Suprasegmental phenomena

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Draft of September 2020

This chapter focuses on the realization of morphosyntactic features through tone, stress or accent—traditionally called *suprasegmentals* because their acoustic correlates (pitch, duration, amplitude) are overlaid on segments.[1] We will examine numerous cases of *grammatical tone*—where morphosyntactic features like force (1)a, case (1)b, or aspect (1)c are realized primarily or exclusively through tone—in addition to cases involving metrical stress, or both tone and stress.

(1) a. *Kalabari imperative* (Rolle 2018:21-22,156)
kúró ~ kúrô ‘fall / fall!’
sɔ̀ ~ sɔ᷈ ‘cook / cook!’
b. *Uspanteko genitive* (Bennett & Henderson 2013)
aqan ~ w-áqan ‘leg/my leg’
ixk’eq ~ w-íxk’eq ‘fingernail/my fingernail’
c. *Logoori consecutive* (Odden 2018, Pak 2019)
kʊ́-kárààng-à ~ -kàrááng-á ‘to fry / and then fried’
kʊ́-déèk-à ~ -dèèk-á ‘to cook / and then cooked’

The ‘internal’ nature of such alternations—e.g. the fact that the imperative morphology in (1)a is marked within the root rather than before or after it—has sometimes led to a perception that suprasegmental morphology represents a challenge for piece-based theories like DM. Boutin (2009), for example, suggests that suprasegmental morphology is better handled by word-and-paradigm theories like Paradigm Function Morphology than by morpheme-based theories like DM:

(2) A morpheme-based approach treats morphemes as a linear string of phonemes which are attached to a base. However, morphosyntactic properties can be realized by suprasegmental features such as tone … Word-and-paradigm…approaches to morphology stress the existence of non-concatenative morphology. The process involves relating a basic form to a derived form by a set of phonological operations. (Boutin 2009:3)

The implicit assumptions here are that (i) *suprasegmental* implies *non-concatenative*, and (ii) non-concatenative morphology involves *processes* rather than *pieces*. These ideas apparently have a long history: in the table of contents to Nida’s (1946) *Morphology*, for example, grammatical tone is classified without comment as a type of ‘Change’ rather than a type of ‘Addition.’ Perhaps not coincidentally, grammatical tone was largely overlooked in the DM literature until quite recently, despite its cross-

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[1] Suprasegmental (=overlaid) features are contrasted with spectral features (e.g. height, frontness) which inherently define segments. See Lehiste 1980:ch1 for comments on this and other definitions of *suprasegmental*. The term *suprasegmental* is also sometimes used more broadly to refer to any feature that could spread over multiple, potentially nonadjacent segments, e.g. nasality, aspiration, laryngeal or vowel-harmony features. Many of the points made in the first part of this chapter will also be relevant for this broader range of phenomena.

linguistic prevalence (see Rolle 2018:§2.2 for a geographic survey; see also Kastner & Tucker, this volume, for a discussion of non-concatenative morphology in DM).

The goal of this chapter is to lay out an explicit account of how suprasegmental morphology can be analyzed in DM. I begin (§§1-2) by showing that—as has long been recognized in work on grammatical tone—the widespread adoption of Autosegmental Phonology (Goldsmith 1976) makes it possible to analyze suprasegmental morphology in a piece-based way. Once it is acknowledged that tones (and other autosegments) can be pieces, the apparent problem they pose for piece-based theories goes away. And in fact, the exclusively process-based approach endorsed in (2) runs into problems when applied to certain cases of tonal displacement, as we will see in §3.

At the same time—while the mere *existence* of suprasegmental morphology is not a problem for DM—there are some cases that seem to involve something more than (or other than) the addition of autosegments. In the Logoori infinitive/consecutive alternation in (1)c, for example, some of the root tones go from H to L while others go from L to H, a pattern that cannot be fully explained by adding a tonal affix. Such cases do, arguably, implicate some kind of phonological 'change' or process, on par with English *sing~sang*; this idea is well-established in the descriptive literature on grammatical tone, where *affixal tone* is distinguished from *replacive tone* as potentially involving process-based morphology (see e.g. Welmers 1973:132).

Traditionally in DM, the *sing~sang* alternation is handled by invoking Readjustment Rules (i.e. morpho-phonological rules; see e.g. Halle & Marantz 1993, Embick & Noyer 2001, Embick & Shwayder 2018). In §5 I demonstrate how Readjustment might play a role, alongside piece-based tonal affixation, in the Logoori infinitive/consecutive alternation in (1)c. I then describe two alternative approaches—Rolle 2018 and Sande et al. 2020—which assume less traditional, hybrid OT-DM architectures and handle replacive tone via morpheme-triggered cophonologies.

