d) this apparently happens cyclically. Cyclicity accounts for example for the fact that [t] is the prefix, not [r]:

(125) *Movable affixes in Huave (Kim 2010)*

a.	**t-**u-c	'(s)he ate (itr.) '	b.	mojk-o-**t**	'(s)he lay face down'
	CP-TV-eat			face.down-TV-CP	
c.	**t-**e-r-u-c	'you ate (itr.)'	d.	**t-**e-mojk-o-r	'you (sg.) lay face down'
	CP-2-2I-TV-eat			CP-2-face.down-TV-2I	

(126) shows the cyclic derivations for (125-c) and (125-d):

(126)

Cycle 1	Morphology	u-c	mojk-o
	Phonology	—	—
Cycle 2	Morphology	u-c-r	mojk-o-r
	Phonology	r-u-c	
Cycle 3	Morphology	e-r-u-c	e-mojk-o-r
	Phonology	—	
Cycle 4	Morphology	e-r-u-c-t	e-mojk-o-r-t
	Phonology	t-e-r-u-c	t-e-mojk-o-r

Strikingly, in the outermost layer of consonantal affixes, no movement happens in the same phonological environment (instead there is vowel epenthesis to resolve the resulting consonant cluster)

(127) *Non-movable outer-layer affix in Huave (Kim 2010:143)*

i-m-a-haw-ej-◎a-r 'we'll see each other'
FUT-SUB-TV-see-REFL-INC

Whereas Kim interprets the minimal pairs of suffixes undergoing and not undergoing movement as the result of morpheme-specific alignment constraints with different rankings, there is a more natural account in stratal terms: Inner consonantal affixes are Stem-Level, outer affixes are word-Level and only the Stem-Level constraint ranking allows for affix movement. If this is correct, cases like ((125)-c) where both [r] and [t] are moved provide evidence for innerstratal cycles.

Other cases from the literature are more problematic and prima facie amenable to analyses without stratum-internal cyclicity. Consider for example the primordial example for word-internal cyclicity in Pesetsky (1979)'s Russian yer analysis. 'Yer's (abstract high lax vowels) are lowered to mid vowels if the following syllable also contains a yer, and otherwise deleted as shown in (128). In (128), yer lowering must apply at least 4 times in different cycles. If there are two word-internal strata this would suggest that the need for additional innerstratal cycles. The fact that yer-lowering also extends to prefixes as in (129) seems to suggest that it is not a simple iterative process.

(128) *Cyclic Yer-lowering with suffixes (Pesetsky 1979:7)*

Cycle 1	Morphology	dɪn	
	Phonology	—	
Cycle 2	Morphology	dɪn-ɪk	
	Phonology	den-ɪk	(yer-lowering)
Cycle 3	Morphology	den-ɪk-ɪk	
	Phonology	den-ek-ɪk	(yer-lowering)
Cycle 4	Morphology	den-ek-ɪk-ʊ	
	Phonology	den-ek-ek-ʊ	(yer-lowering)
Postcyclic Phonology		den-ek-ek-Ø denəcek	(yer-deletion) (other rules)

(129) *Yer-lowering in prefixes (Pesetsky 1979:9)*

Cycle 1	Morphology	ʒɪg	
	Phonology	—	
Cycle 2	Morphology	ʒɪg-l	
	Phonology	—	
Cycle 3	Morphology	ʒɪg-l-ʊ	
	Phonology	ʒeg-l-ʊ	(yer-lowering)
Cycle 4	Morphology	podʊ-ʒeg-l-ʊ	
	Phonology	—	
Postcyclic Phonology		podØ-ʒeg-l-Ø podʒəg	(yer-deletion) (other rules)

However, one might restate Pesetsky's analysis without stratum-internal cycles under the assumption that all involved suffixes are Stem-Level, and all relevant prefixes Word Level. yer lowering would then be simply an iterative process applied left-to right at the Stem Level but apply right to left at the Word Level (ordered before final yer-deletion which is arguably a non-cyclic/Word Level process, as shown by the incorrect derivation in (130) which minimally modifies the one in (128) by assuming cyclic yer-deletion:

(130) *Yer-deletion is not cyclic (Pesetsky 1979:9)*

Cycle 1	Morphology	dɪn	
	Phonology	—	
Cycle 2	Morphology	dɪn-ɪk	
	Phonology	den-ɪk	(yer-lowering)
		den-Øk	(yer-deletion)
Cycle 3	Morphology	den-k-ɪk	
	Phonology	den-kØk	(yer-deletion)
Cycle 4	Morphology	den-k-k-ʊ	
	Phonology	*den-k-k-Ø	(yer-deletion)

Another classical analysis which prima facie shows evidence for innerstratal cycles because of the massive amount of cycles it involves is the argument for word-internal cyclicity in Tiv by Pulleyblank (1986b) with derivations of considerable depth

Consider first the Past Habitual which involves a Ⓗ-suffix (Cycle 2), a complex suffix comprising a floating L, an underspecified vowel and a full segmental /n/ (Cycle 3), and a Ⓛ-prefix (Cycle 4). There are two cases of opacity which cyclicity captures here. *First,* as already discussed above (see (115)), the Ⓛ-prefix must be added after the first cycle because otherwise it would be associated by Left-to-right association. The *second* case of opacity involves the rule which assimilates a L tone to a following floating H (but not to an associated H) in Cycle 2. This must apply before the addition of additional segmental material in Cycle 3 because Assimilation to Ⓗ would be bled by H-association:

(131) *4 cycles Tiv Past Habitual (Pulleyblank 1986b:70+71)*

	Morphology	Phonology	
Cycle 1	Ⓛ dza	L dza	(Left-to-right association)
Cycle 2	L Ⓗ dza	H ⇜ Ⓗ dza	(Assimilation to Ⓗ)
Cycle 3	H Ⓗ Ⓛ dza V n	H H L dza a n	(Left-to-right association)
Cycle 4	Ⓛ H H L dza a n	——	

Whereas the cyclic account without strata naturally accounts for these facts, so does an analysis with two strata which lack internal cycles if we assume that the Ⓗ-suffix is a Stem-Level (Stratum 1) affix and all other exponents of the Past Habitual are Word-Level (Stratum 2). Ⓛ-prefixation still precedes and counterfeeds initial Left-to-right association, and V-suffixation counterfeeds Assimilation to Ⓗ. Both cases of opacity are essentially mutually independent. Hence two strata are enough to capture both simultaneously:

(132) *2-stratum reanalysis of the Tiv Past Habitual (Pulleyblank 1986b:70+71)*

	Morphology	Phonology
Stratum 1	Ⓛ Ⓗ dza	L Ⓗ dza (Left-to-right association)
		H ⇜ Ⓗ dza (Assimilation to Ⓗ)
Stratum 2	Ⓛ H Ⓗ Ⓛ Ⓛ H H L dza V n dza a n	(Left-to-right association)

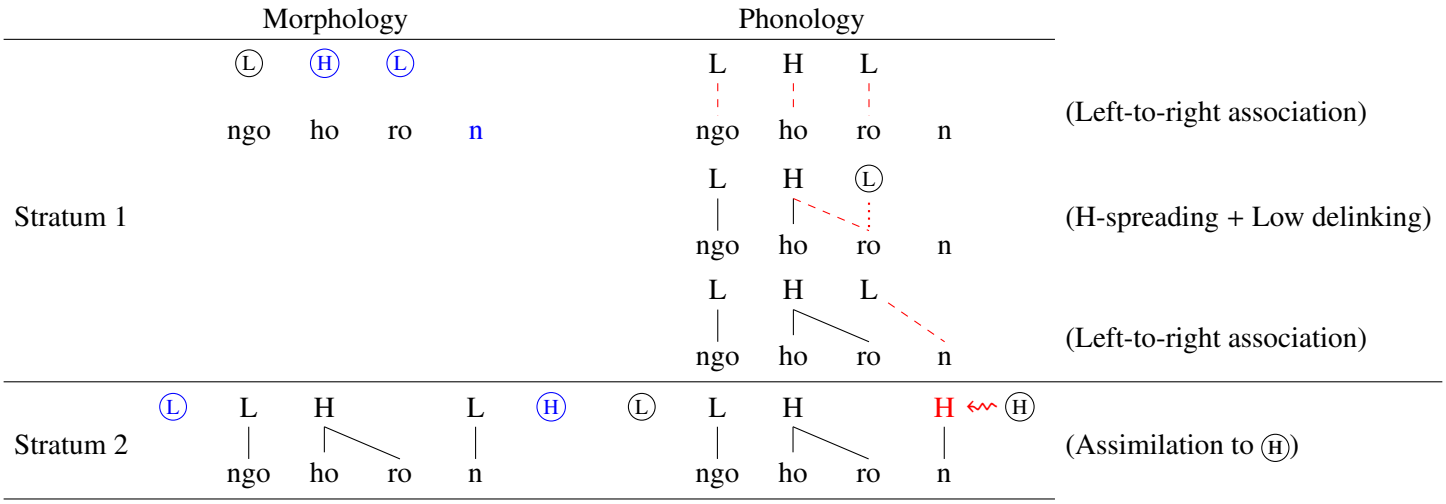
The second case is more complex and at the center of Pulleyblank's ingenious solution to the paradox that some tenses in Tiv seem to exhibit unbounded spreading of an inflectional H-tone (such as the Ⓗ-suffix added in Cycle 2 of (133)), whereas in other contexts toneless vowels receive a default-L even if preceded by an associated H, and the only type of spreading is spreading of a H-tone to a following L-toned syllable with concomitant L-delinking. The analysis uses a Ⓛ-suffix (added here in cycle 3 along with a segmental [n]). This associates first by general Left-to-right association, which in turn triggers H-spreading (recall that H-spreading only targets L-toned syllables not toneless syllables in Tiv), followed by another round of Left-to-right association which re-associates the floating L, but now to the final [n]. A second Ⓗ-suffix added in Cycle 4 triggers Assimilation to Ⓗ and thus only inflectional H-tones remain on the stem:

(133) *5 cycles: Tiv Habitual 3 (Pulleyblank 1986b:88)*

	Morphology	Phonology	
Cycle 1	Ⓛ ngo ho ro	L ngo ho ro	(Left-to-right association)
Cycle 2	L Ⓗ ngo ho ro	L H ngo ho ro	(Left-to-right association)
Cycle 3	L H Ⓛ ngo ho ro n	L H L ngo ho ro n	(Left-to-right association)
		L H Ⓛ ngo ho ro n	(H-spreading + Low delinking)
		L H L ngo ho ro n	(Left-to-right association)
Cycle 4	L H L Ⓗ ngo ho ro n	L H H ⇜ Ⓗ ngo ho ro n	(Assimilation to Ⓗ)
Cycle 5	Ⓛ L H H Ⓗ ngo ho ro n	—	

Despite the considerable derivational complexity of the analysis, only part of it is due to cycles, the reassociation of the L-suffix follows simply from rule application in a single cycle. Thus again there are only two instances of cyclic opacity. The first is that Assimilation to Ⓗ counterbleeds the triggering of H-spreading by the suffix -L, and the second one is once more the counterfeeding of Left-to-right association by L-prefixation. Since these are again mutually independent the analysis can be restated with two strata where the inner Ⓗ-suffix and the Ⓛ-suffix are added at the Stem Level (Stratum 1) and the remaining two tonal affixes at the Word Level (Stratum 2):

(134) *2-stratum reanalysis of the Tiv Habitual 3 (Pulleyblank 1986b:88)*



(135) gives a summary for potential reanalyses for the cases of generic word-internal cyclicity. For three languages – Chamorro, Saami and Maasai/Turkana – with reported word-internal cyclicity there are existing alternative analyses with 2 strata. For a number of other languages not explicitly discussed here (Turkish), Bemba, Nyamwezi, Sundanese), the reported depth of cyclicity is two cycles which can also be captured by positing two strata:

(135) *Potential reanalyses for the cases of generic word-internal cyclicity in (136)*

Language	phonological processes	alternative analysis	
Russian	yer lowering	2 strata + directional iterativity	(see above)
Chamorro	preservation of primary as secondary stress	2 strata	Gleim (2024)
Chamorro	umlaut of stressed syllable	2 strata	Gleim (2024)
Itelmen	schwa epenthesis	??	
Tiv	initial tone association	2 strata	(see above)
Tiv	Interaction of L-raising and association	2 strata	(see above)
Tiv	Interaction of H-spreading and L-raising	2 strata	(see above)
Slovak	Directionality of length dissimilation	Directional iterativity	(see above)
Tagalog	Scope of reduplication	Directional copying	(see above)
Turkish	vowel epenthesis	2 strata	(≈ cyclic depth)
Saami	footing and allomorph selection	2 strata	Trommer (2015b)
Bemba, Nyamwezi	Interaction of interfixation and spirantization	2 strata	(≈ cyclic depth)
Huave	affix order	??	
Sundanese	Interaction of infixation and nasal spreading	2 strata	(≈ cyclic depth)
Turkana, Maasai	directional asymmetries in vowel harmony	2 directional rules	Archangeli & Pulleyblank (

Let us now turn to evidence for innerstratal cyclicity from analyses which provide independent evidence for strata.

(136) *Evidence for stratum-internal cyclicity*

Domain	Language	phonological processes	source
Stem Level	English	preservation of primary as secondary stress	Collie (2007)
Stem Level	Sekani	syllabification and V+N coalescence	Hargus (1985)
Stem Level	Huave	preservation of primary as secondary stress	Noyer (2013)
Stem Level	Huave	vowel raising in primary stressed syllables	Noyer (2013)
Stem Level	Huave	vowel lengthening in primary stressed syllables	Noyer (2013)
Stem Level	Lakota	interaction of Reduplication with palatalization	Paschen (2017)
Stem Level	Igbo	directionality of L-tone dissimilation	Clark (1990)
Stem Level	Igbo	ordering of spreading and floating tone deletion	Clark (1990)
Stem Level	German	syllabification and final devoicing	Rubach (1990)
Stem Level	Finnish	Interaction of vowel coalescence + t-deletion	Kiparsky (1993)
Stem Level	Warlpiri	directionality of vowel harmony	Kiparsky (2023)
Stem Level	Telugu	directionality of vowel harmony	Kiparsky (2023)
Stem Level	Kinande	realization of tonal affixes	Jones (2014)

Vowel+Nasal coalescence in Sekani: Hargus provides evidence for stratum-internal cyclicity from a process of vowel+nasal coalescence in Sekani. The process in question fuses a vowel with a syllable-final nasal consonant into a nasal vowel leading to alternations as in (137). In (136-b) the underlying /n/ surfaces as an onset to the following suffix. In the bare form in (137-a), coalescence takes place since it is word and coda-final. Possessive -[e] in Hargus' analysis is introduced at an early lexical stratum so that the process is transparent. Diminutive -[azi] belongs to a later lexical stratum and thus affixes to a base which already has undergone V+N coalescence:

(137) *Sekani (Hargus 1985:237)*

a. tsə̨̀ 'shit'

b. sə-tson-è 'my shit'
   Pssr.1sg-shit-poss

c. tsə̨̀-azi
   shit-dim

The evidence for cyclicity comes from so-called 'repossessed' inalienable nouns. Possessed nouns as (137-b) have a generic possessive suffix with some lexical conditioned allomorphy (-[e], zero or a low tone) and a prenominal possessor, which is either an incorporated noun or pronominal prefix as in (137-b). Inalienably possessed nouns only appear with possessive morphology and have at least a suffix and a default possessive prefix as in the case of [ton] 'leaf' ('possessed' by the plant to which it is attached) (138-a). If inalienably possessed nouns are possessed by a non-inherent possessor, they are marked as 'repossessed' – hence undergo possessive morphology twice as in (138-b) with two possessor prefixes (ʔə- is the default possessor prefix in forms without an explicit possessor, there is only one overt possessive suffix since the allomorph of the possessive suffix after the root to is zero):

(138) *Repossessed inalienable noun (Hargus 1985:392)*

a. ʔə-t'ò̰-Ø ‘(its) leaves’
PSSR.3SG-leave-POSS

b. se-ʔə-t'ò̰-Ø-è ‘my (its) leaves’
POSSR.1SG-PSSR.3SG-leave-POSS-POSS

Now surprisingly in (138-b) vowel-nasal coalescence seems to have applied before, not after affixation of possessive -[e] (as in the simple possessive form in (137-b)). Cyclicity naturally accounts for this apparent contradiction

(139) *Sekani*

	Morphology	Phonology
Cycle 1	sə-tson-è	—

	Morphology	Phonology
Cycle 1	ʔə-t'òn-Ø	ʔət'ò̰
Cycle 2	se-ʔət'ò̰-è	—-

Reduplication in Lakota: In Lakota, according to Paschen (2017), the overapplication of palatalization in reduplication provides evidence for stratum-internal cyclicity. Paschen provides independent evidence from stress that the reduplicative suffix is a Stem-Level formative. Palatalization of [k] applies after [i]:

(140) *Lakota palatalization (Paschen 2021:37)*

/ni-k^{h}ɑ-[-low]/ → [ni-tʃ^{h}e] ‘(s)he is talking about you’
2OBJ-mean-TERM

In reduplication, palatalization extends to the reduplicant even if it is not preceded by a front vowel:

(141) *Lakota reduplication (Paschen 2021:40)*

a.	/kaɣ/	ki-tʃaɣ	witʃ^{h}a-ki-tʃaɣ-tʃaɣ-ije-ja
		DAT-make	3PL-DAT-make-RED-quick-ADV
		‘to make for somebody’	‘he made it for them quickly’
b.	/koz/	ki-tʃoz	ki-tʃoz-tʃoz-e
		DAT-wave	DAT-wave-RED--FV
		‘to wave to somebody’	‘he waved (his hand) for him’

Syllabification and its interaction with segmental processes in Huave: Huave has a semi-allophonic process where vowel+h sequences (phonetically: long vowels with voiceless articulation in their second half) are in complementary distribution with long vowels (e.g. [ih] ~ [iː]). Noyer argues that the first is underlying and that the long vowels reflect a process of voicing in closed syllables.

(142) *Vowel Voicing in Huave (Noyer 2013:18)*

/a-tsorʲ-ɨhtsʲ/ → [a-tsorʲ-iːtsʲ] 'returns' (vt.)
TH-returns-CAUS

Coda obstruents after long voiced vowels also undergo cyclic voicing. Thus the preterit affix -t which appears in its underlying voiceless form in (143-a) becomes voiced in (143-b):[35]

(143) *Obstruent voicing in Huave (Noyer 2013:24)*

a. /wɑⁿts-A-t/ → [wɑⁿtsɑt] 'she turned (e.g. the head) ' (vi.)
turn-TH-PRET

b. /pʲɑ-A-t-eɾ+An/ → [pʲɑː.dʲɑ.ɾón] 'you (pl.) sat down'
sit-TH-PRET-2+PL

(144) shows the cyclic derivation in Noyer's analysis:

(144)

Cycle 1 rules	pʲɑ-ɑ
Cycle 2 – syllabification + stress	pʲáː-t
Cycle 3 – syllabification + stress	pʲɑː.dʲ-áɾ
E-lowering (/de/ → dʲa)	
Non-cyclic syllabification + stress	pʲɑː.dʲɑ.ɾ+án
Other non-cyclic rules:	[pʲɑː.dʲɑ.ɾón]

But: the only examples Noyer cites for this process are ones where its conditions are fulfilled in a single morpheme. Hence the long vowel could be underlying.

Another semi-allophonic relation holds between [i] and [iə] where the latter occurs in closed syllables before a non-palatalized coda consonant (e.g. [isʲ] 'iguana' vs. [mʲiəs] 'cat' vs. nʲi.pʲi.lán 'people',p.10-12) Noyer captures this by a rule which derives [iə] from underlying /i/. Whereas many cases of [iə] appear morpheme-internally, offgliding is fed by morphological depalatalization. Thus the passive form in (145-b) is formed i.a. by depalatalizing the final consonant of the verb in (145-a), which makes it a suitable context for offgliding:

(145) *Offgliding in Huave (Noyer 2013:29)*

a. /ɑ-tʲilʲ/ → [ɑ-tʲilʲ] 'stabs'
b. /ɑ-h-tʲil/ → [ɑ-tʲiəl] 'is stabbed'

A cyclic case of offgliding is shown in (146-a). The process becomes opaque by addition of the Stem-Level suffix -[ihtsʲ] and resyllabification (146-b):

(146) *Offgliding in Huave (Noyer 2013:28)*

a. /tʲɑ#n-ɑ-.ᵐbʲíl-ɨhtsʲ/ → [tʲɑ.nɑ-.ᵐbʲíə.liːtsʲ]

[35] I adopt here Noyer's notation who separates clitics by '#', cyclic (Stem-Level) affixes by '-', and non-cyclic (Word-Level) affixes by '+'. [A] is an underspecified low vowel.

PROG#1SUB-TH-turn-CAUS

b. cycle 1 - syllabification, stress: ɑ-.^{m}b^{j}íl
cycle 1 - offgliding: ɑ-.^{m}b^{j}íəl
cycle 2 - syllabification, stress: ɑ-.^{m}b^{j}íə.l̪i̪hts^{j}

Noyer reports similar cyclic interactions of syllabification stress assignment for other segmental processes such as e-lowering in (144). A potential problem for these cases (and to a smaller degree for the processes cited above) is that virtually all examples showing cyclic interaction involve cases where the segmental process applies inside a single morpheme. Apparent cyclicity could thus simply be an epiphenomenon of a morpheme-structure constraint (or a morpheme-level stratum, see section 2.2.3 above).

Tone morphology in Kinande verbs: Jones (2014): Tonal morphology: a pattern with two H tone affixes expressing the same category is attached cyclically, explains for example that both are realized under circumstances where single floating tones would be deleted otherwise (by REALIZE MORPHEME). Possible alternative analyses: tonal circumfix enforces deletion of enclosed tones and, therefore both circumfixal tone can be realized (Trommer 2021).

German Syllabification and final devoicing: In a two-stratum analysis German final devoicing is arguably a Word-Level rule since it does not show general cyclic opacity (/list-ig → listige). However Rubach (1990) identifies cases of cyclic opacity with syllabic consonants in intermediate cyclic stages of the derivation. Compare for example /glaub-lix/ believe-POSS → [glaup.liç] 'believable' with regular syllable-final devoicing with /ne:bl-ix/ 'fog'-like → [ne:bliç] with unexpected maintenance of voicing. Rubach derives this from the fact that the second example has a stem with a syllabic consonant where the preceding obstruent is an onset

(147) *German*

Stem Level	Cycle 1	[glaub]$_{\sigma}$	[ne:]$_{\sigma}$[bl̩]$_{\sigma}$	
	Cycle 2	[glaub]$_{\sigma}$[liç]$_{\sigma}$	[ne:]$_{\sigma}$[bl̩]$_{\sigma}$[iç]$_{\sigma}$	
Word Level		[glaup]$_{\sigma}$[liç]	——	(Final devoicing)

Vowel harmony in Warlpiri and Telugu: Both, Warlpiri and Telugu, exhibit Vowel harmony processes which apply left to right in some morphological constructions and right-to-left in others. (Kiparsky 2023) develops an interesting analysis where this is captured by innerstratal cycles. However it is not clear why this is preferable over an approach where one direction of harmony applies at the Stem Level and the other one at the Word Level. See section 2.3.6 for detailed discussion of this point in Warlpiri.

Finnish vowel coalescence and t-deletion: Kiparsky (1993) makes an argument for cyclicity based on an optional process which coalesces mid vowels and following low vowels into long mid vowels (/pimeä/ → [pimeä]/[pime:] 'dark' (nom.sg.)). This is fed by a process deleting intervocalic /t/ after short vowels (/hattu-ta/ hat-PART → [hattua] 'hat (part.)'), but not after long vowels (/ve:se:-ta/ toilet-PART → [ve:se:tä]/*[ve:se:ä] 'toilet (part.)'). t-deletion feeds diphthongization (/nime-tä/ name-PART → nimeä → [nimeä]/[nime:]). However, diphthongization bleeds t deletion (pimeä-tä dark-PART → [pime:tä] but pime:tä → *[pime:ä]). Since there is evidence that partitive -ta and t-deletion are Stem-Level, all these processes should apply at the Stem Level. In the rule-based analysis of Kiparsky, cyclicity ensures that coalescence applies sometimes before and sometimes after t-deletion depending on the morphological structure Alternative take in OT: As shown by the impossibility of t-deletion in forms like [ve:se:tä] with underlying long vowels, there is a dispreference on outputs where a short vowel directly follows a long vowel. This might directly block *[pime:ä] as an output of the Stem Level.

Duanmu (1999) presents a stringent argument for word-internal cyclicity in the prosody of Shanghai Chinese compounding. The involved phonological process is the pervasive tone sandhi process of the language which for specific domains retains only the tone of the domain-initial syllable and assigns predictable default tones to all following syllables of the domain. Duanmu argues that the relevant domain is the foot which covers two syllables if possible, e.g. in even-numbered simplex forms as in (148-b,d,ef)). Additional syllables either lead to ternary right-peripheral feet (148-b,e) or to a monosyllabic foot if the word has just a single syllable (148-a). Duanmu shows that this follows from the ranking PARSE σ ≫ FOOTBINARITY ≫ ALIGNFEETLEFT:

(148) *Shanghai Chinese Foot Structure in Simplex nouns(Duanmu 1999)*

a. 1 syllable: (σ́)
b. 2 syllables: (σ́σ)
c. 3 syllables: (σ́σσ)
d. 4 syllables: (σ́σ)(σ́σ)
e. 5 syllables: (σ́σ)(σ́σσ)
f. 6 syllables: (σ́σ)(σ́σ)(σ́σ)

In many 2-word compounds, the foot-structure mirrors the morphological boundaries (149-a,b,c). Consequently the foot structure in 5-syllabic (149-b) differs from the one in 5-syllabic (148-e). The same contrast is found between (149-c) and (148-c).[36] The crucial evidence for cyclicity comes from compounds where the first word is monosyllabic as in (149-d,e,f). The footings which would mirror the morphological structure (149-d", e", f") would result in a clash of stressed syllables and is therefore avoided according to Duanmu. Still in (149-e,f) the actual pattern is also not the rhythmic pattern found in simple nouns (149-e', f'), but a minimally modified version of the morphological parsing in (149-e", f"), where the initial syllable is integrated into the following foot (←⊡ indicates where the rhythmic or morphological parse coincides with the actual form):

(149) *Shanghai Chinese Foot Structure in two-word compounds (Duanmu 1999)*

	Actual form	*Rhythmic parse*	*Morphological parse*
a. 2+3 (5) syllables:	#(σ́σ)#(σ́σσ)#	←⊡	←⊡
b. 3+2 (5) syllables:	#(σ́σσ)#(σ́σ)#	**not:** b'. #(σ́σ)#(σ́σσ)#	←⊡
c. 2+1 (3) syllables:	#(σ́σ)#(σ́)#	**not:** c'. #(σ́σ#σ́)#	←⊡
d. 1+2 (3) syllables:	#(σ́#σσ)#	←⊡	**not:** d".*#(σ́)#(σ́σ)#
e. 1+3 (4) syllables:	#(σ́#σσσ)#	**not:** e'.*#(σ́#σ)(σ́σ)#	**not:** e".*#(σ́)#(σ́σσ)#
f. 1+4 (5) syllables:	#(σ́#σσ)(σ́σ)#	**not:** f'. *#(σ́σ)#(σ́σσ)#	**not:** f". *#(σ́)#(σ́σ)(σ́σ)#
g. 1+5 (6) syllables:	#(σ́#σσ)(σ́σσ)#	**not:** g'. *#(σ́#σ)(σ́σ)(σ́σ)#	**not:** g". *#(σ́)#(σ́σ)(σ́σσ)#

[36] A fast-speech-variant for (149) is a single trisyllabic foot (#(σ́σ#σ)#). See Duanmu's paper for an analysis.

(150) illustrates Duanmu's cyclic analysis with the second cycle of deriving example (149-f) (StressIdent assigns a violation to every syllable which is underlyingly stressed and unstressed in the output or vice versa). In the first round of cycles the monosyllabic initial noun is assigned a single defective foot whereas the 5-syllable-word is assigned a 2+3 parsing which forms the input to the second cycle (150-a). The violation of *Clash can now be avoided either by a perfect binary parse as in (150-b) or by integrating the initial syllable into the following foot. This is chosen because it is closer to the input parse hence involves less violations of StressIdent:

(150) *Cyclic analysis of (149-f) ↻#2 (Duanmu 1999:148)*

Input: = a.	*Clash	StressIdent	FootBin
a. #(σ́)#(σ́σ)(σ́σσ)#	*!		**
b. #(σ́#σ)(σ́σ)(σ́σ)#		*!**	
☞ c. #(σ́#σσ)(σ́σσ)#			**

(151) shows why a straightforward parallel analysis is doomed to fail, where morphological structure is enforced by the constraint Align (Rt,Ft) ('Assign $*$ to every boundary of a lexical root which doesn't coincide with a foot boundary'). In both (151-b) and (151-c), The Align constraint is violated to satisfy *Clash, but FootBin now incorrectly favours (151-b) with its perfect parse into bisyllabic trochees:

(151) *Failure of a parallel analysis*

Input: = #σ#σσσσ	*Clash	Align (Rt,Ft)	FootBin
a. #(σ́)#(σ́σ)(σ́σσ)#	*!		**
☞ b. #(σ́#σ)(σ́σ)(σ́σ)#		*	
☛ c. #(σ́#σσ)(σ́σσ)#		*	**!

A further aspect which makes the Shanghai compound pattern especially clear evidence for stratum-internal cyclicity is that the cycles may have considerable depth as shown by the data in (152):

(152) *Shanghai Chinese Foot Structure in multi-word compounds (Duanmu 1999)*

	Actual form	*Rhythmic parse*	*Morphological parse*
a. [1+[1+1]] (3) σ's:	#(σ́#σ#σ)#	←⊡	**not:** a''. *#(σ́)#(σ́)#(σ́)#
b. [[1+1]+1] (3) σ's:	#(σ́σ)#(σ́)#	**not:** b'. #(σ́#σ#σ)#	**not:** b''. *#(σ́)#(σ́)#(σ́)#
c. [1+[1+[1+1]]] (4) σ's:	#(σ́#σ#σ#σ)#	**not:** c'. #(σ́#σ)#(σ́#σ)#	**not:** c''. *#(σ́)#(σ́)#(σ́)#(σ́)#
d. [[1+1]+[1+5]] (8) σ's:	#(σ́#σ)#(σ́#σσ)(σ́σσ)#	**not:** d'.*#(σ́#σ)#(σ́#σ)(σ́σ)(σ́σ)#	**not:** d''. *#(σ́)#(σ́)#(σ́)#(σ́σ)(σ́σσ)#
e. [[1+5]+[1+1]] (8) σ's:	#(σ́#σσ)(σ́σσ)#(σ́#σ)#	**not:** e'.*#(σ́#σ)(σ́σ)(σ́σ)#(σ́#σ)#	**not:** e''. *#(σ́)#(σ́σ)(σ́σσ)#(σ́)#(σ́)#

(153) shows how the cyclic analysis derives (152)-c):

(153) *Cyclic analysis of (152)-c): ↻#2 (Duanmu 1999:149)*

Input: = a.	*Clash	StressIdent	FootBin
a. (σ́)(σ́)	*!		**
☞ b. (σ́σ)		*	*

(154) *Cyclic analysis of (152)-c): 3rd ↻ (Duanmu 1999:149)*

Input: = a.	*Clash	StressIdent	FootBin
a. (σ́)(σ́σ)	*!		*
b. (σ́σ)(σ́)		**!*	*
☞ c. (σ́σσ)		*	*

(155) *Cyclic analysis of (152)-c): 4th ↻ (Duanmu 1999:149)*

Input: = a.	*Clash	StressIdent	FootBin
a. (σ́)(σσσ)	*!		**
b. (σσ)(σσ)	*!	**!	
☞ c. (σσσσ)		*	**

The parallel analysis again fails because it incorrectly predicts the choice of (156-b) which globally fares better both wrt Align (Rt,Ft) and FootBin:

(156) *Failure of parallel analysis for (152)-c)*

Input: = a.	*Clash	Align (Rt,Ft)	FootBin
a. #(σ́)#(σ́)#(σ́)#(σ́)#	*!**		****
☞ b. #(σ́#σ)#(σ́#σ)#		**	
☛ c. #(σ́#σ#σ#σ)#		***!	

2.3.4 Non-Cyclicity in Phrasal Phonology

The standard claim in Lexical Phonology and Stratal OT is that phrasal phonology is non-cyclic (Kaisse & Shaw 1985, Bermúdez-Otero 2018b). However there is surprisingly little specific evidence that particular rules *must* apply non-cyclically.[37]

One detailed argument to this effect is found in Yokwe (1986)'s detailed analysis of the phrasal tone of Bari, where he shows that H-dissimilation across word boundaries must apply strictly from left to right, whereas cyclic application would make the wrong predictions. Here is just one of the many examples provided by Yokwe. (157-c) shows the basic dissimilation process. The initial H of [dúmà] becomes Low after the word-final H of [gór]. Now in (157-d) the dame phrase is preceded by a H-final verb. Hence proceeding left to right first the verb causes lowering of the H of gór But since the noun is now not longer H, it doesn't cause lowering on the adjective anymore. (157-e) shows that this effect is really due to the final H on the verb not to the general syntactic context. With a verb ending in a L-tone [gór] keeps its H and consequently triggers dissimilation on [dúma].

(157) *H-dissimilation in Bari (Yokwe 1986:295)*

a.	gór					'spear'
b.	dúmà					'big'
c.	gór	dùmà				'big spear'
d.	lígòtót	à	nít	gòr	dúmà	'the hunter forged a big spear'
	hunter	DEC	forged	spear	big	
e.	tómé	à	ɓèléngù	gór	dùmà	'the elephant broke a big spear'
	elephant	DEC	broke	spear	big	

The correct distribution can only be obtained by left-to right application. Simultaneous right-to-left or cyclic application would all incorrectly predict that dúmà should undergo lowering in (157-d). This is shown in (158) for a cyclic derivation

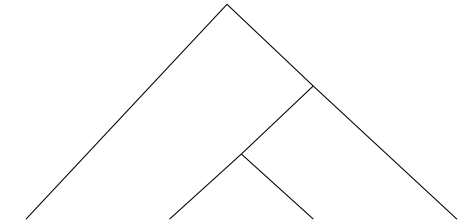
(158) *Bari*

[37] Probably this is due to the assumption that non-cyclic application of rules is the null hypothesis, but I am unaware of a conceptual argument supporting this assumption. Note also that for many common phonological processes, it seems to b e largely irrelevant whether they are applied cyclically or non-cyclically. For example in local assimilation between heterogeneous segments (e.g. place assimilation of nasals to following stops) the output is identical no matter whether all nasal+stop pairs are changed in parallel directionally or cyclically.

Cycle 1	Syntax	gór dúmà
	Phonology	gór dùmà
Cycle 2	Morphology	nít gór dùmà
	Phonology	*nít gòr dùmà

Similar arguments can be made with tone sandhi in Sino-Tibetan. Thus Hyman & VanBik (2004) argue that tone dissimilation in Hakha Lai applies directionally from right to left, independently of hierarchical structure:

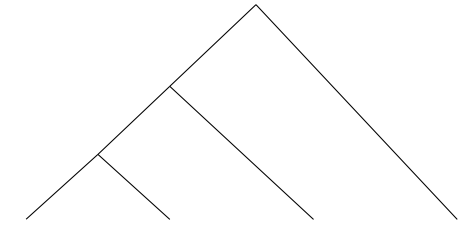
(159) *Left-to-right tone dissimilation in Hakha Lai (Hyman & VanBik 2004:837)*



ka zaán tsaán kooy → ka zaán tsaàn koòy 'my night-time friend'

R R R R F F

a. my night time friend



ʔa síí láw leé → ʔa siì làw leè 'if it isn't (the case)'

R R R R F F

b. it is NEG if

The same holds in Tianjin according to Chen (2004:107), where tone dissimilation is partially left-to-right and right-to-left, but also independent of syntactic structure.

Interestingly, evidence for phrasal non-cyclicity comes also from non-iterative processes, which potentially could apply iteratively (since triggers and outputs are identical). Consider again tone shift in languages like Jita where every H-tone is shifted one syllable to the right at the Phrase Level. Now assume that this applies cyclically in a phrasal recursive domain XP. The prediction is that shifting should only be restricted to one syllable in simple un-embedded XP's. in contrast, every level of embedding should lead to additional cycles and in principle unbounded shifting:[38]

(160)

	Syntax	Phonology
Cycle 1	$[\acute{o}\sigma\sigma\sigma]_{XP}$	$[\sigma\acute{o}\sigma\sigma]_{XP}$
Cycle 2	$[\ldots[\sigma\acute{o}\sigma\sigma]_{XP}\ldots]_{XP}$	$[\ldots[\sigma\sigma\acute{o}\sigma]_{XP}\ldots]_{XP}$
Cycle 3	$[\ldots[\ldots[\sigma\sigma\acute{o}\sigma]_{XP}\ldots]_{XP}\ldots]_{XP}$	$[\ldots[\ldots[\sigma\sigma\sigma\acute{o}]_{XP}\ldots]_{XP}\ldots]_{XP}$

The same argument could also be made with other non-iterative phrasal processes such as binary tone spreading (see e.g. Myers (1987) on Shona) and cases of non-iterative phrasal vowel harmony as in Gua (Obiri-Yeboah1 & Rose 2022, Obiri-Yeboah & Rasin 2023). In fact, Gua vowel harmony also provides a further argument for non-cyclic application of processes if Obiri-Yeboah & Rasin are right in positing that it may only apply inside (but not across) prosodic phrases. Crucially Prosodic phrasing in the language seems to be particularly independent from syntactic structure. Thus Obiri-Yeboah & Rasin (2023) argue that any utterance of four words is parsed as two two-word-phrases whereas any three-word utterance forms a single phrase regardless of syntactic boundaries. Consequently vowel

[38] I make this argument abstractly here because the descriptions of Jita and many other languages with such patterns don't provide detailed data for longer sentences. However, the description by Downing (who doesn't mention any cases of tone shift across more than one syllable) makes it seem highly unlikely that something like the pattern in (160) will emerge. Still thorough confirmation of this claim remains an important task.

harmony applies between the first and 2nd word in the 3-word sentence in (161-a), but not between the second and 3rd word in (161-c) which has 4 words:

(161) *ATR-harmony in Gua (Obiri-Yeboah & Rasin 2023:25)*

a. [átɕì wúrè ǹté] 'A sponge finished quickly'
/átɕì wúrè ǹté/
sponge finish.PST quickly

b. [ǹjɛ́ɛ̀ átɕì wúrè] 'I said that a sponge finished'
/ǹjɛ́ɛ̀ átɕì wúrè/
1SG.say.PST sponge finish.PST

c. [ǹjɛ́ɛ̀ átɕì wúrè ǹté] 'I said that a sponge finished quickly'
/ǹjɛ́ɛ̀ átɕì wúrè ǹté/
1SG.say.PST sponge finish.PST

However, since (161-c) embeds the clause in (161-a), cyclic application predicts that ATR-harmony should also apply in (161-c).

Another potential argument for non-cyclic process application comes again from finality effects. A frequent phenomenon which might be relevant is tonal lowering in utterance-final position.[39] For example in Jumjum according to Andersen (2004) an utterance-final sequence of H-tones is lowered to L. If this would apply cyclically, we would expect the same effect also at smaller phrase boundaries. Whereas Andersen's description clearly implies that this is incorrect, there are no published data which would corroborate this conclusion. As for many other languages with final lowering, much more empirical work is needed to confirm the actual domains in the descriptive literature.[40]

2.3.5 Cyclicity in Phrasal Phonology

There have been only a handful of claims for cycles in postlexical phonology. Somewhat paradoxically, most of them related to tone, but their formal nature is very heterogeneous

(162)

Tone 3 sandhi in Mandarin Chinese	(Kaisse 1985, Chen 2021)
Shanghai	Duanmu (1999)
Dogon	(McPherson & Heath 2014),
Kalabari	(Harry & Hyman 2014)
Izon	(Rolle 2018, 2021)
Kivunjo Chaga	McHugh (1990, 1999)
English 'Rhythm Rule' stress shifts	Kaisse (1985, 1987), Gussenhoven (1991)
English Nuclear Stress	(Bresnan 1971, Legate 2003)

Broadly, these cases fall into two categories, tonal overwriting and phonological sandhi processes.

Cycles of Tonal Overwriting: In Dogon, Kalabari and Izon, phonological phrases are overwritten by a fixed tonal melody (e.g., constant HL, see Rolle 2018 for description of all these cases nd references to additional literature). This overwriting is triggered by specific nouns and nominal modifiers in Izon, and by more general constructions (e.g. all phrases headed by any determiner) in Dogon and Kalabari. As argued by McPherson & Heath (2014), overwriting in Dogon can be understood as a type of head-marking morphology (Nichols 1986) similar to construct-state and Ezafe constructions

[39] Another phrasal finality effect which is problematic for cyclicity is final vowel deletion in Gran Canarian Spanish which applies at the end of intonational phrases, but not in smaller constituents (Broś & Nazarov 2023).

[40] See, e.g., Kukuya (Hyman 1987), Dschang Bamileke (Hyman 1985), and Kikuyu (Clements & Ford 1981) for other languages with reported final lowering. A further methodological problem is that final lowering might be a phonetic not a phonological effect as argued by Herman (1996) for Kipare. At least for Jumjum this seems unlikely since final lowering affects quite long sequences and may even lower utterance initial H-tones (in utterances consisting exclusively of H-tones).

(Kahnemuyipour 2014). Whereas the analysis of McPherson & Heath involves cyclic insertion and phonological evaluation, Trommer (2022) shows that under the assumption of tonal circumfixes, the similar pattern in Kalabari can be captured by tonal circumfixes completely in parallel to the Hausa analysis discussed in section 2.4.2. The same paper also shows that Izon can be modeled in parallel. Assuming with Rolle (2018, 2021) that here overwriting is triggered by trailing floating tones which are part of the idiosyncratic lexical specification of specific nouns and modifiers, it builds on the observation that it is always the floating tonal melody of the leftmost element ín a phonological phrase that overwrites. Again, this can apparently achieved by parallel evaluation without recursive cyclicity.

Iterative Cyclicity: The argument for postlexical cyclicity made by McHugh (1990, 1999) for Kivunjo Chaga involves a type of cyclicity apparently not found anywhere else in the literature. Effectively he argues that in a phonological phrase, rules are first applied to the initial PWord. The output of this cycle is then fed into a second cycle of rule application on the first two words of the phrase, and so on. Thus generally the *n*th cycle applies to the *n* initial words in a phrase. This type of cyclicity is unlike standard types of cyclicity in that the increasing domains it involves don't reflect hierarchical structure, but linearity. While this is more akin to left-to-right iterativity than to genuine cyclicity, it is also different from standard iterative rule application, where iterativity is strictly defined over single rules (not ordered sequences of rules), and invokes a fixed-size application window which iteratively shifts through a given domain, not a domain which recursively extends its size. It remains to be seen if this type of Iterative Cyclicity can be reconstructed as a parallel process in Optimality-theoretic terms.

Standard Cyclicity: Varieties of Chinese provide, as far as I know the only cases of bona fide cyclicity in a standard sense in phrasal phonology. The most famous case is Mandarin Tone-3 sandhi where the first of two adjacent Tone-3 syllables is changed into tone 2 (163).

(163) *Mandarin Tone-3 Sandhi (Chen 2021:1+2)*

	[hao3	jiu3]$_{NP}$	
	good	wine	
Underlying tone:	3	3	
Cycle 1:	[2	3]	(sandhi/ = output tone)

Evidence for cyclicity comes from comparing multiple instances of tone 3 under left-branching (164) and right-branching (165). In both cases it is the inner pair of tone-3 syllables which dissimilates first:[41]

(164) *Mandarin Tone-3 Sandhi: Left-branching cycles (Chen 2021:1+2)*

a.

	[mai3	[hao3	jiu3]$_{NP}$]$_{VP}$	
	buy	good	wine	
Underlying tone:	3	3	3	
Cycle 1:	3	[2	3]	(sandhi)
Cycle 2:	[3	2	3]	(= output tone)

a.

	[xiang3	[mai3	[hao3	jiu3]$_{NP}$]$_{VP}$]$_{VP}$	
	want	buy	good	wine	
Underlying tone:	3	3	3	3	
Cycle 1:	3	3	[2	3]	(sandhi)
Cycle 2:	3	[3	2	3]	———-
Cycle 3:	[2	3	2	3]	(sandhi/= output)

[41] I ignore here the fact that right-branching structures show systematical variation indicative of an alternative flat structure. Chen argues that this is evidence for the assumption that cyclicity is mediated by prosodic structure. See also footnote 43.

(165) *Mandarin Tone-3 Sandhi: Right-branching cycles (Chen 2021:1+2)*

b.	[[zao3	dian3]$_{AP}$	zou3]$_{VP}$	'leave a bit earlier'
	early	a bit	leave	
Underlying tone:	3	3	3	
Cycle 1:	[2	3]	3	(sandhi)
Cycle 2:	[2	2	3]	(sandhi/=output)

c.	[[zao3	dian3]$_{AP}$	zou3]$_{VP}$	hao3]$_{VP}$	'it is good to leave a bit earlier'
	early	a bit	leave	good	
Underlying tone:	3	3	3	3	
Cycle 1:	[2	3]	3	3	(sandhi)
Cycle 2:	[2	2	3]	3	(sandhi)
Cycle 2:	[2	2	2	3]	(sandhi/=output)

Does Mandarin Tone-3 Sandhi necessarily involve cycles? To show that this question is not unfounded, I will sketch a parallel reanalysis based on the cyclic account in Chen (2021) which builds on the specific ton al properties of the language. With Chen, I will assume recursive prosodic phrases (indicated in tableaux by '[,]') and the representation of tone 3 as a L linked to both moras of a syllable (notated here: LL) and of tone 2 (the tone created by sandhi) as a rising tone LH. Similarly to Chen, I will assume that there is a phonetically vacuous possibility to escape OCP violations, here tone fusion (indicated by horizontal lines connecting tones, thus L-L represents a L fused from two distinct L's).[42] As in Chen's analysis, an undominated faithfulness constraint (166-a) blocks tonal changes to the first mora of a syllable (hence .LL. might be changed to .LH., but not to .HL.). I will simply omit this constraint and candidates violating it from tableaux.

One crucial departure from Chen's analysis is the assumption of two OCP-constraints, one for Low-toned syllables, and one for Low-tones in general (166-b,c). They also differ in that *LL can be satisfied by fusion of two adjacent L's (it is only violated by distinct tones, and fusion inherently makes distinct tones non-distinct), but *$\sigma_L\sigma_L$ cannot. The latter constraint penalizes adjacent L-toned syllables no matter whether they are associated to the same L or to different L-tones.

(166) *Mandarin Tone-3 Sandhi – Constraints*

a. Head-Id-τ	Assign * to every initial output mora of a syllable which is associated to a different tone type than the corresponding input mora
b. *$\sigma_L\sigma_L$	Assign * to every pair of adjacent syllables which are exclusively linked to L tones
c. *LL	Assign * to every pair of adjacent distinct L tones
d. *[$\sigma_{\tau\text{-}\tau}\sigma$]	Assign * to every distinct pair of tones τ_1–τ_2 such that in the input σ_1 is linked exclusively to τ_1 and σ_w is linked exclusively to τ_2 and in the output τ_1 andτ_2 are fused in the same minimal phonological phrase
e. *$\sigma_{\tau\text{-}}]_{\text{-}\tau}\sigma$	Assign * to every distinct pair of tones τ_1–τ_2 such that in the input σ_1 is linked exclusively to τ_1 and σ_w is linked exclusively to τ_2 and in the output τ_1 andτ_2 are fused across the right boundary of a phonological phrase
f. Dep H	Assign * to every surface H without a corresponding underlying H
g. *$\sigma_{\tau\text{-}\tau}\sigma$	Assign * to every distinct pair of fused tones

Assuming that PPhrases contain minimally two PWords, this is the smallest dissimilation domain, as shown in (167). Changing the second syllable to LH satisfies *$\sigma_L\sigma_L$, but not *LL (167-b). Fusion of the two L-tones as in (167-c) is blocked by *[τ–τ]. Thus the only way out is to change the first syllable to

[42] Chen posits deletion of the second L with concomitant spreading of the first L to the mora of the second tone in the contexts where I assume tone fusion. Crucially the output effect is in both cases identical, a single tone linked to two several moras.

LH (167-d):[43]

(167) *Mandarin Tone-3 Sandhi – Minimal Binary Phrase*

Input: = a.	*$\sigma_L\sigma_L$	*ττ	*[$\sigma_{L\text{-}L}\sigma$]	*$\sigma_{L\text{-}}]_{\text{-}L}\sigma$	Dep H	*τ–τ
a. [LL.LL]	*!	*!				
b. [LL.LH]		*!			*	
c. [LL-LH]			*!		*	*
☞ d. [LH.LL]					*	

(168) *Minimal Binary Phrase: No Dissimilation between Tone 3 + Tone 2*

Input: = a.	*$\sigma_L\sigma_L$	*ττ	*[$\sigma_{L\text{-}L}\sigma$]	*$\sigma_{L\text{-}}]_{\text{-}L}\sigma$	Dep H	*τ–τ
a. [LL.LH]		*!				
b. [LH.LH]					*!	
☞ c. [LL-LH]						*

*$\sigma_{L\text{-}}]_{\text{-}L}\sigma$ is central for deriving the asymmetry between left- and right-branching. It ensures that in left-branching *ττ cannot be repaired by L-fusion across the boundary of the embedded PPhrase as in (169-d). Both the first and the second tone must be dissimilated (169-e):

(169) *Mandarin Tone-3 Sandhi – Minimal recursive Left Branching*

Input: = a.	*$\sigma_L\sigma_L$	*ττ	*[$\sigma_{L\text{-}L}\sigma$]	*$\sigma_{L\text{-}}]_{\text{-}L}\sigma$	Dep H	*τ–τ
a. [[LL.LL].LL]	*!*	*!*				
b. [[LL.LH].LL]		*!			*	
c. [[LL-LH].LL]			*!		*	*
d. [[LH.LL-]-LH]				*!	**	*
☞ e. [[LH.LH].LL]					**	

Under right-branching, fusion is licit and the first tone may stay L (170-d):

(170) *Mandarin Tone-3 Sandhi – Minimal Recursive Right Branching*

Input: = a.	*$\sigma_L\sigma_L$	*ττ	*[$\sigma_{L\text{-}L}\sigma$]	*$\sigma_{L\text{-}}]_{\text{-}L}\sigma$	Dep H	*τ–τ
a. [[LL[LL.LL]]	*!*	*!*				
b. [LL-[-LL-LH]]	*!		*!		*	**
c. [[LH.[LH.LL]]					**!	
☞ d. [LL-[-LH.LL]]					*	*

At this point it should become clear why the analysis requires *$\sigma_L\sigma_L$ in addition to *ττ. In a fully recursive input as in (170) for the first two syllables, *ττ is repaired by fusion, and *$\sigma_L\sigma_L$ by the change to the second syllable. However if we replace the third tone in (170) by a different tone such as H in (171), fusing the L's of the first two syllables still violates *$\sigma_L\sigma_L$:

[43] Note that *[τ–τ] blocks fusion in simple Tone3 Tone3 (= LL.LL) sequences, but allows for fusion in Tone3 Tone2 (= LL.LH) sequences since the second L is followed by a H-tone. This correctly predicts that in the latter case there is no dissimilation (LL.LH) *→ (LH.LH). Note also that for configurations which Chen interprets as minimal PWPhrases with more than two PWords (such as (3 3 3 3) → (s s s 3) see e.g. her examples (4) (8)), I have to assume that these apparently flat structures are actually left-branching. As a consequence *[τ–τ] will also be effective for these forms.