I have written this chapter with different kinds of readers in mind: DM practitioners who want to learn more about suprasegmental morphology, phonologists and tonologists who want to learn more about DM, and those who are already well-versed in both Autosegmental Phonology and DM and want to read about issues at play in current DM-based approaches to grammatical tone. This last group of readers may wish to skip or skim ahead to §§4-5, where I look more closely at the role of suppletive allomorphy and phonological readjustment in DM-based treatments of grammatical tone.

1. The basics: integrating Autosegemental Phonology with DM

The core premise of Autosegmental Phonology (Goldsmith 1976) is that phonological representations are multi-tiered structures rather than two-dimensional, 'uniformly sliceable' strings of segments. Tones, instead of being features on vowels like [+high] or [+back], exist on their own tier. This allows for representations like (3)a, where a single H on a tonal tier is linked to multiple TBUs on a segmental tier (often observed as tone spread), as well as (3)b, where two tones are linked to a single TBU (observed as contour tone).

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(3)   a.        H                b.    H   L
               / \                      \ /
              a b a                      a
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With autosegmental theory, the Kalabari imperative in (1)a can be modeled by treating the [IMPERATIVE] morpheme as a suffix that contributes phonological material (specifically, HL) on the tonal tier but not on the segmental tier.

(4)

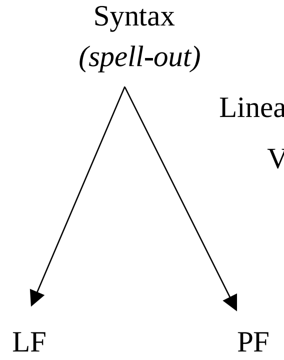
		Step 1: *tone insertion*		*Step 2:* *tier association*
				L HL
Tonal tier	L	HL		| /
Segmental tier	sɔ	Ø	→	sɔ
	[ROOT]	+ [IMPERATIVE]		

Floating tones—i.e. tones that are not underlyingly linked to segments, like this Kalabari imperative HL—are eventually linked to the segmental tier by *tier-association* rules like (5) (or their contraint-based counterparts), which are part of the general phonological component. Tone-association rules are believed to vary by language; not all languages allow contour tones or tone-spreading (Kenstowicz 1994:317, Pulleyblank 1986:78), and even the directionality principle in (5)a-i may have exceptions (Inkelas 2016:521). As we will see in §2, the timing of tone association—i.e. whether it happens cyclically, at the word- or phrase-level, etc.—is also variable (see also Pulleyblank 1986:ch1,§2.2).

(5) a. Match tones to TBUs (i) from left to right, (ii) in a one-to-one relation.
  b. If there are any leftover tones from (a), associate them with the last TBU. (> contours)
  c. If there are any leftover TBUs from (a), assign the rightmost tone to them. (> spreading)

The principles of Autosegmental Phonology are easily folded into the DM architecture in (6). In this model, structures are spelled out phase-cyclically (at each category-defining head *n*, *v*, *a*, etc.) and undergo a set of ordered operations in PF. The two steps involved in deriving e.g. the Kalabari imperative (4)—tone insertion and tier association—map directly to **vocabulary insertion** and **general phonology** in this model.

(6) **DM architecture** (Halle & Marantz 1993, Embick & Noyer 2001)



Linearization of subwords; morphological merger (lowering, local dislocation)
Vocabulary insertion (VI)
Readjustment (morphologically restricted phonology)
Linearization of M-words
General phonology (various types; non-morpheme-specific)

Vocabulary insertion (VI), which adds phonological features to morphemes via rules like (7), applies relatively early in PF, at the stage when syntactic terminals (sub-words) are being linearized. This means that in cases of **allomorphy**—where two or more exponents compete for insertion at the same terminal, e.g. (7)c—the relevant VI rules will only be able to 'see' a limited amount of material. Exactly how much material is an active area of inquiry (see Embick 2010; Gouskova & Bobaljik, this volume). See §4 for further discussion.