(171) *Mandarin Tone-3 Sandhi – Minimal non-recursive Right Branching*

Input: = a.	*$\sigma_L\sigma_L$	*$\tau\tau$	*$[\sigma_{L\text{-}L}\sigma]$	*$\sigma_{L\text{-}}]_{\text{-}L}\sigma$	Dep τ	*τ–τ
a. [[LL[LL.HH]]	*!	*!*				
b. [LL-[-LL.HH]]	*!					*
c. [[LL.[LH.HH]]		*!			*	
d. [[LL-[-LH-HH]]		*			*	*!*
☞ e. [LH[LL.HH]]					*	

The following tableux show that the analysis also captures more complex cases with various inputs:

(172) *Mandarin Tone-3 Sandhi – Double Right Branching*

Input: = a.	*$\sigma_L\sigma_L$	*$\tau\tau$	*$[\sigma_{L\text{-}L}\sigma]$	*$\sigma_{L\text{-}}]_{\text{-}L}\sigma$	Dep H	*τ–τ
a. [LL.[[LL[LL.HH]]]	*!*	*!*				
b. [LL-[[-LL-[-LL.HH]]]	*!*				*	
c. [LH[LH[LL.LL]]]				*!	**	
☞ d. [LL-[[-LH[LL.HH]]]					*	*

(173) *Mandarin Tone-3 Sandhi – Double Right Branching with recursion*

Input: = a.	*$\sigma_L\sigma_L$	*$\tau\tau$	*$[\sigma_{L\text{-}L}\sigma]$	*$\sigma_{L\text{-}}]_{\text{-}L}\sigma$	Dep H	*τ–τ
a. [LL.[[LL[LL.LL]]]	*!**	*!**				
b. [LL-[[-LL-[-LH.LL]]]	*!					**
c. [LL-[-LH[LH.LL]]]					**!	
☞ d. [LH.[[LL-[-LH.LL]]]					**	

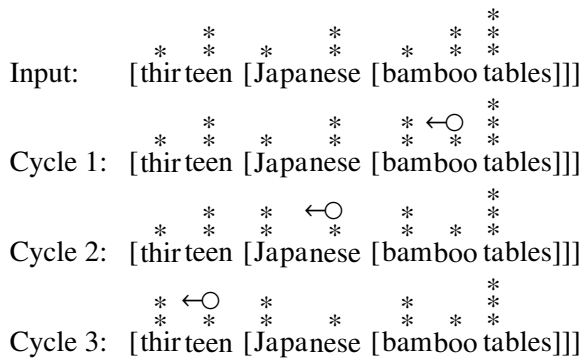
(174) *Mandarin Tone-3 Sandhi – Double recursive Left Branching*

Input: = a.	*$\sigma_L\sigma_L$	*$\tau\tau$	*$[\sigma_{L\text{-}L}\sigma]$	*$\sigma_{L\text{-}}]_{\text{-}L}\sigma$	Dep H	*τ–τ
a. [[[LL.LL].LL].LL]	*!**	*!**				
b. [[[LL.LH].LL].LH]		*!*			*	
c. [[[LL-LH].LH].LL]			*!		*	*
d. [[LH.LL-]-LH]				*!	**	*
☞ e. [[[LH.LH].LH].LL]					***	

Cyclicity has also been diagnosed by a number of authors to apply in the **English Rhythm Rule** (Prince 1983, Selkirk 1984, Gussenhoven 1991, Kaisse 1987). While I cannot do justice here to the complex literature on this topic, I will show that the shift to OT might also obviate the necessity to invoke cyclicity in Rhythm Rule effects. To do this I will show how two classical examples originally discussed in Prince (1983) naturally fall out from optimization alone.

The first example shown in (175) involves iterative movement of grid marks in a right-branching structure. In Cycle 1, The highest (line 1) grid mark of *bamboo* moves to the first sylllable repairing the clash with the initial main stress of *table*.However, this results in a new clash between *Japanése* and *bámboo* which triggers a second application of grid movement (Cycle 2). Only after one further application in Cycle 3 all clashs are removed obviating any further application of the process:

(175) *Cyclic application of the Rhythm Rule: Right-branching (Prince 1983:35)*



It should be easy to see that this pattern can be captured in parallel OT since the output of the cyclic derivation is the globally optimal one (the one with the minimal amount of clashes) assuming a markedness constraint against clashing grid marks as in (176) ranked above a faithfulness constraint against grid movement as in (177). I use the term 'open' here to designate a grid mark which is on top of its grid column:

(176) GridClash: Assign n constraint violations to every pair of line-adjacent line-n grid marks such that there is no open line $(n-1)$ grid mark between them

(177) GridStay: Assign a violation for any output grid mark which is in a different row than a corresponding input grid mark

As shown in the tableau in (178), only moving the three open line-1 grid marks as in (178-d) leads to zero violations of GridClash even though this leads to the maximal number of GridStay violations:

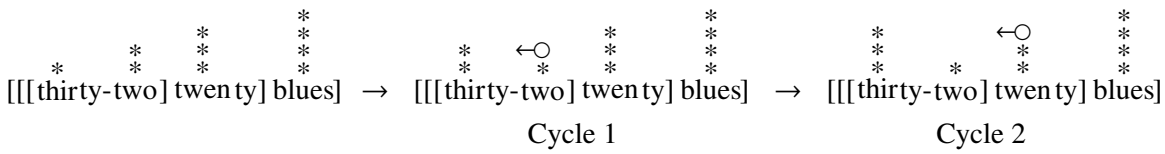
(178) *English Rhythm Rule. Parallel derivation of right-branching cyclicity*

Input: = a.	GridClash	GridStay
a. [thirteen [Japanese [bamboo tables]]]	1!	0
b. [thirteen [Japanese [bamboo tables]]]	1!	1
c. [thirteen [Japanese [bamboo tables]]]	1!	2
☞ d. [thirteen [Japanese [bamboo tables]]]	0	3

The second example from Prince (1983) is more complex and involves moving of a line-1 gridmark in Cycle 1 to the first syllable followed by moving a line-2 gridmark on top of the previously moved item

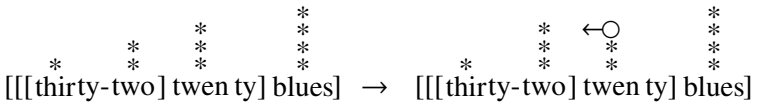
in Cycle 2:

(179) *Cyclic application of the Rhythm Rule (Prince 1983:36)*



Prince' argument for cyclicity is that a single countercyclic application of gridmark movement leads to the stress pattern in (180). (180) appears not only empirically impossible itself, but also doesn't allow to derive (179-c) by further applications of gridmark movement. None of the gridmarks on *two* canmove, the highest one because it would have to target a different line, and the lower ones because they are topped by a higher grid mark:

(180) *Counter-cyclic application of the Rhythm Rule (Prince 1983:36)*



At this point it is useful to consider the general restrictions on Move $*$ posited by Prince, which I formulate in (181) to explicitly summarize his overall assumptions on the operation:

(181) *Move $*$:*
Shift a clashing gridmark on line n and row r to a position on line n and row r' such that the following conditions hold:
(i) OutputSupport: there is a line-$(n-1)$ gridmark on row r
(ii) InputBareness: There is no input line-$(n+1)$ gridmark on row r
(iii) NoIntervention: there is no input line-n gridmark on any row r'' such that $r' < r'' < r$
(iv) MoveLeft: $r' < r$

Now if we interpret the single conditions in (181-i-iv) not as restrictions of a a single Move operations, but as restricting the possible inputs and outputs of candidates in an OT-evaluation (with one or more gridmarks moved simulatneously), we get a limited finite candidate set.[44]

This results since only the topmost 3 gridmarks of the non-initial columns can move with very limited possible landing positions. The tableau provides an exxhaustive listing of these candidates where in (182-b,b',b") only gridmark moves, in (182-c,c',c"), and (182-d) is the only possible candidate where all three of them move. Now, gridmark movement can repair the input clash on line 2 (between *twen* and *blues*) and avoid one of the original lin e-1 clashes. But given that there are 4 columns and 3 line-1 gridmarks one clash cannot be avoided. Hence *GridClash leaves us with the candidates in (182-c) and (182-d). GridStay then correctly selects (182-c) because this involves less instances of gridmark movement.

(182) *English Rhythm Rule. Parallel derivation of left-branching cyclicity*

Input: = a.	*GridClash	GridStay
a. [[[thirty-two] twen ty] blues]	1,1,2	0
b. [[[thirty-two] twen ty] blues]	1,2	1
b'. [[[thirty-two] twen ty] blues]	1,1	1
b". [[[thirty-two] twen ty] blues]	1,1,2	1
☞ c. [[[thirty-two] twen ty] blues]	1	2
c'. [[[thirty-two] twen ty] blues]	1,1	2
c". [[[thirty-two] twen ty] blues]	1,2	2
d. [[[thirty-two] twen ty] blues]	1	3!

Hence again, what looks like local cyclic application of a single rule can be naturally reinterpreted as global optimization of natural markedness and faithfulness constraints.

[44]Note that even for Prince the conditions in (181) seem to have a very heterogeneous status. OutputSupport is a general property of grid representations, InputBareness and NoInterventions are invariable properties of Move $*$, and MoveLeft is a language-specific constraint. In an OT-account one might argue that some of them are part of GEn, and others follow from undominated OT-constraints. I leave thiks question open here.

A final argument for phrasal cyclicity comes from early work on **English sentence stress** by Bresnan (1971, 1972). Bresnan's argument builds on the original version of the Nuclear Stress Rule by Chomsky & Halle (1968) which assigns main stress in a cyclic domain to the rightmost word which has received main stress on the previous cycle (with concomitant downgrading of all other stress values in the domain). Bresnan observes that this correctly predicts the stress in sentences like (183-a) and (184-a) where the object is in its base position, but incorrectly predicts stress on the lexical verb in (183-b) and (184-b), where the object has undergone movement (indicated here by the trace t_i) :

(183) a. Helen has written some **books**.
b. What **books**$_i$ has Helen written t_i?

(184) a. George has plans to **leave**.
b. George has **plans**$_i$ to leave t_i.

(185) illustrates the derivation of (184-a):

(185)

Input:	[George has [plans [to leave]$_S$]$_{NP}$]$_S$ 1 1 1	
Cycle 1:		
Cycle 2:	[George has [plans [to leave]$_S$]$_{NP}$]$_S$ 1 **2** 1	(NSR)
Cycle 3:	[George has [plans [to leave]$_S$]$_{NP}$]$_S$ **2** **3** 1	(NSR)

Now, in the version of transformational syntax assumed by Bresnan not only phonologically rules apply cyclically, but also transformations. Bresnan's solution to the problematic cases is to integrate the NSR in the transformation al cycle between rules of phrasal movement, deletion etc. (184-b) is then derived as in (186). In Cycle 1 on *leave plans*, the accent of *leave* is downgraded as a consequence of main stress assignment for *plan.* In Cycle 2 on *plans to leave plans* the second instance of *plans* is deleted by a transformational rule before NSR applies for a second time.

(186)

Input:	[George has [**plans** [to leave **plans**]$_S$]$_{NP}$]$_S$ 1 1 1 1	
Cycle 1:	[George has [**plans** [to leave **plans**]$_S$]$_{NP}$]$_S$ 1 1 **2** 1	(NSR)
Cycle 2:	[George has [**plans** [to leave]$_S$]$_{NP}$]$_S$ 1 1 2	(deletion under identity)
	[George has [**plans** [to leave]$_S$]$_{NP}$]$_S$ 1 1 **2**	(NSR)
Cycle 3:	[George has [**plans** [to leave]$_S$]$_{NP}$]$_S$ **2** 1 **3**	(NSR)

The main stress on *plans* is thus a consequence of the cyclic interleving of phonological and transformation al rules. Legate (2003) reformulates Bresnan's analysis in contemporary syntactic terms –

minimalist syntax – where syntactic cycles amount to phases in the sense of Chomsky (2001) followed cyclically by phonology.

However, as shown by recent work of Truckenbrodt and others there is also a natural alternative to the cyclic analysis. If the output of complete syntactic derivations still contains remnants of movement processes, the original position of syntactic constituents may still have an effect on prosodic structure. Selkirk (1995) sketches a Prosodic -Phonology account of Bresnan's data based on trace theory, and Truckenbrodt (2019), Büring & Truckenbrodt (2021) develop a fuller optimality-theoretic analysis based on a syntactic multidominance model where 'movement' is conceived as different positions in a tree dominating the same constituent. See especially Büring & Truckenbrodt (2021) for arguments that this approach actually has empirical advantages over the original cyclic account by Bresnan.

2.3.6 *Cycles on roots*

Lexical roots often don't undergo phonological processes applying otherwise word-internally. A well-known example is Finnish assibilation before front vowels (/halut-i/ → [halusi] 'want-PAST') which is blocked root-internally (/koti/ → [koti], *[kosi] 'home', see section 4.2 for more discussion).

In contrast most of the stratal literature assumes that there is an even stricter restriction on bound roots (i.e. roots which in a given language never appear as independent words). Thus Kiparsky (1982b) argues that single morphemes *never* undergo cycles on their own. If a root undergoes a cycle on its own it is not qua being a root but by forming a complete stem (either because it is a complete word form or because all affixes it bears are Word-Level). On the other hand, non-bound (free) roots may undergo Stem-Level phonology on their own, and this according to Kiparsky (1982b) is the source of apparent MSC's.[45] A case in point is Tunica which allows only CV word-initially, a restriction which also holds for non-bound roots (which may occur in this position). On the other hand, there are roots beginning with consonant clusters or vowels in inalienable nouns which are obligatorily preceded by a possessive prefix (Kiparsky 1982b:73 following Kenstowicz & Kisseberth 1977).

Other classical cases which are in line with this generalization are depalatalization in Spanish discussed below, and syllable structure restrictions in Malayalam (Inkelas 1990).

Kiparsky (2023) uses this approach to capture the noun-verb contrast in Warlpiri vowel harmony. Verbs undergo regressive harmony for backness with single suffixes (e.g. /kiji/ 'throw' → [**kiji**-rni] 'throw (PAST)' → [kuju-rnu] 'throw (NON-PAST)'), but nouns trigger progressive harmony on suffixes (e.g., [maliki-**kirli-rli-lki-ji-li**] child-PROP-ERG-then-me-they vs. [kurdu-kurlu-rlu-lku-ju-lu] child-PROP-ERG-then-me-they, p.4). Kiparsky correlates this asymmetry to the fact that verbs are bound roots (they never occur without suffixes), whereas noun roots may occur as independent words without affixes. As a consequence, he argues, the first cycle of nouns is based on a stem comprising only the root, whereas the first cycle for bound verb roots is always on a combination [root + suffix]. The constraint ranking generally favors regressive assimilation to round suffix vowels as in (187-a) for nouns, but this is overwritten by the high-ranked constraint IDENT-STEM [Rd] which protects the rounding specification of segments in the inner stem for verbs. Crucially IDENT-STEM [Rd] is inert in (187-a) in the relevant cycle since the bound verb root doesn't constitute a stem on its own:

(187)

	Cycle 1		Cycle 2		
a.	$[\text{kiji-rnu}]_{\text{Stem}}$	→	$[\text{kuju-rnu}]_{\text{Stem}}$		
b.	$[\text{kurdu}]_{\text{Stem}}$	→	$[\text{kurdu}]_{\text{Stem}}$	→	$[[\text{kurdu}]_{\text{Stem}}\text{-kirli}]_{\text{Stem}}$ → $[[\text{kurdu}]_{\text{Stem}}\text{-}\mathbf{\text{kurlu}}]_{\text{Stem}}$

This analysis also correctly predicts that harmony should be progressive if suffixed verbs are combined with additional suffixes since the complex [root + suffix] constitutes a stem for the following cycles (e.g. [kiji-rni-nji-ni] 'goes and throws (NON-PAST)' vs. [kuju-rnu-nju-nu] 'went and threw (PAST), p.6).

(188)

	Cycle 1			Cycle 2		
a.	$[\text{kiji-rni}]_{\text{Stem}}$	→	—-	→	$[[\text{kiji-rni}]_{\text{Stem}}\text{-nji}]_{\text{Stem}}$	→ —-
b.	$[\text{kiji-rnu}]_{\text{Stem}}$	→	$[\text{kuju-rnu}]_{\text{Stem}}$	→	$[[\text{kuju-rnu}]_{\text{Stem}}\text{-nji}]_{\text{Stem}}$	→ $[[\text{kuju-rnu}]_{\text{Stem}}\text{-}\mathbf{\text{nju}}]_{\text{Stem}}$

Despite the merits of Kiparsky's analysis, there seems to be a plausible stratal alternative. Leftwards harmony is a Stem-Level process, rightwards harmony is Word-Level. Verbal affixes triggering the leftwards variant are Stem-Level affixes. All other verbal and nominal affixes are Word Level. Just as Kiparsky's cyclic analysis it correctly predicts the correct linear order of affixes (Stem Level/regressive harmony affixes precede Word Level/progressive harmony suffixes). [46] Note also that in some Warlpiri dialects immediate future suffixes which like other tense suffixes attach directly to verb roots undergo

[45] The claim that bound roots are not cyclic domains also implies that there cannot be a designated root stratum. The discussion here is thus closely related to section 2.2.3.

[46] The stratal analysis of Warlpiri is akin in spirit to the claim by Harvey & Baker (2005) that leftwards harmony is not productive, but the effect of stored root-affix combinations. See also Yun (2009) for an analysis of noun/verb asymmetries in Korean based on a stratal difference between the involved affixes.

progressive harmony. This pattern is incompatible with the cyclic account, but in the stratal analysis it would simply follow from the fact that these affixes have Word-Level status in the relevant dialects.

Note also that there are a substantial number of counterexamples again st the general claim that MSC's do not hold in bound roots. These are discussed in section 2.2.3.

The root inertia hypothesis is often related to the independent claim by Brame in (189):

(189) *Natural Bracketing Hypothesis (rephrased from Brame 1974):*

Only free words may be cyclic domains

However, in a standard stratal framework including a Stem Level, bound roots are not coextensive with the complement set of free words. They are rather roots which cannot appear independently (without additional affixation) as stems inside words. The stratal interpretation seems to be the correct one, given examples like Albanian where cyclic effects are found on roots which are never appear without (Word-Level) inflection. In fact, this case and related data in other languages seem to provide essential evidence for stratal and against competing paradigmatic approaches (see the discussion of OO-correspondence in section 1.5.4 above).

However, this argument also sheds further doubts on the justification of Kiparsky's Warlpiri analysis. In this context, it is especially striking that the phonological differences between nouns and verbs in Itelmen discussed in section 2.2.3 are the exact mirror image of Warlpiri. In Itelmen just as in Warlpiri verb roots are bound, and nouns are free forms. However, in contrast to Warlpiri the evidence in Itelmen suggests that verb roots, but not noun roots undergo a separate cycle before being merged to suffixes.

Note finally an inherent connection between root cycles and the general question of stem-internal cycles. Under the assumption that there are no stratum-internal cycles even at the Stem Level, it would directly follow by definition that bound roots cannot undergo independent evaluations. Consider for example one of the classical cases typically cited for the Root Inertia Hypothesis, syllable-final depalatalization in Spanish nasals (cf. e.g. [dona] 'Madam' vs. [don] 'Mister'). In verbs, root-final palatalization shows up as expected before vowel initial inflectional suffixes as in [desdeɲar] 'to disdain'. However in related noun forms, depalatalization overapplies in the same context: [desden] 'disdain (sg.)' [desden-es] 'disdains (pl.)'. Kiparsky (1982b) (see also Inkelas 1990) motivates this by the fact that the morpheme is a complete stem in nouns (as established by the singular form [desden]), but a bound root in verbs, where it never appears with inflection at least the thematic suffix -[a]. The pattern is thus closely parallel to Warlpiri. However, if the verb root [desdeɲ] obligatorily selects for a theme vowel (or is store together with it as argued for in Bermúdez-Otero 2013), the assumption that there are no stratum-internal cycles would directly derive the facts.

2.3.7 Cycles on affixes: Symmetric and asymmetric cycles

The Phrase-Level stratum in standard stratal model has a symmetric structure: It combines words which run through all have run through all previous strata (the Stem and the Word Level) before they enter the Phrase Level. This differs markedly from usual assumptions about affixation at the Word Level which is essentially asymmetric: The stem formed around the root and potentially complex has passed through the previous Stem Level stratum, but affixes are affixed separately without having run through previous phonological evaluation.

Bermúdez-Otero (2008) (see also Baker 2005) suggests the possibility of a more symmetric structure of affixation, where affixes also might undergo previous cycles on their own. Trommer (2011) generalizes this idea in an approach he dubs 'Egalitarian OT'.

Evidence for the Egalitarian architecture comes from cases where Stem-Level affixes behave partially like independent grammatical words. For example in Ngalakan, bisyllabic affixes seem to behave like independent PWords with respect to stress assignment Baker (2005). Thus in monomorphemic words, the language exhibits exceptionless alternating stress corresponding to syllabic trochees assigned from left to right:

(190) *Ngalakan: Alternating Stress in Monomorphemic Words* (Baker 2005)

a.	(pólo)	'old person'
b.	(káma)la	'sky'
c.	(káŋa)(mùru)	'long-nose' (native honeybee)
d.	(ká.ɪaŋ)(kàna)(ŋ̀ni)	'wallaby sp.'

However with bisyllabic suffixes, this pattern is disrupted in a predictable way, as shown in (191):

(191) *Ngalakan: Morphologically Disrupted Stress* (Baker 2005)

a.	(ʈótoyʔ)-ki	'aunt-your'
b.	(ʈótoyʔ)-(kí-kkaʔ)	'aunt-your-LOC'
c.	(ʈótoyʔ)-ki-p(púlu)	'aunt-your-PL'
d.	(ʈótoyʔ)-ki-p(púlu-k)kaʔ	'aunt-your-PL-LOC'

The crucial generalization is that "Polysyllabic suffixes and clitics are inherently footed, but the footing of monosyllabic suffixes and clitics is contingent on their surrounding environment." (Baker 2005:5). In Egalitarian Stratal OT, this can be derived as follows: At the Stem Level, foot structure is built on stems and bisyllabic Word-Level affixes, but not on monosyllabic affixes. At the Word Level, Stem-Level foot structure must be maintained. New feet can only be built on hitherto unfooted syllables. A concrete implementation of this may be built on the constraints in (192):

Partially egalitarian evaluation, i.e. previous stratal evaluation for some affixes, but not for others may also be understood as a difference between stratal affixation and stratal compounding. For example, Kiparsky (2023) suggests that a number of verbal suffixes in Yowlumnee Yokuts form compounds with the remainder of the verb stem (in fact these suffixes are partially homophonous to independent light verbs). Where the idea of stratal compounding is crucially different from the idea that affixes go through strata by their own is that affix compounds may be internally complex. For example, Myers (1997) assumes that specific tense prefixes such as Future [cha]- in Shona form (macro-)stems together with agreement prefixes whereas the verb root forms an independent (macro-)stem with suffixes and other prefixes such as present tense [chi]- (192-f). (192-e,f) show that agreement prefixes in specific tenses are also part of the stem formed by the lexical verb root:

(192) *Shona (Myers 1997:856,870)*

a.	[i̲][banga̲]	'it is a knife'	b.	[va̲][se̲ku̲ru]	'grandfather (honorific)'
	COP-knife			2a-grandfather	
	cf. bángá	'knife'		cf. sékúru	'grandfather'
c.	[ndi cha̲][te̲ngesa]	'I will sell'	d.	[v-a̲][te̲ngesa]	'they sold'
	1SG-FUT-buy-CAUS-FV			3PL-PAST-buy-CAUS-FV	
	cf. [ku][téngésá]	'to sell'		cf. [ku][téngésá]	'to sell'
e.	[tí-téngésé]	'we should sell'	f.	[va-chí-tárís-a]	'while if they are seeing'
	1PL.SBJ-buy-CAUS-FV			3PL-PART.PRES-see-FV	

Note that morphemes like Future [cha]- seem to have a hybrid status between affix and root. On the one hand, they can act as bases of affixation, and undergo separate Stem level evaluations on the other hand they are bound and must be attached to a lexical verb. We might call them defective roots.

See also Harris (1993) for the idea that Catalan clitic groups undergo a cycle independent from the rest of the verbal word complex and Bonet & Lloret (2005) for critical discussion of this approach.

2.4 Layering and the Affix Ordering Generalization

The most influential contribution of the stratal literature to the issue of affix order is the integration of the Affix Order Generalization originally proposed by Siegel (1974) Allen (1978) as a purely morphological generalization for English affixes. They propose that derivational affixes in English fall into two arbitrary sets where affixes of the first group (Level 1) always occur inside the affixes of the second group (Level 2). A simple minimal pair are the English negative affixes *in-* and *un-*. Whereas both have the same meaning and the same phonotactic shape, [un-] may be affixed outside of [in-] but not vice versa. Strikingly, they also differ in their phonological other morphological properties (*in-*, but not *un-* may be affixed to bound roots) and the phonological alternations they exhibit (e.g., *il-logical* vs. *un-logical*). I will call this property *Layering* after Selkirk (1995).

2.4.1 Inter-stratal Recursion and the Loop

Layering directly predicts that there should be no recursion involving affixes or morphological constructions associated to different strata. The original argument for the existence of this phenomenon comes from Mohanan (1986) who argues that **Malayalam** has a stratum for subcompounds and one for cocompounds (see section 2.2). On the other hand in the language both types of compounding may be freely interleaved Cocompounds can contain subcompounds and vice versa. On these grounds Mohanan proposes to substantially weaken Layering by positing a "loop" between specific strata which allows the derivation to return to a previous stratum.

However if the approach suggested in section 2.2 is correct and special properties of compounding are typically not stratal but prosodic, then cocompounds and subcompounds may be simply part of the same stratum, and their recursion is unproblematic recursion inside a single stratum. Strikingly this assumption removes two conceptually problematic properties at the same time, the loop and the proliferation of the number of strata.

The same is true for Halle & Mohanan's analysis of English already discussed in section 2.2: Abandoning the empirically problematic assumption that English has a separate stratum for compounding also obviates the loop.

Also, Hargus (1988) provides a loop-based analysis based on compound data in **Sekani**.

In **Sekani**, morpheme-initial continuants are generally voiced word-internally,[47] but voiceless word-initially. This leads to voicing alternations with possessive prefixes (193-a,a') and what Hargus calls Type I compounds (193-b,b'). However, in a second type of compounds (Hargus' Type II), the second compound member doesn't exhibit the expected voicing even though the continuant is word-internal (193-b"). Even more strikingly the two types of compounds also differ in their behavior wrt voicing if they are prefixed, although in a paradoxical way. In this context, Type I compounds *fail* to undergo continuant voicing whereas Type II compounds exhibit voicing (193-c,c'):

(193) *Sekani (Hargus 1985)*

a.	ʃən	'song'	(p.271)	(Bare noun)
a'.	sə-jən-è	'my song'	(p.271)	(Prefixed noun)
b.	ʃe̗ɬ	'trap'	(p.271)	(Bare noun)
b'.	tsa-je̗ɬ	'beaver trap'	(p.271)	(Bare Type-I/root compound)
c.	xəda-ɟè	'moose-horn'	(p.277)	(Bare Type-I compound)
c'.	sə-xəda-ɟè	'my moose-horn'	(p.277)	(Prefixed Type-I/root compound)
b".	tʃsi̗h-xeɬ	'box (stick-like-pack)'	(p.281)	(Bare Type-II/stem compound)
c".	mə-ɣès-ɬe̗	'his testicles (his-egg-??)'	(p.282)	(Prefixed Type-II/stem compound)

Thus we have the crossover distribution in (194)

(194) *The first member of a compound of . . .*

	triggers voicing	undergoes voicing
Type I	+	–
Type II	-	+

Hargus assigns possessive prefixation, type I-compounding and continuant voicing to level 2 accounting for the observed applications in (193-a',b'). Locating type I-compounding at level 5 additionally predicts that the second member of a type II compound remains voiceless.

However, this leads to a paradox: As shown by (193-c") level II compounds can be prefixed with a possessive (level 2) prefix and undergo (level-2) continuous voicing, the morphology and phonology of an earlier stratum. This is essentially Hargus' argument for the loop: After level-5 phonology and morphology there must be the option of going back to level 2.

However, even the loop doesn't account for the full distribution shown in (194), since we still expect that prefixed type-I compounds should undergo voicing if undergoing level 2 prefixation (193-c'). Hargus ascribes that to a structural factor. In type I compounds, the first compound member is a root whereas it is a stem in type-II compound. The rule of continuant voicing is then restricted to apply to stem-initial segments.

Given the fact that also Hargus has to resort to representational differences between the different compound types, the obvious alternative is to derive all differences between them in this way. Instead of directly invoking stems and roots, I will assume that similarly to Malayalam the crucial difference for phonological constraints lies in different prosodic word structures.

[47] Hargus argues that this pattern is limited to nouns and propositions, but the contrastive evidence from verbs she provides is from relatively peripheral prefixes. Thus the difference might well be stratal.

I will capture the allophonic distribution of continuant voicing by two markedness constraints, +cont ⇝ +vc ('Assign ∗ to every voiceless continuant') which captures that continuants are voiced per default, and higher ranked $_{\omega\text{-min}}$[+cont ⇝ -vc ('Assign ∗ to every voiced continuant at the left edge of a minimal PWord') ensuring word-initial voicelessness. The basic alternation pattern in simplex (non-compound) nouns then follows from the natural assumption that these form non-recursive PWords as in (195):

(195) *Sekani simplex noun*

a. *Bare noun*

		$_{\omega\text{-min}}$[+cont ⇝ -vc	+cont ⇝ +vc
	a. $_{\omega}$[jən]	*!	
☞	b. $_{\omega}$[ʃən]		*

b. *Prefixed noun*

		$_{\omega\text{-min}}$[+cont ⇝ -vc	+cont ⇝ +vc
☞	a. $_{\omega}$[sə-jən-è]		
	b. $_{\omega}$[sə-ʃən-è]		*!

If we further assume that root compounds always form minimal PWords (to the exclusion of any affixes), this accounts for compound-internal voicing (196-a) and compound-initial devoicing (196-b):

(196) *Sekani root compound*

a. *Bare compound*

		$_{\omega\text{-min}}$[+cont ⇝ -vc	+cont ⇝ +vc
☞	a. $_{\omega}$[tsa-jɛ̨ɬ]		
	b. $_{\omega}$[tsa-ʃɛ̨ɬ]		*!

b. *Prefixed compound*

		$_{\omega\text{-min}}$[+cont ⇝ -vc	+cont ⇝ +vc
	a. $_{\omega}$[sə]-$_{\omega}$[ɣəda-ɟè]	*!	
☞	b. $_{\omega}$[sə]-$_{\omega}$[xəda-ɟè]		*

This leaves stem compounds which must have a structure where the first member of a compound forms a PWord with prefixes but not with the remainder of the compound, resulting in compound-internal devoicing (197-a) and compound-initial voicing (197-b):

(197) *Sekani stem compound*

a. *Bare compound*

		$_{\omega\text{-min}}$[+cont ⇝ -vc	+cont ⇝ +vc
	a. $_{\omega}$[tʃsi̯h]$_{\omega}$[ɣeɬ]	*!	
☞	b. $_{\omega}$[tʃsi̯h]$_{\omega}$[xeɬ]		*

b. *Prefixed compound*

		$_{\omega\text{-min}}$[+cont ⇝ -vc	+cont ⇝ +vc
☞	a. $_{\omega}$[mə-ɣès]$_{\omega}$[ɬɛ̨]		
	b. $_{\omega}$[mə-xès]$_{\omega}$[ɬɛ̨]		*!

In the absence of a deeper understanding of the structural differences between the two compound types, it is hard to say what the specific justification for these prosodic representations might be.[48] However, it might be enlightening that they can be derived by two simple alignment constraints for compounds formulated in (198-a) and (198-b) interacting with standard markedness constraints on prosodic integration (198-c) and economy (198-d):

(198) *Constraints on Prosodic Words*

a. (√ √) ⇝ ω[√ √ The left edge of every root compound should be aligned with the left edge of a PWord

b. (SS) ⇝ S$_{\omega}$[S The left edge of every **head of a** stem compound should be aligned with the left edge of a PWord

c. PARSE σ Syllables should be parsed in PWords

d. *ω Minimize PWords

[48] Hargus adopts the distinction between compound types from the literature on other Dene languages with more extensive documentation of the phenomenon. For Sekani, she states that it is difficult to pinpoint systematic semantic differences, and identifies the investigation of more complex compounds as a topic for further research.

This is shown in tableaux (199) to (203) for most relevant cases. PARSE σ guarantee the building of exhaustive PWords, *ω ensures that internal PWord boundaries are only licit if satisfying higher constraints, and the higher-ranked two alignment constraints enforces PWord boundaries at the appropriate places for root and stem compounds:

(199) *Sekani Prefixed noun*

		(√ √) ⇝ ω[√ √	(SS) ⇝ $S_ω$[S	PARSE σ	*ω
	a. sə-jən-è			*!**	
	b. ω[sə]-ω[ʃən]-ω[è]				**!*
☞	c. ω[sə-jən-è]				*

(200) *Sekani Bare Type-I (root) compound*

		(√ √) ⇝ ω[√ √	(SS) ⇝ $S_ω$[S	PARSE σ	*ω
	a. tsa-jɛ̨ɬ	*!		**	*
	b. ω[tsa]-ω[ʃɛ̨ɬ]				**!
☞	c. ω[tsa-jɛ̨ɬ]				*

(201) *Sekani Bare Type-II (stem) compound*

		(√ √) ⇝ ω[√ √	(SS) ⇝ $S_ω$[S	PARSE σ	*ω
	a. tʃsįh ɣeɬ		*!	**	
	b. ω[tʃsįh ɣeɬ]		*!		*
☞	c. ω[tʃsįh]ω[xeɬ]				**

(202) *Sekani Possessed Type-I (Root) compound*

		(√ √) ⇝ ω[√ √	(SS) ⇝ $S_ω$[S	PARSE σ	*ω
	a. sə-ɣəda-ɟè	*!		***	
	b. ω[sə-ɣəda-ɟè]	*!			*
	c. ω[sə]-ω[xəda]-ω[ɟè]				***!
☞	d. ω[sə]-ω[xəda-ɟè]				**

(203) *Sekani Possessed Type-II (stem) compound*

		(√ √) ⇝ ω[√ √	(SS) ⇝ $S_ω$[S	PARSE σ	*ω
	a. mə-xès ɬɛ̨		*!	***	
	b. ω[mə-xès ɬɛ̨]		*!		*
	c. ω[mə]-ω[ɣès]ω[ɬɛ̨]				***!
☞	d. ω[mə-ɣès]ω[ɬɛ̨]				**

Hargus also provides a second argument for the loop in Sekani based on affixation and a productive alternation which coalesces a nasal consonant in syllable-final position and a preceding vowel into a nasal vowel. Thus the root-final [n] of [tson] 'shit' surfaces before the vowel-initial possessive suffix -[e] (204-a), but is merged with [o] in word-final position (204-b). However, with other vowel-initial suffixes such as diminutive -[azi] and nominalizing -[i] nasal coalescence overapplies (204-c,d):

(204) *Sekani nasal coalescence (Hargus 1985:237)*

a.	sɛ-tsòn-è	'my shit'
	1SG-shit-POSS	
b.	tsǫ̀	'shit'
c.	tsǫ̀-azi	'small shit'
	shit-DIM	
d.	tʃu-mə-k'eh-sə-kǫ-i	'washstand'
	/sɛ-tʃumək'ehsəkson-i/	
	water-3SGO-on-CNJ-NOM	

Hargus' interpretation of these data is that affixes like Possessive -è are concatenated at the lowest lexical stratum and thus transparently bleed nasal coalescence which applies at the same stratum. On the other hand, -[azi] and -[i] are concatenated at a later stratum after nasal coalescence which consequently overapplies (tsòn → tsǫ̀ → tsǫ̀-azi). Hargus' argument for the loop comes from data as in (205) where Possessive -è and nominalizing -i are combined. This would seem to lead to a contradiction since a higher-level affix (-[è]) is attached outside a lower-level suffix (-[i]). Hargus suggests to resolve this contradiction by allowing a loop back to the initial stratum after nasalization where then affixation of è and vowel deletion apply.

(205) *Possessive -è outside of nominalizing -i (Hargus 1985:249)*

sɛ-tʃumək'ehsəkǫ-è	'my washstand'
/sɛ-tʃumək'ehsəkson-i-è/	
1SG-washstand-NOM-POSS	

However, positing the loop leads to new problems for the formulation of vowel deletion. This process, according to Hargus deletes an affix vowel before another vowel, as shown by the contrast between (206-a) and (206-b). But as (206-c,d) show, root vowels are not triggered in the same context:

(206) *Sekani Suffix Vowel Deletion (Hargus 1985:322,323)*

a.	ʔə-bil-i	'swing'
	UNSPO-V:swing-NOM	
b.	mə-ʔə-bil-è	'his/her swing'
	/mə-ʔə-bil-i-è/	
	3SG-UNSPO-V:swing-NOM-POSS	
c.	dəgi	'swan'
d.	sə-dəgi-è	'my swan'
	1SG-swan-POSS	

However, if -[i] is attached at the Word Level, and vowel deletion applies subsequently at the Stem Level. Bracket Erasure should apply at the transition from one stratum to the other. -[i] should hence be indistinguishable from a stem-final [i], and thus forfeit deletion counter to fact.

A reanalysis without the loop could simply attribute dual-level status to Possessive -e. It would apply at the Stem Level as default, but might be forced to undergo Word Level affixation if the Mirror Principle forces it to attach outside of a Word Level affix such as nominalizing -(e). This would immediately solve the problem with Bracket Erasure since vowel deletion now applies at the stratum (the Word Level) where -[e] is concatenated, hence it should be still identifiable as an affix.

Orgun (1996) and Inkelas & Orgun (1998) identify three constructions in **Turkish** which seem to require the loop. The first is the relativizer affix -[ki]. -[ki] can occur inside the plural suffix -[lar]/[ler] (207-a), but also outside of it (207-b) or on both sides in the same word form (207-c).

(207) *Turkish relativizer -ki*

a. di:dem-in-ki-ler — 'the ones that are Didem's' (Orgun 1996:138)
   Didem-GEN-REL-PL
b. arkadaʃ-lar-iniz-in-ki — 'the one belonging to your friends' (Inkelas & Orgun 1998:369)
   friend-PL-POSS.2SG-GEN-REL
c. ev-ler-de-ki-ler-in-ki-ler — 'the ones that belong to the ones in the houses' (Orgun 1996:138)
   house-PL-LOC-REL-PL-GEN-REL-PL
d. on-un-ki-nden — 'that which is his (abl.)' (Inkelas & Orgun 1998:370)
   3SG-GEN-REL-ABL

(207-c) and (207-d) also illustrates that -[ki] may occur inside and outside of case affixes such as the Genitive suffix -[in] and the Ablative -[nden]. This provides the major argument for the loop since virtually all stratal analyses of Turkish assign case and plural markers to different lexical strata. However, a natural alternative to the loop analysis is the assumption that -[ki] is a defective root which may only be used in stratal compounding constructions. Being a root is tantamount to a 'loop' to the initial state of word formation allowing for all affixes possible on nouns. Thus the structure of (207-c) would be [[[ev-ler-de][-ki-ler-in]][-ki-ler]]. The compounding analysis would also correctly predict that ki doesn't undergo backness and roundness harmony as other suffixes in Turkish (arkadaʃ-lar-iniz-in-ki/*arkadaʃ-lar-iniz-in-kɨ and instead seem to initiate a new vowel harmony domain (on-un-ki-nden/*on-un-ku-ndan/*on-un-ki-ndan). -[ki] would thus be fully parallel to the analysis of Future [cha-] in Shona by Myers (1997) and the Yowlumnee analysis by Kiparsky (2023) as discussed in section 2.3.7.

(208) *Turkish relativizer -ki*

a. [[di:dem-in]-[ki-ler]]
   Didem-GEN-REL-PL
b. [[arkadaʃ-lar-iniz-in]-[ki]] — *arkadaʃ-lar-iniz-in-kɨ
   friend-PL-POSS.2SG-GEN-REL
c. [[[ev-ler-de]-[ki-ler-in]]-[ki-ler]]
   house-PL-LOC-REL-PL-GEN-REL-PL
d. [[on-un]-[ki-nden]] — *on-un-ku-ndan/*on-un-ki-ndan
   3SG-GEN-REL-ABL

Whereas the characteristic effect of defective roots is stratal compounding for a small set of functional elements, we have pursued the hypothesis that productive compounding of lexical roots and stems is typically not stratal but prosodic compounding (see (12) above).

The second alleged looping construction in Turkish is in fact **compounding** which may occur inside and outside of a number of affixes. However, Inkelas and Orgun's argument that this necessarily instantiates a loop is based on the assumption that the specific stress patterns associated with compounding must be captured by assigning to this construction its own cophonology and stratum. Adopting instead the PWord heuristics we expect that the prosody of compounds can be derived purely by invoking prosodic structure, not by a separate stratum. The structural flexibility of compounding in Turkish would then simply make it a dual-level construction which may apply in different strata. The same seems to be true for the third construction in Turkish Inkelas & Orgun adduce as evidence for the loop, the **Sezer stress** pattern which assigns weight-sensitive stress to the antepenultimate syllable of a base if this is heavy and the penultimate light, but penultimate stress if penultimate and antepenultimate have the same weight (both light or both heavy). Inkelas and Orgun without argument posit that the Sezer

construction must constitute an independent stratum, but a representational prosodic solution doesn't seem implausible. The Sezer morpheme might be analyzed as a trochaic suffix head foot with a heavy (bimoraic) first syllable. Its morphological specification thus thwarts the regular iambic (word-final) stress pattern otherwise observed in Turkish.

By default the foot appears in rightmost position resulting in penultima stress. The foot may however shift one syllable to the left (but no more) to match its moraic prespecification resulting in antepenultimate stress if the penultimate syllable is light. Under, this analysis again the positional versatility of the Sezer construction would not derive from the

So far, the evidence for loops we have discussed center around affixation and compounding. A third type of argument for the loop centers around clitics. The most detailed argument to this effect is developed in Hualde (1988, 1989) on Basque dialects. The most interesting pattern is the Ondarroa dialect. Here, final /a/ raises to [e] if the last stem vowel is high (209):

(209) *Ondarroa Basque: Vowel Raising on suffixes (Hualde 1989:675)*

a.	/giʃon-a/	→	[giʃon-a]	'the man'
	/lagun-a/	→	[laɣun-e]	'the friend'
b.	/pelota-ka/	→	[pelotaka]	'throwing a ball'
	/ari-ka/	→	[arik-e]	'throwing stones'
c.	/bat-na/	→	[bana]	'one by one'
	/bi-na/	→	[biɲe]	'two by two'

However, /a/-raising only applies if /a/ is not followed by any phonological material which is part of the same affix (210) or a following suffix (211):

(210) *Ondarroa Basque: No vowel Raising on suffixes if [a] is non-final (Hualde 1989:676)*

		Abs. sing.	Abs. pl	
a.	/uɾ/	[uɾ-e]	[uɾ-ak]	'water'
	/lagun/	[laɣun-e]	[laɣun-ak]	'friend'
	/mutil/	[mutiʎ-e]	[mutiʎ-ak]	'boy'
	/cakur/	[cakur-e]	[cakur-ak]	'dog'
	/mendi/	[mendi-ʃ-e]	[mendi-ʃ-ak]	'mountain'
b.	/giʃon/	[giʃon-a]	[giʃon-ak]	'man'
	/plateɾ/	[plateɾ-a]	[plateɾ-ak]	'dish'
	/ar/	[ar-a]	[ar-ak]	'worm'

(211) *No vowel Raising on suffixes if [a] is non-final* (Hualde 1989:677)

a.	/mutil-a/	[mutiʎe]	'the boy'
	/mutil-a-k/	[mutiʎak]	'the boys'
b.	/ondaru-ɾa/	[ondaruɾe]	'to Ondarroa'
.	/ondaru-ɾa-ko/	[ondaruɾako]	'bound for Ondarroa'
c.	/bin-a/	[biɲe]	'two for each'
	/bin-a-ka/	[biɲaka]	'two by two'
d.	/ari-ka/	[arike]	'throwing stones'
	/ari-ka-da/	[arikaɾa]	'throwing of a stone'

Crucially, clitics such as the copula also undergo raising (212):

(212) *Clitics undergo raising* (Hualde 1989:679)

a. /buru-a da/ → [burure] 'it is the head'
   head-DEF COP
b. /baso-a da/ → [basure] 'it is the forest'
   forest-DEF COP
c. /etʃe-a da/ → [etʃire] 'it is the house'
   house-DEF COP
d. /alaba-a da/ → [alaβire] 'it is the daughter'
   daughter-DEF COP

However, clitics still behave differently from true affixes in that they in turn don't block raising of preceding affixes:

(213) *Clitics don't count for finality (Hualde 1989:678)*

a. /lagun-a da/ → [laɣunera] 'it is the friend'
   friend-DEF COP
b. /mendi-a da/ → [mendiʃera] 'it is the mountain'
   mountain-DEF COP

Hualde interprets this as evidence for a loop from the phrase level to the Stem Level. This derives that they undergo the same phonology but in a different cycle.

However, positing the loop would be in principle unnecessary if the Basque clitics are analyzed as edge affixes (see section 1.2.5). This would directly account for the fact that they undergo the same phonology as in (212). That clitics initiate a second cycle could be derived by assigning them to the Word Level, whereas other affixes are Stem Level under the assumption that raising applies at both levels.

Note also that Hualde's argument is slightly different than other arguments for the loop. Hualde's argument for the loop doesn't allow for recursion: inflectional affixes don't occur outside of clitics.

There is a much broader literature on the loop as a morphosyntactic problem. Thus in many languages apparently at least some types of syntactic phrases may occur as the non-heads of compounds (e.g. English *Don't you dare! look*, Bruening 2018:3) or form the basis of zero derivations (e,g., *this is too last year to wear*, where *last year* functions as an adjective), or affixal derivation (e.g., ex-secretary of the interior). See Pafel (2017) for an overview of literature on phrasal compounds, Bruening (2018) for critical discussion of the broader set of phenomena, and Bermúdez-Otero (2016) for detailed arguments that apparent bracketing paradoxes such as *baroque flautist* and *modern hispanist* do not involve a loop from syntax to the lexicon/morphology. I don't discuss this literature in any detail here because most of it is strictly concerned with the interaction of morphology and syntax, and hardly touches on the role of phonology.

A case with relatively detailed discussion of phonology is prefixal word-formation based on syntactic phrases in Yoruba in the description of Pulleyblank & Akinlabi (1988). Thus the prefix a- 'attaches to a verb phrase to form an agentive nominal that means 'the person or thing which performs the action of X' (X, the particular verb phrase)" (Pulleyblank & Akinlabi 1988:142)

(214) *Yoruba Phrasal Nominalizations (Pulleyblank & Akinlabi 1988:143)*

a.	ā	+	sɛ̄				→	ā-sɛ̄	'strainer'
	AG		strain						
b.	ā	+	pā	+	ènìjàn		→	āpànìjàn	'killer, murderer'
	AG		kill		people				
c.	ā	+	pā	+	ɔ̄mɔ̄-ní	+ ɛ̄kún	→	āpāmɔ̄lɛ́kún	'one who makes a child cry'
	AG		make		child-OBL	cry			

Phrasal nominalization apparently interacts with two phonological processes. Vowel elision deletes the first or second vowel under hiatus (/ra + ògèdɛ̀/ → [/rɔ̀gèdɛ̀] 'buy bananas' and /fɔ + asɔ/ → [/fɔsɔ] 'wash clothes') depending on vowel quality and morphological factors. Low Tone deletion turns the L-tone of a verb into Mid if the verb is followed by an object:

(215) *Yoruba Low tone deletion (Pulleyblank & Akinlabi 1988:162)*

a.	rà	bàtà	→	rā bàtà	'buy shoes'
b.	kù	díɛ̀	→	kū díɛ̀	'it remains a little'
c.	gbà	ēwè	→	gbēwè	'take/accept leaves'

The crucial data are then nominalizations of V+object phrases where the verb has a Mid and a final vowel and hence undergoes M-Deletion and V-deletion

(216) *Yoruba Phrasal Nominalizations: L-Deletion and V-deletion (Pulleyblank & Akinlabi 1988:163)*

a.	a	+	lɔ̀	+	ātā	→	ālɔ̄tā	'person who grinds pepper'
	AG		grind		pepper			
b.	a	+	gbà	+	īpɔ̀	→	āgbīpò	'successor'
	AG		take		employment			

The argument builds on the fact that L and H tones are generally preserved by reassociation to another syllable if vowels are deleted, e.g. /sin (M) + òkú (LH)/ → [sìnkú (LH)] (Akinlabi & Liberman 1995:43).

Because this does not happen in (216), Pulleyblank & Akinlabi conclude that L-deletion must precede V-deletion. Since so Pulleyblank & Akinlabi, L-deletion is a Phrase-Level process and obligatory vowel elision only applies word-internally, word-level phonology must apply after phrase level phonology resulting in a loop.

(217) *Empirical arguments for the Loop*

Mohanan (1986) Halle & Mohanan (1985)	Malayalam English	Compounding
Hargus (1988) Inkelas & Orgun (1995)	Sekani Turkish	Compounding & Affixation
Hualde (1989) Clark (1990)	Basque Igbo	Clitics
(Goldsmith & Sabimana 1989 (Szpyra 1989	Kirundi) Polish)	

2.4.2 The Affix Ordering Generalization

I will use "Affix Ordering Generalization" here in the more general sense (not with specific reference to specific classes of derivational affixes in English), but referring to the general claim that in stratal analyses Stem-Level affixes should appear inside of Word-Level affixes.

It is difficult to quantify the evidence for and against the affix ordering generalization. The same language might involve both. I am listing here the cases known to me, and will discuss some of the evidence against the generalization below.