(7) a. D[+DEF] ↔ ðɪ
b. n[AGENTIVE] ↔ -əɹ
c. T[PAST] ↔ -t/√MEAN, √FEEL …__
-Ø/√HIT, √PUT, √DIG …__
-(ə)d

The **general phonology** becomes active later, after all morphemes have been spelled out and linearized within a spellout domain. *General phonology* is a cover term for a wide range of phonological rules or processes—word-internal, phrasal, segmental and nonsegmental—that are all 'general' in the sense that they are not morphologically restricted (unlike readjustment rules; see §5). Tier association—step 2 in (4)—belongs to this component: each language has a set of rules or constraint rankings that determine how its active autosegmental tiers (tonal, segmental, stress-grid, etc.) are linked to each other; in tone languages, these rules are also implicated in the distribution of contour tones and tone-spread.[2]

This basic two-step approach—VI, followed by tier-association—has already been assumed independently by various DM practitioners. Halle (1998) adopts autosegmental stress-grid theory to analyze English word stress, and Marvin (2002, 2018) further incorporates the notion of cyclic spellout at category-defining phase heads to determine when grid-construction rules apply (§2.4). Kastner 2019 (see also Kastner & Tucker, this volume) analyzes Semitic morphology with a two-step treatment much like the one adopted here: theme vowels are inserted at VI, then general alignment constraints determine how these vowels are interspersed in a triconsonantal root. Bennett & Henderson's (2013) analysis of Uspanteko grammatical tone (§2.3) is very much in the same spirit: tone-insertion at VI, tier-association in the general phonology. My goal is to extend this approach to a wider range of cases in suprasegmental morphology.

2. Suprasegmental exponents and their placement: a two-step derivation

When autosegmental theory is incorporated into DM, vocabulary items like (7) are 'expanded' to include any autosegmental tiers that are active in the language. Some exponents contain overt material on every tier, while others have no content (Ø) on one or more tiers. In the former case, tiers may be pre-linked in the vocabulary item or linked later by tier-association in the general phonology.

2.1 Pre-linked segment + tone exponents

We'll start with a relatively simple example: the future prefix /bɛ́/ in Asante Twi (Paster 2010:88), which always surfaces with H:

(8)	ési **bɛ́**-tɔ́ pɛ̀n	'Esi will buy a pen.'	ési tɔ́ pɛ̀n	'Esi buys pens.'
	yàw **bɛ́**-tɔ́ pɛ̀n	'Yaw will buy a pen.'	yàw tɔ́ pɛ̀n	'Yaw buys pens.'
	ési **bɛ́**-nôm ìnsyù	'Esi will drink water.'	ési nôm ìnsyù	'Esi drinks water.'
	yàw **bɛ́**-nôm ìnsyù	'Yaw will drink water.'	yàw nôm ìnsyù	'Yaw drinks water.'

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[2] I assume that the general phonology is rule-based (see Pak 2008), but the basic two-step model described here is also compatible with approaches where the general phonology is constraint-based. See Kastner & Tucker, this volume; Bennett & Henderson 2013; and others for examples of tier-association via alignment constraints. The hybrid OT-DM approaches taken by Rolle 2018 and Sande et al. 2020 represent more extreme departures from the architecture in (6), although they maintain some key DM assumptions; see §5 for more discussion.

Because the H tone on /bɛ́/ is unvarying (and because H and L are contrastive in Twi), we can assume that the vowel in /bɛ/ is linked to its H tone underlyingly, in the vocabulary item—just as the tones distinguishing e.g. *má* 'mother' and *mâ* 'scold' in Mandarin are underlyingly (pre-)linked to their vowels. Such examples seem unremarkable, but they serve as a useful baseline—we will see that both subsequent types of exponents differ only minimally from (9).

(9)
H
|
T[FUT] ↔ bɛ

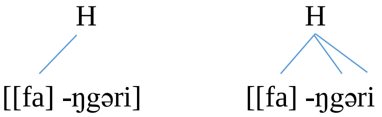
2.2 Non-linked segment + tone exponents

It is possible for an exponent to contain material on two tiers that are not pre-linked in the vocabulary item. In Margi, the suffix *-ŋgəri* 'onto' is argued to contribute a H tone that it is not underlying linked to (i.e. a floating H), as modeled in the following vocabulary item (step 1):

(10)
H
[LOC] ↔ -ŋgəri

Later in the PF derivation, in the general phonology (step 2), this floating H gets linked to the segmental tier by association rules. In Margi, tier-association operates as follows: H docks first on the (toneless) root, then spreads rightward through the suffix (Pulleyblank 1986:71ff). The tonal part of the exponent is ultimately realized earlier than its segments—demonstrating a kind of **tonal displacement**.