(218) *Empirical Evidence for the Affix Ordering Generalization*

Aingae		prestressing	Dąbkowski (2021)
Albanian	derivation vs. inflection	stress	Trommer (2013a)
Arabic	Subject agreement vs. object clitics	Stress	Kiparsky (2000)
Armenian	Derivation vs. inflection	vowel/diphthong reduction/deletion	Dolatian (2020b)
Catalan	Affixes vs. pronominal clitics	V-epenthesis	Bonet & Lloret (2005)
Cherokee	Stem vs. Word affixes	H-tone	Uchihara (2013)
Chumash		vowel harmony	Applegate (1972)
Dagaare	suffixes vs. enclitics	H-dissimilation and downstep	Anttila & Bodomo (2023)
Choktaw	inner vs. outer affixes	Rhythmic lengthening	Ulrich (1986)
Dakota	affixes vs. enclitics	Stress	Shaw (1980)
English	Level 1 vs. Level 2 affixes	stress nasal place assimilation	Kiparsky (2020)
Eton	suffixes vs. enclitics	H-spreading, downstep	van de Velde (2008)
Gaahmg	Affixes vs. Clitics	Gliding+Tone	Stirtz (2011) Trommer (2024b)
Guébie	affixes vs. enclitics	vowel harmony + tone	Sande (2017)
Huave	"Cyclic" vs. "non-cyclic" affixes		(Noyer 2013)
Karimojong	inner vs. outer verbal suffixes	vowel harmony	Lesley-Neuman (2012)
Kashaya		Stress	Buckley (1994a)
Kinande	(Macro-)Stem vs. Word	H-dissimilation	Mutaka (1994), Jones (2014)
Korean	consonant cluster simplification	nominal vs. verbal affixes	Yun (2009)
Kuria	(Macro-)stem vs. word	Floating tone association	Trommer (2024a)
Latin	Suffixes vs. enclitics	Stress	Halle & Kenstowicz (1991)
Malayalam	Derivation vs. inflection	Stress, gemination??	Mohanan (1986)
Manam	Suffixes vs. enclitics	Stress	Halle & Kenstowicz (1991)
Moses Columbian Salish	lexical vs. grammatical suffixes	Czaykowska-Higgins (1993)	
Nez Perce??			
Nuuchahnulth	lexical vs. grammatical suffixes	reduplication, ʔ-deletion glottalization,delabialization	Stonham (2007)
Rarámuri	Inner vs. peripheral suffixes	Stress	Caballero (2008)
Sekani		tone deletion, hiatus resolution	Hargus (1988)
Shona	(Macro-)stem vs. word affixes	H-dissimilation and spreading	Myers (1987, 1997)
Tetsǫ́t'iné		stress, tone	Jaker & Kiparsky (2020)
Turkish	inner vs. outer suffixes	velar drop, prosodic minimality	Inkelas & Orgun (1995)
Vedic		Accent	Kiparsky (1982c) Halle & Mohanan (1985)
Finnish	Consonant gradation	Kiparsky (2003)	
Warlpiri	inner verbal affixes vs. outer verbal and nominal suffixes	vowel harmony	
Yidiɲ	derivation vs. inflection	consonant deletion, affix order	

(219) *Empirical Evidence against the Affix Ordering Generalization*

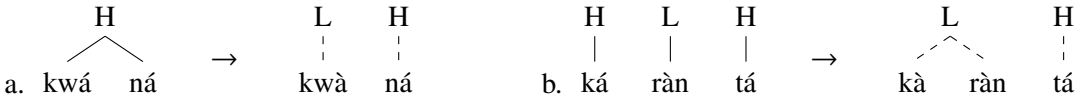
English	Aronoff & Sridhar (1983), Fabb (1988)	
Hausa	Inkelas (1998)	
Moses Columbian Salish	Accent assignment	Czaykowska-Higgins (1993)
Rarámuri	Accent assignment	Caballero (2008)
Kannada	Aronoff & Sridhar (1983)	
Turkish	Inkelas & Orgun (1998), Orgun (1996)	
Seri	Cole (1986)	
Karimojong	Lesley-Neuman (2012)	

There is a vast literature on the affix ordering generalization in **English**. Whereas there is a broad consensus that Fabb (1988) shows that it is empirically wrong, Kiparsky maintains in recent work that it is generally correct, and apparent exceptions have principled explanations, namely dual-level affixes such as -able, and combinations of affixes which have developed into single affixes (e.g. -ist-ic → -istic, A phenomenon called potentiation). See Kiparsky (2020) for detailed discussion. See Stump (2017) for independent evidence for potentiation in English. Here, I will focus on the evidence against the Affix Ordering Generalization from languages outside English. I will also set aside the arguments of Inkelas & Orgun (1995) against the affix ordering generalization based on Turkish which have already been discussed in section 2.4.1 on the loop.

The most dramatic arguments against the Affix Ordering generalization are based on two detailed cases from Hausa (Inkelas 1998) and Moses Columbian Salish (Czaykowska-Higgins 1993).

In **Hausa**, there is a well-documented tonal difference between affixes (Newman 1986). 'tone-non-integrating' suffixes simply add their tone to the right of the base tone. Thus in verbal nouns, the sequence Low-High is additively suffixed (in addition to the segmental suffix -[wa]), e.g. /káràntaː + waLH/ → [káràntáː-wá] 'reading', Inkelas & Zoll 2007:146). On the other hand, 'tone-integrating' suffixes completely overwrite (replace) the base tone with their specified tone melody. For example, the Imperative has the same characteristic tone as verbal nouns, but imposes this on verbs of any underlying tone (e.g. /kwáːná/ → [kwàːná] 'spend the night!', /káràntáː/ → [kàràntáː] 'read!', Newman 2000:262-263):

(220)



Inkelas (1998) argues that this dichotomy of affixes is parallel to Vedic (see section 1.4.1), where Stem-Level affixes overwrite the accents of their bases whereas Word-Level affixes don't; both types are associated to different cophonologies. But in contrast to Vedic, in Hausa 'tone-integrating' affix may either follow or precede 'tone-non-integrating' ones. Hence the Affix Ordering Generalization is proven wrong.

However, this argument depends on the assumption that the difference in tonal (non)-overwriting must be captured by Cophonologies. Trommer (2021) shows in a detailed reanalysis of the Hausa data that the tonal difference between affixes can also be captured representationally. Non-integrating affixes have suffixal tone (e.g. -LH in Verbal Noun formation), and integrating affixes have tonal circumfixes (e.g., L- -H for the Imperative), a phenomenon widely attested in African tone languages (see e.g. the Tiv Habitual 1 discussed in section 1.2.3). Overwriting then follows from a general Contiguity constraint which requires that no overt tones may occur between two tones affiliated to the same morpheme.

Also the argument by Czaykowska-Higgins (1993) against the Affix Ordering Generalization based on **Moses Columbian Salish** seems to be open to a reanalysis in representational terms. Czaykowska-Higgins (1993) shows that the lexical accent system of the language in addition to accented and unaccented affixes also has an orthogonal difference between dominant and recessive suffixes. As Inkelas she interprets this difference in parallel to the Vedic accent systems and shows that dominant suffixes may either follow or precede recessive ones.

Strikingly, for other morphophonological properties, Moses Columbian Salish seems to exhibit a layered structure based on lexical vs. grammatical suffixes much in the way of Nuuchahnulth (see section 1). The free interspersing of dominant and recessive affixes seems to happen only at what seems to be the Word Level of this structure. Trommer (2023a) shows that the difference between dominant and recessive Word-Level affixes corresponds to an independent difference. Moses Columbian Salish obligatorily deletes unstressed vowels after the stressed syllable. Thus vowels of recessive suffixes alternate with zero depending on the surface position of stress. On the other hand, dominant suffixes never undergo post-tonic vowel deletion. Trommer translates this distinction in one between full vowels (dominant suffixes) and defective/moraless ghost vowels (recessive suffixes). Based on this assumption the different behavior of both suffix types can be captured in purely phonological terms: In contrast to ghost vowels, Full vowels are protected by an undominated faithfulness constraint thus the rightmost full vowel attract stress in order to avoid vowel deletion in accord with obligatory deletion of vowels in posttonic position.

Representational strength of vowels might also account for the **Seri** data adduced by Cole (1986) against the Affix Ordering Generalization. Cole shows that most lexical processes are triggered by inner – mood and negation – prefixes, but not by outer – agreement and directional – prefixes. However, whether a vowel is deleted under hiatus before another vowel doesn't correspond to linear order. Whereas Mood prefixes, one of the directional prefixes and several oblique agreement prefixes undergo the process the prefixes marking subject and object agreement for 1st and 2nd person are immune to deletion.

(221) *Seri: Application of phonological processes (Cole 1986:151)*

Vowel deletion	+	+			+	+	
o-epenthesis	??	(n.a.)			+	+	
i-deletion					+	+	
	Oblique	Directional	Object	Subject	Mood	Negation	Verb Root

The aberrant behavior of left-vowel deletion would however directly fall out if vowel deletion is not determined by stratal affiliation, but by strength: Weak vowels delete under hiatus, strong vowels are kept.[49] Again the representational difference invoked here is independently motivated by the behavior of ghost vowels in many other languages (see Rubach 2013 on Slavic yers, Dolatian 2022 on Armenian and Zimmermann 2019 on Catalan and Mohawk).

[49]Cole provides a second argument against the Affix Ordering Generalization based on the 3rd person object prefix [i]-. Cole claims that [i]- triggers a rule of post-vocalic Low-vowel deletion otherwise only found with inner prefixes, but precedes subject agreement prefixes which don't trigger the process. Whereas the statement of the different phonological behavior of these affixes can be verified with Cole's empirical source, Marlett (1981), the statement that 3O [i]- linearly precedes subject agreement seems to be wrong due to an erroneous assumption by Cole that [i]- is linearly ordered as other object markers. However, in fact, [i]- follows nominalizing [k]- as in (a), whereas other object prefixes such as 2pl [masi]- precede it (b). On the other hand, in most paradigms, [i]- doesn't cooccur with overt subject markers since it is restricted to clauses with a 3rd person subject which is zero marked. In the only context where [i]- and non-null subject agreement are found in a single form in what Marlett calls 'hybrid nominalizations', subject agreement precedes [i]- (c,d):

a.	/k-i-ap/ NOM-3OBJ-sew	→ Short Low V-Deletion	[kip]	'who is sewing it'	(Cole 1986:155)
b.	/masi-k-noptotka-ʔa/ 2PLOBJ-NOM-hit-DECL	→	[masiknoptotkaʔa]	'we are hitting you'	(Cole 1986:155) (Marlett 1981:34)
c.	/ʔ-k-i-aʔit/ NOM-3OBJ-eat	→	[iʔkiʔit]	'I ate it'	(Marlett 1981:64)
d.	/ma-k-i-aitox/ S2PL-NOM-3OBJ-eat.PL	→	[makitox]	'you (pl.) ate it'	(Marlett 1981:64)

3Obj [i]- can therefore straightforwardly be considered an inner affix patterning phonologically with other inner affixes, perfectly in accordance with the Affix Ordering Generalization.

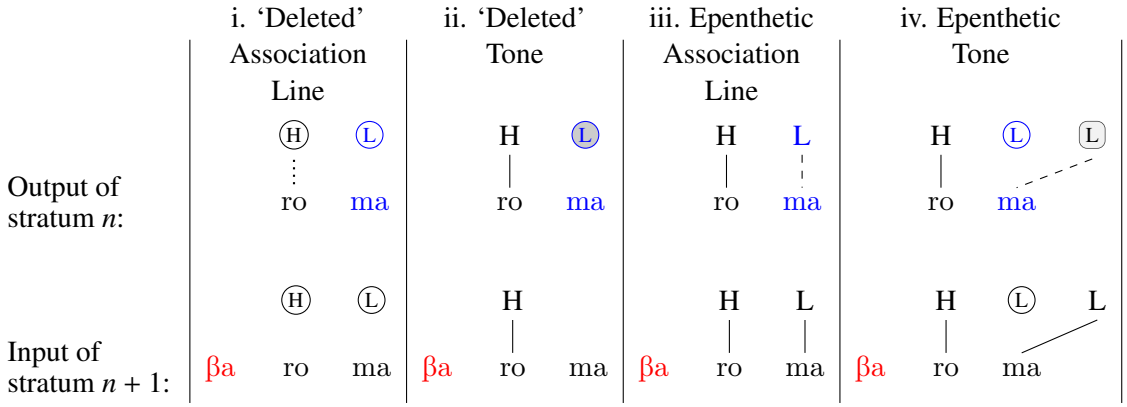
2.5 *The Nature of Bracket Erasure*

Bracket Erasure was originally conceived as a general mechanism which affects both morphosyntax and phonology. Thus it would ensure one of the basic tenets of lexicalist approaches to the morphology-syntax interface, the invisibility of morphological structure to syntactic operations such as movement.

In contrast, current approaches to Bracket Erasure treat it as a purely phonological phenomenon. Thus Bermúdez-Otero (2012): shows that Bracket Erasure can be derived in a Correspondence-theoretic version of Stratal OT from a simple assumption of the Generator function GEN, which in OT specifies the set of possible outputs in optimization processes. If GEN in phonological optimization is restricted to outputs which only contains material of a strictly phonological nature, any morphological information still present/accessible in the input will be lost at the transition from one stratum to the next. Crucially this way of capturing BE does not affect morphological structure itself, but only phonological representations.

The same also holds for the process of Monochromization in Colored Containment Theory (Trommer 2011, Paschen 2021, Trommer 2024a) which assigns all material which has undergone joint evaluation at a given stratum S_n the same color at the transition to the following stratum S_1. This is illustrated in (222) with a hypothetical example from Trommer 2024a, where an affix [ma] is added to a root [ro] at stratum n carrying different colors. At the following stratum $n + 1$ both acquire the same color, but are still distinguished in color from the prefix βa- which is added at $n + 1$:

(222) *Monochromization ("Bracket Erasure") and Clean-up between strata (Trommer 2024a)*



Since color in Containment Theory is conceived as a phonological entity (although ultimately derived from proper morphological affiliation), again this type of Bracket Erasure doesn't affect morphological representations.

The monochromization approach also nicely illustrate that Bracket Erasure might extend beyond brackets, like the information that a floating tone and a TBU belong to the same morpheme or not, a state of affairs which cannot be easily captured by bracket notation. Similarly Bracket Erasure is typically thought to make inaccessible any information triggering morpheme-specific phonology such as morphological indices or exception features (Mohanan 1986).

In terms of domains, there are three basic possibilities how BE might be implemented illustrated in (223) with the phrase *these calamities*. Conceptually, the most simple and approach (equivalent to BE in SPE, see footnote 3) would be to erase all even the outermost brackets from previous strata (223-a). However, this has hardly ever been adopted in practice since it wouldn't allow to state the fact that a given process does only apply across a lower boundary. Phrasal processes are often restricted to word edges, and many lexical processes apply only across a boundary at their stratal level (see section 4.2 on a discussion of the extensive empirical evidence for this phenomenon). This situation is compatible with the weaker versions of BE in (223-b,c), but not with (223-a). The crucial difference between (223-b) and (223-c) is that (223-b) preserves the information which internal constituent has undergone a previous stratum:

(223)

	Stem Level	Word Level	Phrase Level
a. Strong Bracket Erasure:	$[\text{calamity}]_{\text{Stem}}$	$[\text{calamitys}]_{\text{Word}}$	$[\text{these calamities}]_{\text{Utterance}}$
b. Weak Bracket Erasure:	$[[\text{calam}]_{\text{Stem}}\text{-}[\text{ity}]_{\text{Aff}}]_{\text{Stem}}$	$[[\text{calamity}]_{\text{Stem}}\ [\text{s}]_{\text{Aff}}]_{\text{Word}}$	$[[\text{these}]_{\text{Word}}\ [\text{calamities}]_{\text{Word}}]$
c. Intermediate Version:	$[[\text{calam}]\text{-}[\text{ity}]]_{\text{Stem}}$	$[[\text{calamity}][\text{s}]]_{\text{Word}}$	[[these][calamities]]

A further potential distinction between versions of BE is whether it applies at the end of every cycle in a give stratum or only at the end of the stratum itself. The first position originally proposed by Pesetsky (1979) is only rarely advocated in the stratal literature. [50] See Jones (2014:180): for a possible argument based on Kinande tone morphology. This parameter of course becomes vacuous if strata are conceived as generally lacking internal cycles as proposed by Bermúdez-Otero (2012) (see section 2.3).

I will shortly discuss here some of the more innocuous problems for BE from the literature, and turn to the more dramatic problems in section 3.1.

2.5.1 Visibility of boundaries on later strata

The literature contains significantly few and heterogeneous arguments against the phonological version of Bracket Erasure.[51] Inkelas (2014) cites Bantu tone melodies as a case in point. In many Bantu languages TAM is marked by prefixes in what is standardly assumed an outer domain and tone melodies on stem domains even though TAM prefixes and stems may be separated by other affixes such as object markers. Thus it appears that the prefix trigger a tonal change on a domain. However tone melodies are not phonological processes, but morphological exponence. Thus a more natural approach would be to posit that these are cases of multiple exponence: The same TAM categories are expressed by ton al markers at the Stem Level and independently by segmental prefixes at the Word Level.

Kiparsky (2023) argues for violations of BE in Karimojong based on work by Lesley-Neuman (2012) based on the claim of an 'introfixation' pattern where suffixes of a higher stratum are linearized preceding a suffixes of a lower stratum. This in Kiparsky's account captures the fact that the 'introfixing' suffixes do not participate in vowel harmony even when there is harmony between the stem preceding and the suffixes following them. Introfixation of this type would require abandoning morphological BE.

Shaw (2008) argues against BE based on data from stress in Musqueam (Salish). Her claim is based on the observation that left-alignment of predictable stress in Musqueam involves three different domains. The lexical root (in Shaw's terms: the MRoot) the morphological stem (MStem, the lexical root plus reduplicative prefixes) and the morphological word (MWord) containing in addition further non-reduplicative prefixes. MWord prefixes are never part of the stress domain. On the other hand, the asymmetry between the MRoot and the MStem domain are more contingent on phonological properties. In most contexts, footing and stress seems to involve only the lexical root and suffixes, but in specific phonological constellations they extend to MStem prefixes. In Shaw's analysis, this naturally follows from a parallel OT-evaluation which can simultaneously access all three boundaries (MRoot, MStem and MWord). However in a theory using strata and independent prosodic domains, this conclusion is by no means necessary. We might assume that stress is exclusively computed at the Stem Level that MWord prefixes are Word Level, and that the Word Level phonology cannot shift stress leftwards. The domain effects between Mroot and MStem would then be captured by the fact that there is a PWord boundary between prefixes and the root in line with the PWord Heuristics formulated in section 1.2.2.[52]

[50] See Orgun & Inkelas (2002) for arguments for this position in a Cophonology approach which also embraces the strong interpretation of BE in (223)-a. However, in classical Cophonology Theory, strata and cycles are basically coextensive.

[51] Cole (1986) provides an impressionistic argument against BE based on a process of [i]-deletion in Seri, but since the stratal structure of Seri is at best uncertain (see section 2.4.2 for discussion), it is unclear whether the process and the morphosyntactic information to which it is sensitive are really located in different strata.

[52] To be sure, the PWord Heuristics doesn't exclude stratal differences between different classes of prefixes. Note further that the differences between PStem and PWord prefixes might also be related to the fact that the former class are reduplicative and the latter ones strictly segmental.

Some of the most detailed arguments for relaxing BE come again from Athabaskan languages. Thus Hargus (1985) argue that several segmental processes in Sekani which she locates at later strata (3 and 4) make reference to the (stem) boundary of stratum 1 (see Jaker & Kiparsky (2020) for a similar argument based on Tetsǫ́t'iné). Strikingly again most of these arguments depend on the extremely articulated stratal structure assumed for these languages. Thus, as Hargus acknowledges, if it could be shown that less strata are necessary, this would concomitantly also obviate the violations of BE (Hargus explicitly discusses this for the possibility to collapse her level 2 and 3). See section 2.4.1 for an argument that one of Hargus' case studies, Sekani suffix vowel deletion should be captured in an analysis with less strata in line with standard BE. The same point also seems to extend to the BE problem Hargus attests for Continuant Voicing.

Note finally an often overlooked mitigation of BE. BE deletes morphological information, but not phonological representations. Thus phonologically defective morphemes such as affixes consisting of floating tones can be inherited from one stratum to the next. Similarly the prosodic structure built at a given stratum *n* will often be inherited to subsequent strata. Since the construction of prosody typically involves sensitivity to morphosyntactic boundaries (e.g. prefix-root boundaries), this amounts to a partial recoverability of morphological structure at subsequent strata. These possibilities will be the basis of the argument in the following section that also the most serious objections against BE raised in the literature can be captured in a principled modular way.

In a stratal architecture, a potential problem for BE also emerges if phonetic interpretation is sensitive to word-internal morphological boundaries. This is in principle unexpected since phonetic interpretation is assumed to strictly follow Phrase-Level phonology, and Phrase-Level Phonology follows Word Level Phonology under BE. A case in point is the finding by Sugahara & Turk (2009) that the duration of stems in forms with Scottish English word-level affixes (e.g. *ax-es*) is significantly shorter than the portion of homophonous monomorphemic items (e.g. *axis*). However, Bermúdez-Otero (2011) shows that the explanation of this fact by Sugahara & Turk is fully compatible with BE: Affixed and monomorphemic forms have different prosodic representations. In the proposal by Bermúdez-Otero, *axis* would have an exhaustive bisyllabic foot $([\text{a.xis}]_{\text{Ft}})_{\text{PWord}}$, but *ax-es* a monosyllabic initial foot with a second syllable directly attached to the prosodic word $([\text{a}]_{\text{Ft}}.\text{xis})_{\text{PWord}}$. The phonetic interpretation is sensitive to this difference not to the morphological structure itself. In principle, the same type of account by different prosodic representations might also explain the findings by Plag et al. (2017) that different s-morphemes in English have different relative durations, where 3sg-*s* and plural-*s* differ from the short clitic variants of *has* and -*s* and both differ from Genitive-*s* (see Plag et al. for critical discussion).

2.5.2 Visibility of morpheme (type)s on later strata

It is important to note that there are many cases in the literature where specific roots show a distinctive phonological behavior in Phrase-Level phonology which might be construed as violations of BE, but standardly interpreted as triggered by defective phonological representations.

One of the most detailed and prominent cases in the literature is tone in the Bantu language Kikuyu, introduced by the classical work of Clements and Ford (see Gjersøe 2015 for recent instrumental confirmation of Clements and Ford's fieldwork). In Kikuyu, specific nouns in (such as LLH /kàŋɛ̀rí/ in (224-b)) trigger tonal downstep on following words, while other nouns with the same tonal shape (e.g. LLH /ɣàkìrí/ in (224-a)) don't.

(224) *Kikuyu downstep in subject + verb (Clements & Ford, 1981:321)*

a. ɣàkìrí ɔ́-nír-ɛ́ 'Gakiri saw' b. kàŋɛ̀rí ɔ́-↓nír-ɛ́ 'Kangeri saw'

In a cophonology or indexed constraint analysis, this could be interpreted as lexically specific phonology violating BE since the phrasal phonology must distinguish the lexical roots Gakiri and Kangeri, information which should be unavailable at the Phrase Level by BE. To my knowledge no one has ever proposed this kind of analysis for the Kikuyu data. Clements & Ford (1981) argue for a much simpler analysis where downstepping is a consequence of lexemes carrying floating tones which directly trigger

the observed downstep phonologically. Independent motivation for this analysis comes from the fact that nouns triggering downstep also block another Phrase-Level process of utterance-final lowering.

This is of course in line with the Indirect Reference assumption adopted here, where there should be no morpheme-specific phonology in the technical sense whether conform to BE or violating it. In fact, the Kikuyu data are closely parallel to the Tiv pattern discussed above in section 1.2.3. Similar examples from tone languages are extensively documented in the literature (see, e.g., Hyman 1979 on Aghem, McKendry 2013 on Mixtec, McPherson 2016 on Awa, and Rolle 2021 on Izon), but there are also well-known cases related to length and segments. *Radoppiamento Fonosintattico* (=RS) in Italian dialects, word-initial gemination which is partially triggered by phonological factors but in many cases also by an arbitrary set of function words.[53] Thus in Tuscan, the preposition /a/ triggers gemination on following nouns (225-d) whereas neither the preposition /in/ (225-b) nor the minimally different definite article /la/ (225-c) do. Note that initial /k/ undergoes intervocalic lenition in (225-c) as other singleton plosives do.

(225) *Root-to-word length mutation: Italian Radoppiamento Fonosintattico (Amato 2019)*

a. kasa → ˈkaːsa ‘house’ c. la kasa → laˈxaːsa ‘the house’

b. in kasa → iŋˈkaːsa ‘in the house’ d. a kasa → aˈ**kː**aːsa ‘at home’

Again, classical analyses don’t interpret this as lexeme-specific Phrase-Level phonology, but as defective structure on the triggering morphemes (a floating mora or X-slot, Clements & Keyser (1983), Passino (2013), van Oostendorp (2015), Bonet et al. (2018)).

Wolf (2008a:411) adduces final obstruent devoicing in Turkish as a possible example. He argues that the process at least in some varieties must be Phrase Level since it can be circumvented by resyllabification as in [sarap aldi] ~ [sarab aldi] ‘he brought’ wine. On the other hand, final devoicing in Turkish has lexical exceptions. However, if we adopt a representational approach to lexical exceptionality, the problem disappears. Thus Inkelas (1995) argues that Turkish obstruents only undergo final devoicing (and word-internal voicing) if they are underlyingly unspecified for voicing. Obstruents Fully specified for voicing don’t undergo alternations for this feature. Under this account it doesn’t matter whether final devoicing applies at the Phrase Level. If the Stem and Word Level phonology leave voicing specifications unaltered, these are computed on purely phonological information at the Phrase Level.

A representational solution might also extend to another problem for BE discussed by Wolf, the fact that the phrasal incarnation of the English Rhythm rule may have lexical exception. Thus the Rhythm rule may apply to *compléx próblem* which optionally becomes *cómplex próblem*, but not to *discréte próblem* (**díscrete próblem*.[54] A representational solution to this problem in accordance with BE is developed by Gussenhoven (1991). Gussenhoven assumes a hybrid representation of stress employing both prosodic structure (feet and prosodic words) and an accent tier, where the Rhythm Rule affects the latter representation. At the output of the Lexical phonology, *discrete* has a representation with a single final accent (dis $\overset{*}{\text{crete}}$), while *complex* has two ($\overset{*}{\text{com}}$ $\overset{*}{\text{plex}}$). The Rhythm Rule is then not shifting stress, but deleting middle accents under clash ($\overset{*}{\text{com}}$ $\overset{*}{\text{plex}}$ $\overset{*}{\text{prob}}$ lem → $\overset{*}{\text{com}}$ plex $\overset{*}{\text{prob}}$ lem). In other contexts, the fact that the second syllable of *complex* appears greater prominence than the first is accounted by Gussenhoven by the fact that it carries boundary tones.[55]

[53] Phonological RS occurs predictably after word-final stressed vowels, whereas idiosyncratic RS is triggered by items with final unstressed vowels and cannot be predicted by phonological factors (compare e.g. /a/ and /la/ in the examples).

[54] For Kaisse (1985) this pattern is not an argument against BE, but for an early phrasal stratum which has access to lexeme identity and full morphosyntactic structure. See section 2.2.1 for discussion.

[55] A variant of Gussenhoven’s account could be modeled in grid theory under the assumption that discrete has a well-formed left-prominent grid at the output of Lexical Phonology (2 gridmarks on the first, one on the second syllable), whereas *discrete* has a defective symmetric grid (2 grid marks on both syllables). Again the Rhythm Rule could be captured by deletion (e.g. of the final line-2 grid mark of *complex*), but secondary stress could be directly implemented as default deletion of the initial line-2 gridmark.

A further argument by Wolf (2008a:413) is based on Ondarroa Basque, where according to Côté (1999, 2000) word-final stops undergo several processes if they precede consonant-initial words. These processes are obviously Phrase-Level since they not only occur at word boundaries, but their frequency also depends on Phrase Level prosody.[56] The apparent violation of Bracket Erasure comes from an asymmetry between morpheme types: nominal and adjectival roots undergo (optional) a-epenthesis (226-a). Nominal modifiers (226-b) and suffixes (226-c) undergo optional deletion of the final stop. The crucial contrast is between (226-a) and (226-c) because it apparently shows that the Phrase Level phonology can still determine whether the final stop of the first word is part of a root or of an affix:

(226) *Ondarroa Basque (Côté 1999:57,Côté 2000:295)*

a. /kokot bat/	→	[kokotbat]/[kokot(a)bat]
neck one		'a/one neck'
b. /semat batel/	→	[sematbatel]/[semaØbatel]
how.many boats		'how many boats'
c. /giʃon-ak topa dau/	→	[giʃonaktopaɾau]/[giʃonaØtopaɾau]
man-ERG.SG find-PERF AUX.3SGS.3SGD		'the man has found it/him/her'

What is potentially problematic about this argument is the status of [a] in forms as (226-a). According to Côté, [a] in Ondarroa Basque is not a general epenthetic vowel, but occurs only at the right edge of nominal and adjectival roots (in other environments the epenthetic vowel is [e]), exactly the position where also the absolutive singular article suffix -[a] would show up. At the same time, Côté states that suffixal -[a] which in most dialects of Basque is only used for marking definite DP's has largely lost its semantic content and also occurs variably with indefinite nouns. A plausible interpretation of this situation is that -a in Ondarroa has eroded both morphosemantically and phonologically. Morphologically it has become a nominal theme vowel similar to the theme vowels characteristic of Romance vowels, phonologically it has become a defective ghost vowel (plausibly lacking a mora) whose realization is variable and partially dependent on the phonological context. That a can show up in (226-a), but not in (226-c) is then simply a consequence of the fact that the Word-Level morphology has added -[a] to the noun root [kokot], but not to the suffix -[ak]. Even the impossibility of consonant deletion in (226-a) may plausibly derive from the fact that there is an intervening unpronounced vowel

Wolf also takes Poser's (1990) argument that some exceptional suffixes in Japanese form independent Minor Phrases – a phrasal prosodic category from as evidence against BE. The idea behind this is apparently that a stratal architecture would have to assume an idiosyncratic phrasal rule or constraint which effects that these affixes coincide with this type of phrases. However at least in OT there doesn't seem to be any formal mechanism which would exclude that these affixes are underlyingly prespecified as Minor Phrases.[57].

Let us finally discuss two well-known phenomena from French, h-aspire and liaison, which are highly relevant for this discussion. h-aspire words are roots which phonetically start with a vowel, but

[56]Wolf (2008a:412) makes a similar argument wrt mutation in Celtic and in Mende stating that they are both sensitive to Phrase-Level prosodic structure and exhibit lexical exceptions. However if lexical exceptionality is captured by the contrast between underspecification and full specification as argued here for Turkish (see also Kim & Pulleyblank (2009b) on a a detailed analysis along these lines for several patterns of consonant mutation in Nuuchahnulth). exceptionality and the status of mutation as a Phrase-level process are not necessarily in conflict. Note also that Wolf himself (Wolf 2007) and more in detail Iosad (2012b, 2014) argue that mutation in Celtic is heterogeneous. Some patterns are word-internal morphology others Phrase Level.

[57]This raises of course the question why there are otherwise no prosodic phrases inside of words. I think that the implicit account for this fact in standard approaches to Prosodic Phonology is simply the Parsimony property of OT. Prosodic categories are erected due to correspondence constraints (of the alignment or Match type) requiring specific morphosyntactic boundaries to coincide with prosodic boundaries. Under the plausible assumption that there are correspondence constraints requiring prosodic phrases to align with syntactic phrases but no such constraints aligning them with parts of words, these would be only created in the phrasal phonology simply because words do not contain syntactic phrases an axiom of lexicalist grammar

behave phonologically as if they would start with a consonant. Thus the vowel of the definite article is maintained before consonants, but deleted before vowels (e.g. *la flatterie* vs. *l'avarice*, Selkirk & Vergnaud 1973:249). In contrast, the vowel is maintained before the h-aspire word *horde* (*la horde*, Selkirk & Vergnaud 1973:249). In the approach of Tranel (1996), this is captured by morpheme-specific alignment constraints. Thus there would be a constraint ALIGN(horde,σ) which requires that the left edge of the root coincides with the left edge of a syllable. *l'orde is then excluded because it either violates this constraint (if the l of the article becomes the onset of root-initial o) or l lacks a syllable nucleus. Again, this would violate BE since the Phrase level phonology would need access to the morphological identity of specific roots. On the other hand, many authors have argued for representational alternatives. Thus in the analysis of Clements & Keyser (1983) h-aspire words have an onset which consists of an empty consonant (a X-slot) t hat blocks elision.

Liaison consonants are word-final consonants which show up before vowel-initial words (under complex syntactic-prosodic conditions), but are deleted otherwise. e.g. the [t] in *cet accord* deleted in *ce conflit* (Selkirk & Vergnaud 1973:250) Crucially the process also depends on the specific morpheme. Thus the [t] in *net* 'clear' is never deleted (Côté 2011:2.1). One possible interpretation advanced for example in Selkirk (1972) is that the alternation is due to consonant deletion rules sensitive to lexeme-specific exception features, again a breach of BE. Alternatively man y analysis assume that lexemes like *net* have full consonants whereas liaison consonants are in some way phonologically deficient e.g. by lacking a segmental slot Clements & Keyser (1983), Tranel (1996) or a root node (Zoll 1996) or full activation (Smolensky & Goldrick 2016). Whereas the empirical situation is complex with substantial arguments for both kinds of approaches (Côté 2011), the only approach compatible to H-aspire and liaison compatible with Stratal Phonology and BE seems to be the representational one (see also Bermúdez-Otero 2018a).

(Wolf (2008a):413)

3 Problems for Stratal Models

In this section, I discuss apparent general problems for Stratal Phonology, i.e., data which seem to imply that Stratal Phonology makes wrong empirical predictions for system-immanent reasons. Section 3.1 addresses single processes which apply in domains not predicted by Stratal Phonology since they do not correspond to morphosyntactic constituents. Section 3.2 turns to the interaction of different phonological processes where the process which arguably applies earlier corresponds to a larger morphosyntactic domain, whereas stratal architectures predict the opposite ordering. Another domain-related problem is discussed in section 3.3, processes which apply in domain of variable size ('brittle domains'). Again this is not predicted by strata which (in contrast to prosodic units) are assumed to be fixed for any given language. For all these cases, I will argue that there are plausible reanalyses making use of prosodic structure and autosegmental representations. The last two subsections address problems of substantially different types, specific to Stratal OT. Section 3.4 discusses the claim that stratum-internally opacity is well-documented especially at the Phrase Level, whereas Stratal OT predicts this to be impossible (McCarthy 2007, Wolf 2008a). Here, I will argue that the evidence is relatively limited and can be captured either by autosegmental representations or reference to underlying representations in Containment Theory. A further objection specific to Stratal OT is that it also *over*generates in allowing for stratal grammars in single languages which are too different. This is addressed in section 3.5. Based on recent work by Kaplan (2024), I will claim that divergent stratal grammars are rare, but actually empirically attested.

3.1 Counter-stratal domains and Failure of Bracket Erasure

A central prediction of Stratal Phonology is that phonological processes apply in specific morphosyntactic domains. However, the combination with full prosodification at all levels modifies this prediction. Thus for the **Italian** example discussed in section 1.2.2, positing the prosodic structure $[\text{Prefix}]_{\text{pword}}$ $[\text{Root+suffixes}]_{\text{pword}}$ at the Word Level allows for restricting *s*-voicing in a way which doesn't directly correspond to any

morphosyntactic constituent. in Italian, the domain for *s*-voicing can be argued to be strictly contained in a stratal domain (the Word Level). However, there are cases for which it has been argued that there is a more problematic mismatch such that domains are partially defined by boundaries of the Stem Level and partially by boundaries of the Phrase Level. A case in point is **Kuria**, where the Remote Future is marked by a H-tone on the third mora of the stem (excluding prefixes):

(227)

c. *Remote Future μ3*	d. *Inceptive μ4*
n-to-re-[hootó́ótér-a]	to-ra-[hootoó́tér-a]
FOC-1PL-TAM-[reassure-FV]	1PL-TAM-[reassure-FV]
'we will reassure'	'we are about to reassure'

However if the stem is shorter than this the H-tone may occur on a following independent word

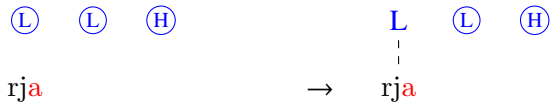
(228) *Morphological H on a following object (MMP:259)*

a. *Remote Future μ3*		b. *Inceptive μ4*	
n-to-re-[rom-a]	é ɣétɔ́ɔ́kɛ	to-ra-[rom-a]	eɣétɔ́ɔ́kɛ
FOC-1PL-TAM-[bite-FV]	banana	1PL-TAM-[bite-FV]	banana
'we will bite a banana'		'we are about to bite a banana'	

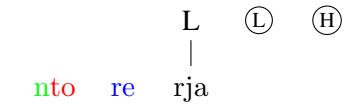
Sande et al. (2020) interpret this as evidence for a phonological process (morphologically conditioned H-tone shifting across a mora) which applies in a cyclic domain crosscutting the lexicalist division of stems words and phrases. However, Trommer (2024a) argues for an approach where the Remote Future is a morphological tone melody LLH, which associates left to right. Since floating tones can be inherited across strata, leftover tones may simply be associated at a later stratum.

(229) *Sample derivation of stratal straddling (Remote Future μ3)*

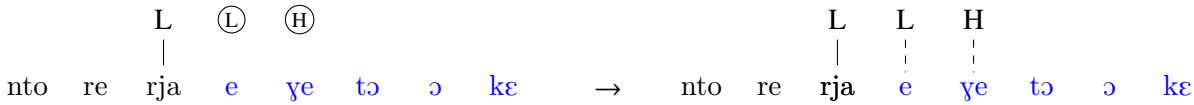
a. Stem Level:



b. Word Level:



c. Phrase Level:



See Hyman & Ngunga (1994) for an analysis in the same spirit of a simpler case in **Ciyao** where a floating morphological tone is inherited across strata.[58]

A problem which is the mirror image to the one in Kuria is vowel shortening in Kimatuumbi. Whereas in Kuria a morphophonological process apparently triggered in the stem domain applies in a phrasal domain, in Kimatuumbi there is a process which modifies the stem but is triggered by phrasal context. All stem vowels are shortened in verbs if the verb is followed by any material in the VP: Similarly, vowels in nouns are shortened whenever there is additional material in the NP:

[58] Other cases which seem to be susceptible to a representational autosegmental solution can be found in Limbum and Gã. In Gã, a phrasal tone alternation – phrase-final raising of Low tones – is sensitive to the presence of specific affixal morphemes. In Trommer (2019) this is captured by positing a floating H affiliates with the trigger affixes, which only becomes effective at the Phrase Level. In Limbum, Low boundary tones for intonational phrases only appear on specific lexical items. Gjersœet al. (2019) derive this by assuming that the boundary element is a defective register tone which can only be realized if the phrase-final syllable carries an empty tonal root node.

(230) *Kimatuumbi Construct Shortening (Odden 1993:118)*

a. ki-kóloːmbe	'cleaning shell'
b. ki-kólombe kăːngu	'my cleaning shell'
c. ki-tûːmbılı	'monkey'
d. ki-túmbılı jwaːwiːlé	'monkey who diesd'
e. naːki-twêːti	'I took it'
f. naːki-twéti ki-kóloːmbe	'I took a cleaning shell'

(231) *Kimatuumbi Construct Shortening (Odden 1996:225)*

a. naːn-kálaːngiːle	'I fried for him'
b. naːn-kálangile lı	'I didn't fry for him'
c. naːn-kálangile mambôːndo	'I fried for Mambondo'
d. naːn-kálangile jôːpáta ěːla	'I fried for him to get money'

There are several ways to understand this pattern which violate basic tenets of Stratal Phonology. Odden himself argues for a non-lexicalist model where syntax precedes phonology. Another natural interpretation is that the process applies at the Phrase Level, but Bracket Erasure hasn't applied and thus the rule can still refer to stem boundaries.

I will suggest instead a reanalysis based on unpublished work by Daniel Gleim and Ricardo Bermúdez-Otero, which combines feature percolation and the reinterpretation of shortening as nonconcatenative morphology. Assume that Kimatuumbi has a feature [+/-Combinative] which is a hybrid variant of the edge and head features discussed in section 1.2.5. More specifically, it obeys the following condition on cooccurrence and percolation, again defined over local trees in a GPSG-architecture:

(232) A non-maximal projection *P* of a lexical category has the feature value [+Combinative] iff either one or both of the following conditions hold:
(i) *P* has a right-adjacent sister node or
(ii) *P*'s mother node has the feature value [+Combinative]

Again, the morphology is essentially blind to this convention and to the corresponding syntactic representations. It simple generates [+Combinative] and [-Combinative] word forms for lexical categories. In the syntax, the conditions in (232) will then ensure that [+Combinative] forms are only used in appropriate contexts.

This leaves the question of the morphophonology of the process. In contrast to Odden, I assume that shortening is not a phonological process, but nonconcatenative morphology, namely the affixation of two moras – a moraic circumfix – expressing [+Combinative] (see Trommer 2015a on independent evidence folr moraic circumfixes from templatic lengthening in Dinka). CONTIGUITY-μ requires that no overt moras should intervene between two moras of the same morphological color (this constraint is parallel to the tonal contiguity constraint used in Trommer 2024afor tonal overwriting by circumfixes on the tonal tier) . Still higher-ranked V ▷ μ requires that every vowel should be associated to at least one mora. For a bisyllabic base, this makes it optimal to replace the underlying moras by the two circumfix moras:

(233) *Kimatuumbi Construct Shortening*

Input: = a.	*X	V ▷ μ	CONTIGUITY-μ	MAX μ
a. twe ti			*!**	
b. twe ti		*!*		
☞ c. twe ti				***

For longer bases, full contiguity of the affix moras cannot be achieved without either leaving some vowels without any moras (234-b), or without violating the constraint against line crossing (notated here simply as "X") as in (234-c). Consequently all long vowels are shorten ed to minimize violations of CONTIGUITY-μ (234-d):

(234) *Kimatuumbi Construct Shortening*

Input: = a.	*X	V ▷ μ	CONTIGUITY-μ	MAX μ
a. ka lan gi̧ le			***!***	
b. ka lan gi̧ le		*!*		
c. ka lan gi̧ le	*!*			
☞ d. ka lan gi̧ le			**	***

Note that the Kimatuumbi case is superficially similar to another famous problem for stratal architectures, **Hausa** final vowel shortening as discussed by Hayes (1990). Hayes' approach is broadly similar to the shortening is a phonological process However, Chrysmann shows convincingly that the Hausa case involves a morphological not a phonological process, where shortening is only one of the exponents in specific verb classes. Thus it seems that Hausa does not involve a straddling of morphology and syntax because all involved morphosyntax and phonology applies word-internally.

Similarly, other cases of apparent postsyntactic Bracket Erasure violations which seem to straddle lex-

icon and syntax are plausibly due to the fact that all involved processes are in fact (post-)syntactic. A case in point is Kukuya. As shown by Hyman (1987), in combinations of prefixed nouns all phonological processes apply either in the stem (the noun root) or in a string of a noun root and the following prefix (all prefixes in the data are nominal class prefixes depending on their base noun, specific nouns also lack a prefix).

(235) *Phonological domains in Kukuya (Hyman 1987)*

$$\begin{array}{cc} \{\ \text{Domain}_1\ \} & \{\ \text{Domain}_1\ \} \\ [\text{Prefix} + \text{NounRoot}] & [\text{Prefix} + \text{NounRoot}] \\ \{\qquad \text{Domain}_2 \qquad\} & \end{array}$$

Thus in Domain_2 L's are deleted between two H's. This affects the HLH configuration in (236-a) which is contained in a noun root + prefix sequence, but not in the one in (236-b) because here the initial H of the HLH configuration is in the prefix preceding the root (the initial H in (236-b) is the copular tone):

(236) *L-deletion between H-tones in Kukuya (Hyman 1987:320+321)*

a. H L H L → H L H L
tɛ mɛ lɪ:-mɛ → tɛ́mɛ́ límɛ̀
axe PREF-my

b. H L H L → H L H L
kɪ-ko kɪ:-mɛ → kíkɔ̀ kí:mɛ̀ 'it's my cloth'
PREF-cloth PREF-my

Crucially, in a stratal architecture, Domain_2 must be a postlexical domain, possibly a prosodic word because it comprises material from different words, but this means that the boundary between a prefix and its root must still be visible at this point. The solution to this dilemma Hyman considers is based on the observation that Kukuya not only exhibits rich segmental and tonal evidence for Domain_2, but also systematically lacks processes targeting the [Prefix + NounRoot] complex. One might take this as evidence that the apparent prefix is actually an independent functional element (hence syntactically a word), which obligatorily precedes nouns, but is prosodically integrated into a preceding prosodic word.

Another open question is if the percolation approach provides a solution for cases of 'pausal' morphophonology where word-level phonology seems to be sensitive to the position of a word in an utterance. These have been raised as a problem for stratal architectures by Dresher (1983) for Tiberian Hebrew and by McCarthy (2011) for Classical Arabic. Similar phenomena are also found in tonal systems. Thus in Margi (Hoffmann 1963, Pulleyblank 1986b, Tranel 1992), toneless suffixes receive a tone by spreading if the word is utterance-internal, but become Low utterance-finally. A possible percolation-based approach might be to posit a Word-Level L-tone suffix expressing the feature [Last], and only surfaces on toneless moras. Clela, Bemba

3.2 Counter-stratal process interactions

Maybe the strongest counterevidence against a stratal architecture would consist in the interaction of processes P_1 and P_2 which empirically require a serial ordering such that P_1 must precede P_2 ($P_1 \prec P_2$), but whose stratal domain implies the opposite order $P_2 \prec P_1$.

A case in point is vowel deletion and pitch accent assignment in Ondarroa Basque Hualde (1996). Default accent assignment at the Phrase Level targets the penultimate syllable of a phrase, but the penultimate position is computed in a way that it is sensitive to vowels which are deleted by a word-level process of vowel deletion. The vowel deletion process emerges in one of the most frequent Basque suffixes, the definite article suffix -a (cf. e.g. [giʃon] 'man' [giʃon-a] 'the man', [laɣun] 'friend' and [laɣun-e] 'the friend' with raising due to the preceding high vowel). In vowel-final nouns (except nouns

ending in i), the stem-final vowel is raised and the suffix vowel is deleted (e.g. [etʃe] 'house', /etʃe-a/ → [etʃi] 'the house', [baso] 'forrest', /baso-a/ → [basu] 'the forrest').

Phonological phrases without underlying accent are assigned a default accent on the penultimate syllable of a phonological phrase as shown in (237) for phrases of different length:

(237) *Phrase-level default accent (Hualde 1996:201)*

giʃón-a	'the man'
giʃón-a ra	'it is the man'
gure giʃón-antzakó ra	'it is for the man'
gure giʃón ederá ra	'it is our handsome man'

The counterstratal pattern emerges when vowel deletion interacts with default accent assignment. These words exceptionally exhibit default accent on the final, not the penultimate syllable (238-a):

(238) *Accent in underlyingly accentless words with final deleted vowel (Hualde 1996:204)*

a. Unaccented			b. Accented		
/alaba-a/	alabí(V)	'the daughter'	/∗eskola-a/	eskóli(V)	'the school'
/buru-a/	burú(V)	'the head'	/∗leku-a/	léku(V)	'the place'
/etʃe-a/	etʃí(V)	'the house'	/etʃe-∗ak/	étʃi(V)k(V)	'the houses'

The final vowel in these forms of course is the penultimate vowel of the underlying forms. Thus if default accent was assigned before vowel deletion, we would get the correct result. However this would require that a phrase-level process (accent assignment) applies before a word level-process (V-deletion), an ordering pattern inherently excluded by a stratal architecture. Thus we seem to face a stratal paradox.

Note that the data are actually also problematic in fully parallel OT which doesn't allow for process ordering. In both parallel and Stratal OT we might solve the problem if we assume that vowel deletion is incomplete, i.e. leaves a floating mora behind. Thus the input of [alabí] in the Phrase Level phonology would be as in (239-a).[59] Obl(igatory)(φ,∗) then enforces epenthesis of an accent which appears as rightmost as possible without violating NonFinality(μ). Crucially the final mora is unpronounced but still counts for positioning the epenthetic accent:

(239) *Basque accent (Phrase Level)*

[59] I assume that accents in Basque are always assigned (associated) to nucleus moras, and that there is no phonological weight distinction, hence all syllables are monomoraic.

Input: = a.		Obl(φ,∗)	Faith(∗)	NonFin(μ)	∗ →	NonFin(σ)
a.	σ σ σ | | | μ μ μ μ | a la bi	*!				
b.	σ σ σ | | | * μ μ μ μ | a la bi			*!		
☞ c.	σ σ σ | | | * μ μ μ μ | a la bi				*	*
d.	σ σ σ | | | μ * μ μ | a la bi				**!	

(240) *Constraints used in (239)*

Obl(igatory)(φ,∗)	Assign ∗ to every phonological phrase which has less than 1 accent
∗ →	Assign ∗ to every mora which intervenes between an accented mora and the right edge of a phonological phrase
Faith(∗)	Assign ∗ to every mora which is associated to an accent in the input but not in the output
NonFin(ality)(μ)	Assign ∗ to every accent which is associated to the final mora of a phonological phrase
NonFin(ality)(σ)	Assign ∗ to every accent which is associated to a mora in the final syllable of a phonological phrase

An interesting complication underlined by Hualde in his criticism of a stratal approach is that Ondarroa Basque also exhibits a penultimate effect at the Word Level: Underlying accents surface on the penultimate syllable of a word. This is shown for the accented word 'bean' in (241) (in (241-d) also [edéra] 'beautiful' has underlying accent):

(241) *Position of underlying accent (p.199)*

a. inddár-a	'the bean'
b. inddár-a ɾa	'it is the bean'
c. gure indar-antzáko ɾa	'it is for our bean'
d. gure índar edéra	'our beautiful bean'

Strikingly, as shown in accented forms with final vowel deletion (242), the penultimate position targeted here doesn't take into account the underlying vowel: (since it is unpredictable whether a morpheme has an underlying accent, but its output position is fully predictable, the position of underlying accent is systematically opaque and notated here as an asterisk preceding the morpheme which introduces it, the lexical roots in a. and b., and the plural suffix in c.):

(242) *Accent in underlyingly accentless words with final deleted vowel (Hualde 1996:204)*

a.	/∗eskola-a/	eskóli(V)	'the school'
b.	/∗leku-a/	léku(V)	'the place'
c.	/etʃe-∗ak/	étʃi(V)k(V)	'the houses'

This is intuitively unexpected because Word-level accent is derivationally closer to the underlying form than Phrase Level accent. However in the autosegmental approach taken here the floating mora is in principle available to both the output of Word Level and Phrase Level phonology. Whether it becomes actually effective depends on the constraint ranking. If we assume that at the Word Level not only Nonfinality for the last mora but also for the rightmost syllable is effective, the difference between both levels directly falls out (see Hyde 2011 for independent arguments that languages might invoke both versions of Nonfinality):

(243) *Basque accent (Word Level)*

Input: = a.	∗ ▷ μ	NonFin(μ)	NonFin(σ)	∗ →
a. σ σ | | ⊛ μ μ μ | | le ku	*!			
b. σ σ | | * μ μ μ | | le ku		*!		
c. σ σ | | * * μ μ μ | | le ku			*!	*
☞ c. σ σ | | * | μ μ μ | | le ku				**

Bedouin Hijazi Arabic: In open non-final syllables, Short high vowels are deleted:

(244) *Bedouin Hijazi Arabic i-deletion (Al-Mozainy 1981:46+149, McCarthy 2007:187)*

/kitib-t/	→	[ktíbt]	'you.MASC.SG were written'
/ti-rsil-uːn/	→	[tirslúːn]	'you.MASC.SG send'

Low short vowels become high in open non-final syllables:

(245) *Bedouin Hijazi Arabic a-raising in forms of /katab/ (Al-Mozainy 1981:58, McCarthy 2007:189)*

a.	[kí.tab]	'he wrote'
b.	[ki.tábt]	'you.MASC.SG wrote'
c.	[ki.táb.tum]	'you.MASC.PL wrote'
d.	[ki.táb.na]	'we wrote'
e.	[k.tí.bat]	'she wrote'

Note that a-raising and i-deletion are in a counterfeeding relation. [i]'s from underlying /a/ are not deleted (e.g. (245-a) doesn't become *[ktáb]). McCarthy assumes that this implies ordering of i-deletion before (on an earlier stratum) than a-raising.

An independent asymmetry between the two processes emerges if consonants in word-final closed syllables are resyllabified at the Phrase Level before vowel-initial following words. The vowel of the final opened syllable now undergoes i-deletion:

(246) *Resyllabification feeds i-deletion (Al-Mozainy 1981:50-51, McCarthy 2007:12)*

/kaːtib#al-ʒuwab/	→	[kaːt.bal-ʒu.waːb]	'writing the letter'
writing#the-letter		*[kaː.ti.bal-ʒu.waːb]	
/tiʕtˤuːnih#al-museːʕiːdi/	→	[tiʕ.tˤuːn.hal.mu.seː.ʕi.di]	'you gave it to the one of the clan of Musaīd'
		*[tiʕ.tˤuː.ni.hal.mu.seː.ʕi.di]	

However, in the same context no a-raising applies:

(247) *Resyllabification counterfeeds a-raising*

[ʔa.ba.d#alˤ.lˤah]	'he worshipped Allah'
*[ʔa.bi.d#alˤ.lˤah]	

According to McCarthy this shows that a-raising is a Word-Level, but i-deletion a Phrase-Level process. The paradox emerges by putting together this fact (a-raising stratally precedes i-deletion) with the argument that the counterfeeding between processes implies the opposite order (i-deletion stratally precedes a-raising) resulting in a contradiction.

However a straightforward **Reanalysis** in Stratal OT is worked out in detail by Gleim (2024): Counterfeeding between a-raising and i-deletion at the Word Level is not achieved by rule-ordering but by high ranking of the constraint MAX [a] which protects underlying /a/ (but not underlying /i/) from deletion. a-raising applies only at the Word Level, but [i]-deletion at both Word and Phrase Level albeit in slightly different versions. At the word level only [i] is generally deleted in open syllables. At the Phrase Level only [i] in open syllables at the end of a Prosodic Word is deleted. What about utterance-final [i]?