(11) a. tone matching b. tone spreading



fá- ŋgə́rí 'take many onto'
cf. fà 'take many' (default L)

Another possible example of tonal displacement is found in Hausa (Inkelas 2016: 519), where [DEF] is marked by both a consonantal suffix *-n/-r* and a L that docks on the preceding vowel:

(12) *Hausa*

gídá:	gídâ-n	'house/the house' (MASC)
rì:gá:	rì:gâ:-r	'gown/the gown' (FEM)
ɗǎ:kì:	ɗǎ:kì:-n	'hut/the hut' (MASC)

This pattern can also be modeled in two steps: first, VI inserts the following exponents for the MASC. and FEM. definite markers:[3]

(13)
L
[DEF.M] ↔ -n

L
[DEF.F] ↔ -r

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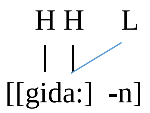
[3] Solely for illustrative purposes, I have assumed fusion of gender and definiteness features in (13) ([DEF.M], [DEF.F]). An alternative analysis would have gender-agreement and definiteness as two distinct (non-fused) morphemes, with the segmental suffix *(-n/-r)* realizing gender agreement and the L tone alone realizing [DEF]. Yet another possibility would be allomorphy of *-n/-r* at DEF, conditioned by an adjacent gender-agreement feature. All of these possibilities are formulable in the model sketched here.

Then, in the general phonology, the tones in the VIs are linked to TBUs by tier-association rules. Because TBUs are vowels here, the tones end up being realized slightly earlier than the segments *-n/-r*.

(14)



2.3 Tone-only exponents

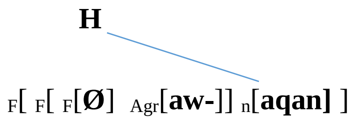
Some exponents contain material on the tonal tier only. As such, they necessarily show displacement effects: the floating tones they introduce *must* ultimately dock on a segment belonging to some other morpheme. The Kalabari imperative (4) is an example where the grammatical tone docks on the root. The genitive case marker in Uspanteko ((1)b, repeated below) is another example. Bennett & Henderson 2013 propose the VI in (16) (slightly modified here) for the case morpheme 'F':

(15) a. aqan 'leg' w-áqan 'my leg', aw-áqan 'your leg'
b. pix 'tomato' ín-pix 'my tomato,' qá-pix 'our tomato'

(16) F[+PARTICIPANT] ↔ $\overset{H}{Ø}$

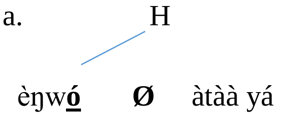
In the general phonology (step 2), the H-tone introduced by (16) docks on the penult of the M-word. The fact that H 'skips over' the possessor-agreement morpheme Agr and docks on the noun root in (15)a (cf. (15)b) indicates that tier-association applies after the entire M-word has been spelled out—another case of tonal displacement.

(17)



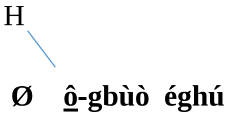
The Igbo subordinate marker [SUB] (Goldsmith 1976:78ff) produces an even more striking instance of tonal displacement. Goldsmith argues that [SUB] is (a feature of) a syntactic head located between the subject and the verb (I'll assume Tense). The exponent of [SUB] is a floating H that docks *leftward* onto the final syllable of the preceding subject (18)a. Only if there is no overt material before [SUB] does H dock rightward (18)b.

(18) a.



[[monkey] [**SUB** [eat 3PL]]]
'lest a monkey eat them' (< èŋw**ò**)

b.



[**SUB** [3SG-kill leopard]]
'lest he kill a leopard' (< **ò**-gbùò)

As in the previous examples, the first step in the analysis is VI:

(19) T[SUB] ↔ $\overset{H}{Ø}$

Also as in the previous examples, the floating tone docks on a TBU by association rules in the general phonology (step 2).[4] In Igbo, however, tier-association does not apply at the M-word level but much later, after the entire clause has been linearized. At this late stage, the subject *èŋwò* has become 'visible' to [SUB] (whereas it was not visible when [SUB] H was first inserted, at VI[5]). This kind of non-local interaction—where one morpheme appears to affect another separated from it by multiple phrase boundaries—is possible because tier-association happens in the general phonology, which includes phrase-level phonology.

At the other end of the tier-association timing continuum, the Tiv pattern in (20) has been attributed to floating-tone affixes that are assigned to TBUs by *cyclic word-internal* rules (Pulleyblank 1986:82ff). Pulleyblank argues that General Past in Tiv is a L prefix, Recent Past is a H suffix, and the root *yevese* has an underlying 'lexical' H tone. Tones are assigned cyclically by the rule in (22); then, once the entire M-word has been spelled out, a non-cyclic rule assigns default L to leftover toneless vowels.