(248)

Word Level	/tirsiluːn/ (tirsluːn))$_{PW}$	/katab/ (kitab)$_{PW}$	/kaːtib/ (kaːtib)$_{PW}$	/ʔa.ba.d/ (ʔa.ba.d)$_{PW}$
Phrase Level	—	—	(kaːti)$_{PW}$ (balʒuwaːb)$_{PW}$	(ʔa.ba)$_{PW}$ (dalˤ.lˤah)$_{PW}$

Tigrinya: Wolf (2009) constructs a stratal paradox based on phonologically conditioned allomorphy in Tigrinya, and a phonological process of Epenthesis of [ɨ] after complex codas (/sɨʔl/ → [sɨʔlɨ] 'picture'). The first case of allomorphy is found with the plural suffix which has two variants:

(249) *Allomorphy of plural affix*

-tat after vowels
-at after consonants

Nouns like /sɨʔl/ show up with the postvocalic allomorph -tat after the epenthetic vowel which implies that the plural suffix is added after epenthesis as in (250-a) not before it (250-b):

(250) *(Wolf 2009:3)*

a.		b.	
Underlying Representation	/sɨʔl/		/sɨʔl/
Epenthesis	sɨʔlɨ	Plural suffixation	sɨʔl-at
Plural suffixation	sɨʔlɨ-tat	Epenthesis:	n/a
Surface form	[sɨʔlɨtat]		*[sɨʔl-at]

Possessive suffixes show similar suppletion depending on the final sound of the base:

(251) *Allomorphy of possessive suffixes (Wolf 2009:3)*

	singular		plural	
	after C	after V	after C	after V
1	-äj	-jäj	-na	
3 masc	-u	-ʔu	-atom	-ʔatom
3 fem	-a	-ʔa	-atän	-ʔatän

However, after words with complex codas possessives appear with the post-consonantal allomorph and without vowel epenthesis ([sɨʔl-u]/*[sɨʔlɨ-ʔu] 'his picture'). This indicates that possessive suppletion happens before (or at least simultaneously with) vowel epenthesis.

The different interaction of plural and possessive suppletion with epenthesis thus seems to imply that possessive morphology is stratally earlier than possessive suffixation, but this leads to a contradiction with the actual linear ordering of affixes where plural affixes always occur inside of possessive suffixes ([sɨʔlɨ-tat-u] 'his pictures').

Buckley (1994b) shows that a representational analysis is possible in a staged derivation where lexically consonant clusters are resolved by forming a syllable with an empty mora /sɨʔl/ → (sɨʔ)$_\sigma$(lμ)$_\sigma$). The mora is then only filled with an actual vowel postlexically (sɨʔ)$_\sigma$(lμ)$_\sigma$) → (sɨʔ)$_\sigma$(lɨ)$_\sigma$). Now both possessive and plural suffixation apply lexically after mora but before vowel epenthesis. The difference is that only possessive suppletion is strictly sensitive to final vowels vs. consonants. In contrast, the plural allomorph -tat selects for bases with a final mora that is the nucleus of a syllable (i.e. stems like (sɨʔ)$_\sigma$(lμ)$_\sigma$) or stems with underlyingly final vowels) with -at being the default allomorph. The empty mora is then again filled with a default vowel postlexically. When (sɨʔ)$_\sigma$(lμ)$_\sigma$) combines with possessive suffixes such as -u (because its last segment is a vowel), the empty mora is filled by the affix vowel.

Seenku: McPherson (2019) identifies a complex pattern of strata-straddling process interaction in the Mande language Seenku between two alternations.

Plural raising is the regular formation of plural by raising the tone on the final syllable of a noun by one step (e.g. Low to High and High to Superhigh), a bona fide word-level process. Sandhi is apparently a phrase-level process which changes a tone of a word after the tone of a preceding word in a complex heterogeneous way (sometimes lowering sometimes raising depending on the combination of the involved tones), which I will call here simply 'polarity'. If a pluralized noun precedes another word under the appropriate conditions, plural raising feeds sandhi polarity as expected (Seenku has 4 different tone levels which I will here notate with numbers such that 1 is the lowest and 4 the highest tone):

(252) *Plural raising feeds sandhi polarity (McPherson 2019:9)*

	bɛ^{1} + ni^{4}	bɛ^{1}-PL + ni^{4}
Plural Raising	—	bɛ^{2} ni^{4}
Sandhi Polarity	bɛ^{1} + ni^{1}	bɛ^{2} ni^{2}
	bɛ^{1} + ni^{1} 'pig's father'	bɛ^{2} ni^{2} 'pigs' father'

However, if a potential trigger of sandhi precedes a plural noun, it seems that sandhi polarity feeds plural raising. Thus /ce/ in (253) is apparently first lowered by Polarity and then raised by plural raising (the opposite order would incorrectly result in mo^{3} + cɛ^{3}-PL – Plural Raising → mo^{3} cɛ^{4} – Sandhi Polarity → *mo^{3} cɛ^{1}) :

(253) *Sandhi polarity feeds Plural raising*

	mo^{3} + ɲa^{3}	mo^{3} + cɛ^{3}-PL
Sandhi Polarity	mo^{3} ɲa^{1}	mo^{3} cɛ^{1}
Plural Raising	—	mo^{3} cɛ^{2}
	mo^{3} ɲa^{1} 'my mother'	mo^{3} cɛ^{2} 'my hands'

This would instantiate counter-stratal process interaction where a Phrase-Level process feeds a Word-Level process.

However, Gleim & Jolin (2024) propose a reanalysis which reconciles the data with the predictions of a stratal model. This is based on the assumption that the complex effects of the Sandhi process must actually be decomposed into two independent factors, a regular Phrase-Level assimilation process, and a lexical alternation reflecting selectional properties of the item which shows the effect of the alternation. This is motivated by the fact that whether two words undergo sandhi or not depends strongly on their syntactic relations and on morphological features such as the realis/irrealis inflection of verbs. The lexical component of Sandhi under this interpretation is thus a kind of Ezafe morphology similar to Kimatuumbi vowel shortening (see section 3.1). In a second step, Gleim & Jolin show that in forms where Sandhi seems to feed Pluralization as in (253), the contrast between sandhi and non-sandhi form is due to the lexical Ezafe process. On the other hand, in data like (252), where pluralization feeds Sandhi, Sandhi results from Phrase-Level assimilation. In both cases, the feeding relationship is fully compatible with a stratal architecture.

3.3 Brittle Phonological Domains

Stratal domains are a subset of the domains made available by morphosyntax, a property called 'Impoverishment' by Bermúdez-Otero (2007). This means that the edge of a stratal domain must be strict. It cannot be extended or shrinked under purely phonological conditions. 'Brittle' boundaries which are variable contingent on phonological properties thus pose a potential problem for Stratal Phonology. A similar problem according to Bonet & Lloret (2005) arises when phonological domain boundaries appear to be slightly off expected morphosyntactic boundaries, but not due to phonology. Thus they show that for Catalan a stratal approach would require at least a domain comprising the grammatical word and the first clitic attached to it (independently of the identity of the specific clitic which appears to be innermost). This kind of domain would thus be 'brittle' in that it doesn't strictly correspond to any well-defined morphosyntactic boundary. The central problem with the argument against strata from brittle domains is that it presupposes a version of Stratal Phonology where strata are the only phonological domains.

Marantz (1987) on reduplication in Kihehe: In Kihehe, verbal reduplication targets generally only the stem excluding prefixes (e.g., *ku-tova* INF-beat 'to beat' → *ku-tova-tova* 'to beat a bit'). However under specific phonological conditions (e.g. vowel-initial stems preceded by a glidable vowel as in (254-a)), higher prefixes are copied along:

(254) *Kihehe reduplication (Marantz 1987:203+205)*

a. /ku-ita/
INF-pour
[kwiːta] → [kwiːta-kwiːta]
'to pour' 'to pour a bit'

b. /va-kû:-n-longa/
3PL-ASP-1SG-nag
[vakûːndonga] → [vakûː-ndonga-ndonga]
'they nag me' 'they nag me a bit'

This pattern is adduced by Marantz (1987) and Newell (2019) as a Bracketing paradox problematic for Stratal Phonology. However, it would only be problematic in a version of Stratal Phonology where all morphological processes apply cyclically, or if there is a stratum boundary between the reduplicative prefix and the other prefixes. Assuming that both the reduplicative prefix and the other prefixes are Word-Level affixes, and that the Word Level doesn't have internal cycles, all material which is copied by reduplication is available simultaneously at a single level.

Buckley (2017) on Kashaya: Buckley shows that two phonological processes in Kashaya, lengthening of stressed open syllables in iambs, and 'foot 'flipping', a process where vowel length shifts from the first to the second syllable of an iamb apply only in the Stem Level of the language. Both processes require that the target syllable is open. However, while Word-Level affixes are n ever lengthened by these processes, initial consonants of Word-Level affixes might block them if they form the coda of these syllables in the overall Word form. This leads to a type of paradox. Lengthening should be Stem Level to capture its domain of application, but it should also be Word-Level to capture its domain of conditioning.

Downing & Krämer (2022) on Kinande vowel harmony: Downing & Krämer argue that in Kinande Word-Level harmony is iterative and targets vowels of any height. In contrast, Phrase-Level is generally non-iterative (applies only to one vowel preceding the trigger) and targets only high vowels. However, if word-initial consonants resyllabify in adjective+noun combinations, there is unrestricted vowel harmony across both words. This according to Downing & Krämer provides evidence for a prosodic account, where the prosodic word domain can extended under specific phonological conditions. The problem for a stratal account would be that the domain for harmony would be fixed. Crucially, this

argument presupposes a stratal model without supplementary prosodic structure. Thus a standard account where Phrasal phonology also contains prosodic words, could model the sensitivity of word-level domains to other phonological factors.

Bonet & Lloret (2005) on Catalan: The argument of Bonet & Lloret against Stratal Phonology is based on [ə]-epenthesis in pronominal clitics. Prima facie these seem to provide evidence for strata because clitics exhibit [ə]-epenthesis to repair consonant clusters which are licit inside of lexical words:

(255) *Catalan [ə]-epenthesis (Bonet & Lloret (2005):1306)*

a. /tírə#m#lə / [tí.rə.mə.lə]/*[tí.rəm.lə] 'throw it (fem.) to me!'
cf. circumloqui [sir.kum.lɔ́.ki] 'circumlocution'
fem la [fɛm.lə] 'let us do it (fem.)!'
fum lila [fum.lí.lə] 'purple smoke'

b. /uz#lə#tírə/ [u.zə.lə.tí.rə]/*[uz.lə.tí.rə] 'she throws it (fem.) to you (pl.) '
cf. islàmic [iz.lá.mik] 'Islamic'
es lamenta [əz.lə.men.tə] '(s)he complains'
cos líquid [kɔz.lí.kit] 'liquid body'

c. /nz#lə#dónə/ [ən.zə.lə.ðónə]/*[ənz.lə.ðónə] 'she gives it (fem.) to us'
cf. ens lamentem [ənz.lə.mən.tém] 'we complain'
sons laterals [sɔ́nz.lə.tə.ɾáls] 'lateral sounds'

This could be obviously be captured in a stratal account by assigning clitics to a later stratum than lexical words (and affixes proper). The problem Bonet & Lloret identify for the stratal approach is epenthesis with vowel-less pronominal clitics attaching to consonantal bases. The resulting consonant cluster is resolved by [ə]-epenthesis *outside* of the clitic for a clitic adjacent to the verb:

(256) *Catalan: External Epenthesis for Verb-adjacent clitic (Bonet & Lloret 2005:1305)*

a. /m#tírə/ [əm.tí.rə]/*[mə.tí.rə]/*[m.tí.rə] '(s)he throws to me'
b. /tirém#n / [tí.rém.nə]/*[tí.ré.mən]/*[tí.rɛmn] 'let's throw some'

On the other hand, [ə]-epenthesis targets the position inside the consonantal clitic if this is not adjacent to the verb (257-a,b). In (257-c), a medial schwa appears between two consonantal clitics satisfying both positional generalizations:

(257) *Catalan: Internal Epenthesis for **non**-verb-adjacent clitic (Bonet & Lloret 2005:1305)*

a. /m#lə#tírə/ [mə.lə.tí.rə]/*[əmlə.tí.rə]/*[mlə.tí.rə] '(s)he throws it (fem.) to me'
b. /s#t#m#lə#béw/ [sə.tə.mə.lə.béw] '(s)he drinks it (fem.) up on me and you'
c. /m#l#tírə/ [mə.l.tí.rə] '(s)he throws it (masc.) to me'
d. /tírə#m#lə/ [.tí.rə.mə.lə] 'throw it (fem.) to me!'

Taken together, it looks like the first clitic attached to a verb still partially reflects the phonology of the inner stratum (no [ə]-epenthesis), but that all further clitics belong to the higher stratum allowing for epenthesis. However, this would be a paradoxical situation for a stratal account where boundaries of strata should correspond to specific morphosyntactic boundaries.

However, these data don't seem to posit a major problem for a theory where strata are supplemented by prosodic domains. Thus we may assume that pronominal clitics in Catalan are Word-Level affixes (edge affixes in the sense of section 1.2.5) whereas more internal affixes are Stem-Level. I will assume further that prosodic words erected in the Stem-Level phonology are preserved at the Word Level resulting in recursive PWords (e.g. [m-[tirə]$_{\omega}$]$_{\omega}$). The special distribution of epenthesis at edges could then be captured by the high-ranked Contiguity constraint in (258) in Word-Level evaluations:

(258) Contiguity (Ctg) $S_{\omega\text{-min}}$ Assign $*$ to every segment S contained in a minimal PWord such that S is adjacent to some other segment S' in the input but not adjacent to S' in the output

The following tableaux show how (258) would interact with the other constraints used by Bonet & Lloret (σ-Struc is a cover constraint for the basic phonotactic regularities of Catalan deriving for example that a syllable cannot start with an [mt]- or an [ml]-sequence). Crucially, Ctg $S_{\omega\text{-min}}$ is violated by (259-b) since [t] is part of a minimal Prosodic Word, and separated from [m] (to which it iks adjacent in the input) by the epenthetic [ə]. The illicit [mt]-sequence is thus repaired by external epenthesis (259-c):

(259) *Catalan External Epenthesis*

	σ-Struc	Ctg $S_{\omega\text{-min}}$	Ons	NoCoda	Dep ə
a. [m-[tirə]$_\omega$]$_\omega$	*!				
b. [m(ə)-[tirə]$_\omega$]$_\omega$		*!			*
☞ c. [(ə)m-[tirə]$_\omega$]$_\omega$			*	*	*

On the other hand, in (260-b), epenthesis between [m] and [l] is unproblematic. Although both segments are underlyingly adjacent, neither of them is part of a minimal PWord. Thus epenthesis between the clitics doesn't violate Ctg $S_{\omega\text{-min}}$ and is favored over initial epenthesis (260-c) by Onset:

(260) *Catalan Internal Epenthesis triggered by* Onset

	σ-Struc	Ctg $S_{\omega\text{-min}}$	Ons	NoCoda	Dep ə
a. [m-lə[tirə]$_\omega$]$_\omega$	*!				
☞ b. [m(ə)lə-[tirə]$_\omega$]$_\omega$					*
c. [(ə)m-lə[tirə]$_\omega$]$_\omega$			*!	*	*

In suffixes, NoCoda will trigger epenthesis:

(261) *Catalan Internal Epenthesis triggered by* NoCoda

	σ-Struc	Ctg $S_{\omega\text{-min}}$	Ons	NoCoda	Dep ə
a. [[tirə]$_\omega$]-m-lə$_\omega$				*!	
☞ b. [[tirə]$_\omega$]-m(ə)-lə$_\omega$					*

Finally, in words without clitics, all segments are contained in the (non-recursive) minimal PWord, andd hence

(262) *Catalan Blocking of Epenthesis*

	σ-Struc	Ctg $S_{\omega\text{-min}}$	Ons	NoCoda	Dep ə
☞ a. [sir.kum.lɔ.ki]$_\omega$				*	
b. [si.r(ə).kum.lɔ.ki]$_\omega$		*!			*

3.4 Innerstratal Opacity

A central reason for the shift from Lexical Phonology to Stratal OT was the possibility to impose principled restrictions on opacity, where opacity ideally would be limited to the effects of sequential ordering between strata. Several authors have raised possible empirical problems for this approach especially from the perspective of phrasal phonology, which is typically assumed to consist only of a single postlexical stratum. Thus Kavitskaya & Staroverov (2010) claim that **Tundra Nenets** phrasal phonology exhibits an opaque interaction between the debuccalization of coronals and an apocope process which deletes /ʌ/ at the end of the word or before a word-final [ʔ], where debuccalization feeds apocope, but apocope counterfeeds debuccalization:

(263) *Opaque interaction between apocope and debuccalization (Kavitskaya & Staroverov (2010):264)*

	Feeding	Counterfeeding
Input	tʲimjʌs	xadʌ
Debuccalization	tʲimjʌʔ	—
Apocope	tʲimjØʔ	xadØ
Output	tʲimjʔ	xad

However, Staroverov (2020) argues that apocope in Nenets is actually, not deletion, but reduction of /ʌ/ to a null vowel which is still minimally phonetically realized in many contexts. Under, this interpretation the failure of debuccalization to apply before an apocopated /ʌ/ could be attributed in a non-opaque way to the fact that it applies only to consonants which are strictly word-final (see Staroverov & Kavitskaya 2017 for an other case of apparent phrasal opacity in Nenets, which they reanalyze as transparent).

Wolf (2008a) provides another example of postlexical opacity: Russian /v/ behaves as a sonorant for Phrase-Level processes such as voicing assimilation, but is an obstruent in the output. Must be a sonorant (/w/) in the input to the Phrase level becomes an obstruent at its output, but obstruentization comes after (counterfeeds) voicing assimilation. An alternative account is provided by Iosad (2018), who takes Russian /v/ to be a sonorant throughout the phonollogy – all obstruent-like properties are the effect of gradient phonetic implementation.

McCarthy (2007) also claims the existence of opaque interactions fortitions and lenition in English fast speech, but Kiparsky (2015) shows in detail that these data are due to probability effects of interacting optional rules, and do not exhibit actual opacity.

A stronger case for phrase-level-internal opacity is made by Obiri-Yeboah & Rasin (2023) on **Gua** in a discussion of the opaque interaction between mid-vowel fusion and ATR-harmony in Gua, illustrated in (264). The ATR-harmony process described more in detail in section 2.3.4 changes a [-ATR] vowel of a word-final syllable to [+ATR] if preceding a syllable with a [+ATR] vowel (/àŋɛ̰́ kwè/ → |àŋḛ́ kwè|). Vowel fusion merges two adjacent non-high vowels into a long vowel with the quality of the second segment (/kwè ɛ̀dɛ̀/ → | [kwɛ̀ ɛ̀dɛ̀]). This renders ATR-harmony opaque because on the surface the final vowel of [àŋɛ̰́] in (264) is now followed by a [-ATR] not a [+ATR] vowel:

(264) *Opaque interaction of ATR-harmony and vowel fusion in Gua (Obiri-Yeboah & Rasin 2023:3)*

[àŋɛ̰́ kwɛ̀ ɛ̀dɛ̀] ‘A man grinds something’
/àŋɛ̰́ kwè ɛ̀dɛ̀/
man grind.HABIL something

Obiri-Yeboah & Rasin show meticulously that both processes are productive by demonstrating their application to nonsense phrases, and that they apply in exactly the same phrasal domains (the same seems to hold for the cases of opacity in in Jumjum phrasal tone discussed by Trommer (2018)). This latter argument is important since it provides evidence against an analysis in terms of multiple phrasal strata (see section 2.2.1).

Wolf (2008a) cites two cases of opacity at the Phrase Level from Dutch dialects, both related to the deletion of segments in attributive adjectives. First, in certain Flemish dialects, word-final /d/ is deleted in this position, but the final devoicing it is supposed to undergo triggers voicing assimilation on a following noun (/roːd zand/ → roːt zant → roːt sant → [roː sant] ‘red sand’). The second case is Aalst Dutch where the final inflectional [ə] of the attributive adjective is deleted. However the deleted schwa still blocks otherwise regular place assimilation between nasals and following obstruents:[60]

(265) *Blocking of place assimilation in Aalst Dutch* (van Oostendorp, 2004:17)

[60]Wolf also adduces the interaction of flapping and Canadian Raising in varieties of Northern American English as evidence for innerstratal opacity at the Phrase Level following a similar claim in. However, this claim is based on the single impressionistic example [dõlʌirəmi] ‘Don’t lie to me’ (Idsardi 2006:124). In a thorough review of the current literature on Canadian Raising, Bermúdez-Otero (2019) concludes that in all varieties with a more exhaustive description raising is clearly a word-bound process.

		Underlying	Surface
a.	'handsome guy'	schoo/n/ ventje	schoo/ŋ/ ventje
b	'beautiful woman'	schoo/nə/ vrouw	schoo/n/ vrouw

A further case of postlexical opacity cited by Wolf occurs in the single word tˢəkj 'just' which optionally loses its final *k* if it is not utterance final. This interacts with a more general process which deletes word-initial /j/ if it is both preceded and followed by a mid vowel: (266) shows Wolf's rendering of this opaque interaction by rule ordering:

(266) *Trukese (Wolf 2008a:406)*

Underlying representation:	/jiːji tˢək je sineːj/
$j \rightarrow \emptyset / V_{mid}\_\_V_{mid}$	n.a.
$k \rightarrow \emptyset / \_\_]_{\sigma} \ldots]_{Utt}$	[jiːji tˢəØje sineːj]

The Flemish case could simply be handled as compensatory devoicing independent from voicing assimilation in parallel to the palatalization pattern in Hijazi Bedouin Arabic (section 1.2.3). van Oostendorp (2004) discusses several possible analyses along these lines. For Aalst he argues for an analysis where deletion of the schwa is incomplete and leaves a mora behind which forms a syllable with the preceding nasal. Under the assumption that assimilation only targets coda consonants this blocks the process in the case at hand. An alternative analysis is proposed by Trommer (2011) who captures the data based on a Containment approach by the assumption that the deleted segment intervenes in the feature spreading process which may only target strictly adjacent segments. This approach also naturally transfers to the Trukese case: If |j|-deletion is triggered by a markedness constraint against the sequence V_{mid} j V_{mid} under a generalized containment interpretation the intervening |k| will block it even if it is deleted. Note also that the |k| is also plausibly an instance of a ghost segment since word-final |k| is not generally deleted in the language. Thus its non-integrated/non-overt status in the output would simply replicate its position in the input

Summarizing, there seems to be a limited amount of innerstratal opacity at the Phrase Level, but this does not seem to be an insurmountable problem for Stratal OT. All cases discussed above seem to be amenable to analysis in terms of autosegmental feature compensation or Containment. Thus, in Containment Theory, Gua ATR harmony could be captured by a requirement that vowels share the feature of a following [+ATR] vowel whether the [+ATR]-specification is underlying or overt. The same data could also be captured as autosegmental compensation in parallel to the case of palatalization in Hijazi Bedouin Arabic discussed in section 1.2.3. The data in (264) would then actually not exhibit [ATR]-harmony, but reassociation of the delinked [-ATR]-feature of /ɛ̀/ in kwɛ̀ to the final vowel of àŋɛ́. Both approaches would still be more restrictive than the use of ordered rules as in Lexical Phonology or global process ordering in OT with Candidate Chains (McCarthy 2007, Wolf 2008a) since opacity would be necessarily restricted to input representations: neither autosegmental representations nor Containment involve intermediate representations as allowed by derivational approaches to opacity. For example this predicts – apparently correctly – that there are no innerstratal Duke-of York derivations (see section 4.3 for interstratal patterns of this type, and Zimmermann & Trommer 2024 for a more general discussion of the limits Containment imposes on opacity).

3.5 Overgeneration by Reranking

A further objection against Stratal Phonology in the literature is based on the fact that the phonological grammars of single strata in a given language are conceptually completely independent. In combination with the assumption that the overall phonologies of existing languages are harmonic in some sense to be made precise, i.e. do not exhibit contradictory phonological systems, this leads to the claim that Stratal Phonology overgenerate: they predict overall phonological grammars not found in natural languages.[61] Note that this is a problem specific to Stratal OT. Lexical Phonology was typically thought to be bound by substantial universal restrictions on holw strata in single languages might diverge – see section 4.3 for discussion.

The best worked-out argument to this effect is found in Wolf (2012) who discusses several pathological systems predicted by Stratal Phonology. In one such system the Stem Level of the language would assign iambs from left-to-right and reduce unstressed syllables to [ə]. The Word Level, would then replace this footing with bisyllabic iambs. As a consequence, all stressed syllables would be schwa and vice versa, clearly an unnatural distribution since schwas crosslinguistically are connected with unstressed positions.

(267) *Hypothetical language with systematic stress of [ə] (Wolf 2012, Kaplan 2024)*

Underlying	/pa.ta.ka.ba.da.ga/
Vowel Reduction	pa.**t**ə.ka.**b**ə.da.ga
Surface	pa.tə̀.ka.bə̀.da.gá

A weakness in this argument is that it presupposes that Stem Level and Word Level are coextensive. Thus in a form where the Stem-Level output [patə́kabə́dadaga] would be augmented by affixes the correlation of [ə] and stress would break down ([ti-pátəkábədádaga]).

In fact, systems similar to the one (267) although rare seem to be attested. One example is Tübatulabal under the analysis of Benz (2018), which shows vowel lengthening indicative of left-to-right trochees, but a surface stress pattern requiring trochees assigned from right-to-left[62]. Kaplan (2024) argues in detail for a stratal analysis of Southern Pomo, where the Word Level has syncope based on iambs assigned from left to right, but the actual stress pattern on the surface are trochees assigned from right to left. In contrast to Wolf's hypothetical example, the Pomo data also show the expected extension across strata. Syncope is strictly word-bound, but surface stress domains include phrasal clitics and multiword-domains.

4 The Inheritance from Lexical Phonology

A central difference between Lexical Phonology and Stratal OT is Lexical Phonology's assumption that there are more general substantial differences and connections between strata. Thus it was assumed that Structure Preservation (section 4.1) universally distinguishes lexical and post-lexical phonology, and Strict Cyclicity sets apart cyclic and non-cyclic strata (section 4.2), whereas principles like the Strong Domain Hypothesis delimit the possible stratal spans of application for specific processes (section 4.3). Most of the claims discussed here were bold, theoretically appealing hypotheses, which have honorably failed thorough empirical evaluation. Proponents of Stratal OT have generally considered this important insight as a positive result since many of these hypotheses like Structure Preservation cannot or only with difficulty be stated in a constraint-based account. However, in importing earlier

[61] See also Archangeli & Pulleyblank (2002) who argue based on a Strong Domain effect in Kinande vowel harmony that this can only be captured by stringent constraint ranking in a parallel evaluation. But see Downing & Krämer (2022) on empirical evidence against this claim (phrasal harmony is more restricted than Word-Level harmony). A similar, more general claim is made in Benua (1997) – see footnote 67.

[62] There are a number of other languages showing metrical incoherence, for which it is less clear whether they are amenable to a stratal analysis. Benz (2018) cites Washo which has predictable stress on roots, but a lexical stress system at the word level. Eastern Mari

analyses and claims into Stratal OT it is important to keep in mind that authors who worked in Lexical Phonology often assumed that principles like Strict Cyclicity are essential axiomatic properties of Stratal Phonology. Thus one often encounters the claim that a rule is cyclic without any empirical evidence for cyclicity in the literal sense, only based on the observation that a process doesn't apply to single morphemes (see, e.g. Cole (1986)'s ppper on Seri). Or that a rule cannot be cyclic because it doesn't obey Structure preservation (see Booij & Rubach (1987) on Canadian French). Finally, the heritage from Lexical Phonology still contains challenges for future theoretical work. Thus whereas the Nonderived Environment Blocking assumed in LP as a universal exceptional Principle has been shown to have robust exceptions, effects of this tgype are still pervasive and difficult for current approaches in Stratal Phonology

4.1 Structure Preservation

Kiparsky (1985) advances the hypothesis that lexical and postlexical phonology contrast systematically in that lexical processes may only create structure also licit in underlying representations, whereas postlexical processes may create representations not available in underlying forms. Examples: English Voicing assimilation between obstruents creates obstruents also distinctive underlyingly. On the other hand, the postlexical processes devoicing sonorants and flapping creates sounds not present underlyingly.

A central prediction of the Structure Preservation hypothesis is that allophony should not be sensitive to word-internal structure (which would imply that it is a Stem- or Word-Level process) since it creates variants of sounds not present in underlying representations. That the hypothesis today is generally considered to be incorrect is due to the fact that the literature has revealed many cases of allophony which contradict this claim. Thus, as shown in detail by Hall (1989), the allophony between [x] (after back vowels, e.g. [ba**x**] 'torrent', [lɔ**x**] hole) and [ç] (elsewhere, e.g. [ʔɪç] 'I', [mançə] 'some', [çemiː] 'chemistry') is sensitive to word-internal morpheme boundaries. For example, default [ç] appears even after a back vowel if both sounds are separated by a suffix boundary (e.g. [kuː-çən] cow-ᴅɪᴍ 'little cow', cf. the minimally distinct monomorphemic [kuːxən] 'cake').

Other reported counterexamples to Structure Preservation are nasal allophony in Malayalam (Mohanan & Mohanan 1984), Bantu vowel harmony (Harris 1987), several allophonic English Level 2 rules (Borowsky 1986), Dagbani falling tones (Hyman 1993), Belfast Dentalization Harris (1989, 1990) and Dakota syllable structure (Kyle 1994).

Myers (1991) argues for deriving a relaxed form of SP by deriving it from the Strong Domain Hypothesis. Prediction: SP holds in initial strata, but the watershed between its application and non-application might be between any two subsequent strata for any given process in a specific language.

4.2 (Non-)Derived Environment Blocking and the Strict Cycle Condition

A simple example of a potential Strict Cycle Condition effect is hiatus resolution in Emai where a word-final vowel is deleted if it is followed by a vowel-initial word (e.g. /kɔ/ 'plant' +/ema/ 'yam' → [kema], Casali 1997:513). This could be captured by a Phrase-Level rule as in (268):

(268) $V \rightarrow \emptyset \,/\_\_V$

Word-internal hiatus is not repaired in the same way. Thus the noun [oa] 'house' apparently surfaces as such in isolation (not as *[o]) and in contexts where it triggers vowel deletion across words (e.g., /ɔli/ 'the' + /oa/ 'house' → [ɔloa], Casali 1997:512). This asymmetry could be captured in a stratal model of phonology with three stratal domains (Stem Level, Word Level, and Phrase Level) and no stratum-internal cycles by a condition as in (269):

(269) *Strict Cycle Condition (SCC):* A phonological process in a given stratal domain S applies if and only if its focus and context match material not exclusively contained in a single stratal domain embedded in S.

Under the standard assumptions that internal brackets of a stratum are deleted at the point when computation enters a subsequent stratum, at the Phrase Level the only embedded domains visible for SCC are the Word Level boundaries, as in (270):

(270) $[[\text{ɔli}]_{\text{Word Level}}\ [\text{oa}]_{\text{Word Level}}]_{\text{Phrase Level}}$

Thus (269) correctly predicts that rule (268) is not applied to the string **oa** since both the focus and the context V of the rule are contained in a single Word Level domain. On the other hand, (1) applies to the string **io** where **i** (matching the focus-V) is contained in one embedded domain and **o** (matching the context-V) in a different embedded domain.

The SCC can also be applied to word-internal processes. Thus probably the most-discussed case of a SCC in the stratal literature is the triggering of spirantization ('assibilation') on preceding coronal stops by front vowels in Finnish as shown in (271-a). However this happens only across morpheme boundaries (271-b):

(271) *Assibilation in Finnish (Kiparsky 1993, see also Wolf 2008a, Rasin 2023)*

a.	/halut-i/	→	[halusi]	'want-PAST'
	/halut-a/	→	[haluta]	'want-INF'
b.	/koti/	→	[koti], *[kosi]	'home'

This asymmetry could be captured by (269) under the assumption that bare roots are Stem-Level domains in a SOT architecture whereas Assibilation applies at the Word Level:

(272) a. $[[\text{halut}]_{\text{Stem Level}}\ \text{i}]_{\text{Word Level}}$ b. $[[\text{koti}]_{\text{Stem Level}}\ ]_{\text{Word Level}}$

In the heydays of Lexical Phonology, the Strict Cycle Condition was of central importance to Stratal Phonology with the major goal to find a universal cognitive principle which would account for data as in Emai and Finnish. However, this goal was fraught with serious conceptual and empirical problems from the beginning.

First, the Strict Cycle Condition potentially violates locality and modularity phonological computation must look 'back' and see morphosyntactic domains.

Second, the bulk of data analyzed by the SCC were cases of NDEB as in Finnish assibilation, i.e., patterns where a phonological process doesn't apply inside of underived roots. However, roots have been argued to be not cyclic domains (see section 2.3.6).

Third, it was always obvious that the phonological Strict Cycle Condition could not, as its syntactic predecessor be conceived as a universal property of all phonological derivations. An especially well-documented case violating the SCC is American English flapping which changes intervocalic coronal stops after stressed vowels into flaps:

(273) *American English flapping (Kenstowicz 1994:195)*

a. á[ɾ]om	cf. a[t]óm-ic	c. whát[ɾ] is wrong? cf. whá[t]
b. méé[ɾ]ting	cf. méét[t]	

Flapping happens across word boundaries, as shown by (273-c), hence must be phrasal, but also happens inside single words/morphemes (273-a,b), which would violate the SCC if it is a Phrase Level process.

Another case is Arabic vowel insertion which breaks up consonant clusters. It is clearly a phrasal process since it can be bled by a following vowel-initial word, but it applies in single isolated words:

(274) *Arabic vowel insertion: /fihm/ 'understanding' (Kiparsky 2000:352)*

a. fíhm il-wálad	'the boy's understanding'
b. fíhim	'understanding'
c. fíhimna	'our understanding'

As a consequence of SCC-violations as in English and Arabic, the general research strategy in Lexical Phonology has been to define a class of processes that are universally subject to the SCC and a complement class that is not. (275) lists the most important hypotheses pursued in this tradition:

(275) *Potential criteria for SCC compliance*

SCC-compliant	*SCC-non-compliant*
a. lexical phonology	postlexical phonology
b. neutralizing/phonemic	allophonic/non-phonemic
c. structure-changing	structure-building
d. cyclic	non-cyclic

However, this all failed. Kiparsky (1993) provides a general refutation of most of these claims, and we have already seen some other counterexamples. Thus Emai is a bona fide case of a phrasal phonological process which is SCC-compliant counter to (275-a). Vowel epenthesis in Arabic is neutralizing and non-allophonic violating (275-b). The Finnish coalescence process discussed by Kiparsky (1993) is clearly structure-changing and cyclic but not subject to the SCC (violating (275-c) and (275-d)). Note also that in the version of Stratal OT adopted here there is no stratum-internal cyclicity, hence there is no distinction between cyclic and non-cyclic processes.

An alternative to a general unviolable SCC in Stratal OT is to derive apparent SCC effects follow from specific constraints sensitive to morphosyntactic colors in the sense of Colored Containment Theory (see section 1.2.1).[63]

van Oostendorp's crucial observation is that most cases of SCC effect involve feature spreading, and as pointed out by Wolf (2008b:329) this holds also for Finnish assibilation which might be interpreted as spreading of [+continuant] from a high front vowel to a left-adjacent [t].

High-ranked ALTERNATION as defined in (276) would block this process morpheme-internally (e.g. in [koti]) since the [+cont] feature of [i] and the root node of [t] have the same morphological color, and spreading would mean that an epenthetic association line links them.

(276) ALTERNATION: Assign $*$ to every epenthetic association line connecting two nodes of the same morphological color (rephrased after van Oostendorp 2007:16)

Ranked above the relevant constraint triggering spreading (here: SHARE), this predicts assibilation across a morpheme boundary (277-a), but not inside a morpheme (277-b) (see below on the encoding of morphemes by color/background shading):

(277) *Finnish assibilation*

Input: a.	ALT	SHARE
[+cont] [+cont] a.		*!
[+cont] [+cont] ☞ b.		

Input: a.	ALT	SHARE
[+cont] [+cont] ☞ a.		*
[+cont] [+cont] b.	*!	

[63] Approaches to Nonderived Environment Blocking which seem to be incompatible with Stratal OT are global constraints on process interaction (Wolf 2008a). Local conjunction of constraints (Łubowicz 2000)

There are both conceptual and empirical reasons to assume that SCC effects are due to specific violable constraints and not to a general inviolable convention. Conceptually there doesn't seem to be a natural way to implement the idea that a process must involve new material in OT. This is because OT lacks a reified notion of process (which are largely equivalent in rule-based phonology where a rule typically captures a process). Consider again the case of Emai. Vowel deletion is an operation of GEN, but vowel deletion by itself (i.e., viewed independently from its trigger) doesn't happen in any reasonable sense across morpheme or word boundaries. It is always the vowel of a single morpheme (and word) which is deleted. One might consider requiring that a general SCC convention should restrict the application not of processes, but of markedness constraints triggering them. However, under the standard assumption that vowel deletion under hiatus is due to the constraint ONSET, this also would not work out for Emai since the relevant ONSET at a word/morpheme boundary as in [ebe ɔna] would also be restricted to a single word/morpheme (the syllable containing [ɔ]).

Another alternative approach to Nonderived EB compatible with a stratal architecture has recently been proposed by Rasin (2023). Rasin proposes that NDEB effects follows from phonological applying to single morphemes before all other phonological rules thus at a morpheme/root stratum or as a MSC (see section 2.2.3). I will illustrate Rasin's approach with Finnish assibilation in an OT implementation (Rasin gives a rule-based version). Assibilation applies at the Word Level assuming that [t]'s which don't precede an [i] in a single morpheme are underlyingly underspecified for the feature [+/-continuant] indicated here by capital 'T'. Since underspecification is excluded in the output (by undominated *T), T must either become [s] or [t]. Before [i], the first option is taken (due to (*ti)), as in (i). Otherwise DEP [+continuant] leads to realization as [t] (ii). In contrast underlying [t] which precedes a tautomorphemic [i] is assumed to be fully specified as [-continuant], and protected by MAX [+/-continuant]. Thus it stays [t] even before [i] (278-iii). (278-iv) shows that the ranking also derives faithfulness for underlying /s/:

(278) *Word Level*

(i)

Input: c.	*T	MAX +/-cont	*ti	DEP +cont
a. at-i			*!	
☞ b. as-i				*
c. aT-i	*!			

(ii)

Input: c.	*T	MAX +/-cont	*ti	DEP +cont
☞ a. at				
b. as				*!
c. aT	*!			

(iii)

Input: a.	*T	MAX +/-cont	*ti	DEP +cont
☞ a. ti			*	
b. si		*!		*
c. Ti	*!	*		

(iv)

Input: b.	*T	MAX +/-cont	*ti	DEP +cont
a. ti		*!	*	
☞ b. si				
c. Ti	*!	*		

The underspecification assumption of course begs the question why some [t]'s are underspecified and others are fully specified in the input to the Word Level. This is achieved by the core component of Rasin's approach, phonology at the Morpheme level. Crucially this employs very different output patterns than the Word-Level phonology. Thus it enforces underspecification in specific contexts, here for non-s coronal sounds as long as they do not precede an [i]. Both /T/ and /t/ neutralize in this context to underspecified T (i+ii, turning them into [s] is excluded by DEP [+continuant]). In contrast, before morpheme-internal [i], both /t/ and /T/ become t due to undominated *Ti (iii+iv). Tableaux (v)+(vi) again show that the analysis also extends to fully specified underlying /s/.

(279) *Morpheme Level*

(i)

Input: a.	*Ti	DEP +cont	*t	MAX +/-cont
a. at			*!	
b. as		*!		*
☞ c. aT				*

(ii)

Input: c.	*Ti	DEP +cont	*t	MAX +/-cont
a. at			*!	
b. as		*!		
☞ c. aT				

(iii)

Input: a.	*Ti	DEP +cont	*t	MAX +/-cont
☞ a. ti			*	
b. si		*!		*
c. Ti	*!			*

(iv)

Input: c.	*Ti	DEP +cont	*t	MAX +/-cont
☞ a. ti			*	
b. si		*!		
c. Ti	*!			

(v)

Input: b.	*Ti	DEP +cont	*t	MAX +/-cont
a. at			*!	*
☞ b. as				
c. aT				*!

(vi)

Input: b.	*Ti	DEP +cont	*t	MAX +/-cont
a. ti			*!	*
☞ b. si				
c. Ti	*!			*

Gleim (2023) shows that Rasin's approach in principle also extends to cases of NDEB outsde of word-level phonology. He illustrates this with Catalan for whikch je claims that gliding of high vowels (/i/ → [j]//u/ → [w]) before other vowels applies across word boundaries (e.g. [/pruduirá] + [uksidəsjó] → [/pruduirá] + [wksidəsjó] 'produces oygenation'), but not generally in side words (e.g. [korneu]/*[kornew] 'I cultivate'). Gleim derives this by a Word-Level rule which changes high vowels in word-initial position to underspecified high segments. At the Phrase Level these are realized as high vowels by a default rule, but as glides after other vowels. On the other hand, high vowels which are not word-initial are fully specified at the Word Level and hence not susceptible to those alternation at the Phrase Level.

4.3 Restrictions on the Relation between Strata

Many scholars working with stratal models have shared the intuition that the relation between the processes applying at different levels of a given language is not completely arbitrary, but subject to general restrictions. The most important ideas to this effect are listed in (280):

(280) *Hypotheses*

		Possible Counterexample
Continuous Domain Hypothesis (Mohanan 1986:47)	Each phonological process applies in a contiguous set of strata in any given language	
Strong Domain Hypothesis (Borowsky 1986)	Each phonological process applies in a contiguous set of strata including the initial stratum in any given language	Malayalam ə-epenthesis (Mohanan 1989) Turkish Velar Drop (Inkelas & Orgun 1998)

The most in-depth discussion of the Strong Domain Hypothesis is found in Borowsky (1986) on English – based on short remarks in previous work by Kiparsky. In general, English shows a strong tendency that Stem Level rules such as nasal place assimilation are switched off at the Word Level. Apparent counter examples to the SDH are either due to the fact that their structural descriptions refer to syntactic representations still not available in lexical strata (such as the Nuclear stress Rule which assigns phrasal stress depending on syntactic bracketing) or because their earlier application is blocked by general conditions on derivations. Thus flapping is blocked from applying inside the Lexical phonology under the assumption that this cannot introduce segments which are not part of the underlying phoneme inventory of the language ('Structure Preservation').[64]

A number of other languages provide counterexamples to the SDM inside the lexical phonology, such as Velar Drop in Turkish (Inkelas & Orgun 1998): Affixes which trigger deletion of intervocalic /k/ are outside of affixes tolerating it. The SDH is also incompatible with many of the Word-Level processes argued in section 2.3.2 to provide evidence for noncyclic (Word-Level) application. Thus since German Final Devoicing is arguably a Word-Level process, the SDH implies incorrectly predict that it should also apply at the end of stems. Dahl's Law is also a Word-Level process which apparently fails to apply to stems. Mohanan (1989) argues that Malayalam is a case where syllable structure *constraints* violate the SDH, since some of them apply earlyx whereas others only become active at later strata (see Myers (1991) for critical discussion). Counterexamples involving phrasal phonology can be found in many processes which apply only across Word boundaries, but not inside words See, e.g. the discussion of Emai and Catalan in section 4.2, a tonal case is H-tone spreading in Bari, Yokwe (1986).[65]

Maybe the most suggestive counterevidence against the SDH are languages where strata seem to perform Duke-of-York Derivations, i.e. a representation A is chnged into B at one Level which is changed back into A at a subsequent Level. A suggestive case is found in Arapaho under the analysis of Gleim (2019): An [i] is inserted at the Stem Level to repair illicit codas and to save floating tones. At this point [i] also triggers segmental processes such as consonant fronting. At the word level [i]'s which don't carry H-tones are deleted Ø→ [i] → Ø.[66]. Other detailed arguments for stratal Duke-of-York Derivations are found in Bermúdez-Otero (2001) for Catalan obstruent voicing, and in Rubach (2003) on palatalization in Polish. Also the approach to NDEB developed by Rasin (2023) involves Duke of York derivations.

[64]Note that violations of the SDH might be difficult to detect. Thus a number of Bantu languages are described as having an unbounded tone spreading process at the Phrase Level, but not at the Word Level. However this often is only the most parsimonious way to describe the system. It would be equally possible to assume that unbounded spreading already applies at the Word Level and is then continued at the Phrase Level.

[65]All three cases cannot be saved by invoking Structure Preservation in word-internal phonology. This is true for vowel deletion in Emai, which by definition doesn't create any new structure. Glides in Catalan are also present lexically, and Bari has lexical H-tones (and longer H-tone spans).

[66]Arapaho and the other cases cited here are instantiations of *non-vacuous* Duke-of-York Derivations in the terminology of McCarthy (2003): whereas the original representation A becomes again A, it triggers collateral changes during its intermediate changed state (in the case of Arapaho: consonant fronting). McCarthy (2003) claims that *non-vacuous* Duke-of-York derivations are typologically unattested and invokes this as an argument against Stratal Phonology

Duke of York derivations by definitions involve violations of the SDH since the restorative change in the second step (B → A) applies only at a stratum which comes after the stratum of the original change (which lacks it). Similar problems for the SDH are found with the Tübatulabal and Pomo cases discussed in section 3.5 where different stratal levels employ different stress algorithms, which means that the rules/constraints characteristic of the later Level must have been inactive at the earlier level.

A conceptual reason why the SDH has not been pursued in Stratal OT is that OT does not have a reified notion of process. An alternation is not implemented by a single rule, which can be present or absent at a given stratum, but by the ranking of constraints which are otherwise assumed to be present in all strata of all languages.

One obvious idea would be to reformulate the SDH by arguing that subsequent strata can only differ from a given stratum by promoting faithfulness constraints (see Benua 1997 and Itô & Mester (2003) for speculative discussion).[67] However, this would not strictly derive the SDH.

Suppose, for example, a language which avoids a marked cooccurrence of segments XY by deletion at the Stem Level (XY → X), but by featural change at the word level (XY → XZ). This could be captured in Stratal OT by changing the Stem Level ranking of *XY ≫ IDENT ≫ MAX to *XY ≫ MAX ≫ IDENT in accordance with Faithfulness Promotion. However, this would violate the SDM since the process changing Y into Z is an alternation at the Word Level not present at the Stem Level.

Note also that Borowsky's original solution to the problem that American flapping doesn't apply word-internally due to Structure Preservation doesn't transfer naturally into OT. In the rule-based version, the SDH is a restriction strictly on rules and can be circumvented by a constraint like Structure Preservation because constraints are outside of this system, but in OT, Structure Preservation would just be another (universal) constraint, and it it is not obvious why it should have different effects than other constraints.

In contrast to the SDH, there has been little critical discussion on the Continuous Domain hypothesis. Potentially problematic are the cases from Seri, Hausa and Moses discussed in section 2.4.2 as problems for the affix ordering generalization. If these are captured by a proliferation of strata, this would mean alternating strata with rule/constraint system 1 and rule/constraint system 2 which would violate contiguity.

5 Abbreviations and notational Conventions

[ə]	ə as a surface segment
/ə/	ə as an underlying segment
|ə|	ə as an underlying segment in an intermediate step of a derivation or used ambiguously wrt derivational status
ⓔ	epenthetic ə
ə	deleted əLP
NDEB	Non-derived environment blocking
PWord	Prosodic Word
SCC	Strict Cycle Condition
SDH	Strong Domain Hypothesis

lexical Phonology

[67] Ironically, Benua (1997) takes the alleged inviolability of the Strong Domain hypothesis as evidence against Stratal OT. arguing for a model where Morphophonological effects are mediated by indexed faithfulness constraints triggered by affixation processes. This derives as a theorem that affixed forms will always be more faithful than unaffixed forms. Benua's version of the SDM makes substantially different predictions compared with a stratal one since it doesn't address the role of postlexical strata or the relation between strata employing different affixes. Also in most existing stratal analyses there is no root stratum.

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A Empirical Evidence for the Affix Ordering Generalization

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Aingae	prestressing	Dąbkowski (2021)	
Albanian	derivation vs. inflection	stress	Trommer (2013a)
Arabic	Subject agreement vs. object clitics	Stress	Kiparsky (2000)
Armenian	Derivation vs. inflection	vowel/diphthong reduction/deletion	Dolatian (2020b)
Catalan	Affixes vs. pronominal clitics	V-epenthesis	Bonet & Lloret (2005)
Cherokee	Stem vs. Word affixes	H-tone	Uchihara (2013)
Chumash		vowel harmony	Applegate (1972)
Dagaare	suffixes vs. enclitics	H-dissimilation and downstep	Anttila & Bodomo (2023)
Choktaw	inner vs. outer affixes	Rhythmic lengthening	Ulrich (1986)
Dakota	affixes vs. enclitics	Stress	Shaw (1980)
English	Level 1 vs. Level 2 affixes	stress nasal place assimilation	Kiparsky (2020)
Eton	suffixes vs. enclitics	H-spreading, downstep	van de Velde (2008)
Gaahmg	Affixes vs. Clitics	Gliding+Tone	Stirtz (2011) Trommer (2024b)
Guébie	affixes vs. enclitics	vowel harmony + tone	Sande (2017)
Huave	"Cyclic" vs. "non-cyclic" affixes		(Noyer 2013)
Karimojong	inner vs. outer verbal suffixes	vowel harmony	Lesley-Neuman (2012)
Kashaya	Stress	Buckley (1994a)	
Kinande	(Macro-)Stem vs. Word	H-dissimilation	Mutaka (1994), Jones (2014)
Korean	consonant cluster simplification	nominal vs. verbal affixes	Yun (2009)
Kuria	(Macro-)stem vs. word	Floating tone association	Trommer (2024a)
Latin	Suffixes vs. enclitics	Stress	Halle & Kenstowicz (1991)
Malayalam	Derivation vs. inflection	Stress, gemination??	Mohanan (1986)
Manam	Suffixes vs. enclitics	Stress	Halle & Kenstowicz (1991)
Moses Columbian Salish	lexical vs. grammatical suffixes	Accent assignment	Czaykowska-Higgins (1993)
Nez Perce	Stem Level vs. Word Level	Syncope	
Nuuchahnulth	lexical vs. grammatical suffixes	reduplication, ʔ-deletion glottalization,delabialization	Stonham (2007)
Raramuri	Inner vs. peripheral suffixes	Stress	Caballero (2008)
Sekani		tone deletion, hiatus resolution	Hargus (1988)
Shona	(Macro-)stem vs. word affixes	H-dissimilation and spreading	Myers (1987, 1997)
Tetsǫ́t'iné		stress, tone	Jaker & Kiparsky (2020)
Turkish	inner vs. outer suffixes	velar drop, prosodic minimality	Inkelas & Orgun (1995)
Vedic		Accent	Kiparsky (1982c) Halle & Mohanan (1985)
Finnish	Consonant gradation	Kiparsky (2003)	
Warlpiri	inner verbal affixes vs. outer verbal and nominal suffixes	vowel harmony	

Moses Columbian Salish:

Different modalities of accent assignment (Trommer 2023a):

Lexical suffixes:	Accent falls on an initial accented syllable if immediately followed by a single accented syllable otherwise on the rightmost accented vowel otherwise on the rightmost vowel
Grammatical suffixes:	Accent falls on leftmost vowel with underlying accent, otherwise on the rightmost vowel

The final two slots in the affix template – object and subject suffixes – never receive accent:
"…object and subject suffixes are all recessive…" (Czaykowska-Higgins 1993:268)

Nez Perce: Kiparsky (2021):426,435

Stem Level:	An unaccented short vowel is deleted in the context V.C__.CV
Word Level:	No syncope

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