(20) ꜝyévèsè ~ yévésè 'fled.GEN.PAST/REC.PAST' *Tiv*

(21) a. $\overset{\text{L}}{\text{[GEN.PAST]} \leftrightarrow \text{Ø-}}$ b. $\overset{\text{H}}{\text{[REC.PAST]} \leftrightarrow \text{-Ø}}$

(22) Match tones to TBUs (i) from left to right, (ii) in a one-to-one relation.

(23) Cycle 1: yévese
Cycle 2: ꜝyévese

Because tone-association applies cyclically, the root *yevese* crucially has its lexical H linked to its first syllable *before* the general-past L prefix is added; when general-past L is added at Cycle 2, it manifests as downstep. If (22) had applied only once, after the entire M-word had been spelled out, the output would have been **yèvésè*: general-past L on the first syllable, lexical H on the next, and default L on the final.

2.4 Exponents with stress-grid features

So far I have been focusing on grammatical tone, but the basic ingredients of this approach can be applied to other kinds of suprasegmental morphology as well, e.g. English word stress. The contrast between the primary-stressed diminutive suffix *-étte* (*major-étte, kitchen-étte*, *cigar-étte*) and the unstressed superlative suffix *-est* (*fúnny-est, bítter-est, áwesome-est*), for example, could be explained with a two-step derivation parallel to (4).

Halle (1998) models the stress plane as a **bracketed grid**, a structure with a grid mark (x) on line 0 corresponding to each syllable and additional grid marks projected onto higher lines depending on the underlying constituent structure and the grid-construction rules of the language. We could assume that the

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[4] The fact that L+H simplifies to H on the final syllable of *èŋwò̲* is part of the general phonology of Igbo (Goldsmith 1976:82-82).

[5] This is likely the case whether [SUB] is a free morpheme or a prefix on the verb. While [SUB] could adjoin to *v*[*ataa*] by either head-movement or lowering, there is no way that [SUB] could adjoin to the preceding subject *eŋwo* without violating the basic and well-established locality conditions on these operations (Head-Movement Constraint; Embick & Noyer 2001, etc.).

VI for *-étte* 'brings along' a constituent boundary mark (parenthesis) on the metrical tier, causing it to be parsed as a foot, while the VI for *-est* does not:

(24)	(x	x
	n[DIM] ↔ ɛt	Deg[SUP] ↔ ɛst

In the general phonology (step 2), the leftmost 'x' in each foot is projected onto the next-higher line by a grid-construction rule of English. Since the exponent of *-est* does not include a parenthesis on line 0, it is not parsed as a foot, does not project an 'x' onto line 1, and thus never bears stress.

(25)	x x	x
	(x x] (x	(x x] x
	major ette	bitter est

Following Halle 1998, Marvin (2002, 2013) explains the pre-stressing behavior of certain English suffixes, e.g. *–ity*, *-ic*, *-al*, by claiming that certain grid-construction rules apply cyclically at each category-defining head (*n*, *a*, *v*, etc.). In the derivation of *governmentalese*, for example, an additional line-0 bracket is inserted at [$_{v}$ g**ó**vern] and again at [$_{a}$ [[góvern] m**é**nt] al], and the resulting stress is preserved on later cycles ([gʌ̲vəɹnmɛ̲ntəliz]).[6]

Many languages have been claimed to have both tone and stress. In the Uspanteko case from (15), for example, the H-tone exponent of the genitive docks on the *penult* of the M-word, suggesting that tones are linked to a metrical-stress grid rather than directly to vowels. I assume that in such languages, tier-association may refer to multiple autosegmental planes (e.g. 'Associate H with the vowel with the highest grid-mark'). See Goldsmith 1991 and Pak 2019 for analyses of metrically-sensitive tone-association in Logoori, and Anttila & Bodomo (1996:17-18) for additional examples of tone-to-stress attraction in Bantu.

3. Interim discussion: Non-piece-based theories need autosegments too

We have now seen how a wide range of cases of suprasegmental morphology can be analyzed in a DM-based model. The apparent problem for DM referred to in (2) disappears once autosegmental theory is adopted: autosegments 'make tones concatenative' (Trommer 2008) and thus potentially amenable to a straightforward piece-based analysis. A question that might linger, though, is whether autosegments are an undesirable complication, forced on DM just to solve the 'problem' of suprasegmental morphology. Could a non-piece-based theory like Paradigm Function Morphology (PFM) handle suprasegmental morphology more simply, without autosegments?

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[6] Notice that in the derivation of *govern-ment-al*, both $_{n}$[-ment] and $_{a}$[-al] are phase heads that trigger spell-out, but only $_{a}$[-al] triggers the Main Stress Rule and Edge-Marking Rules. Marvin follows Halle (1998) in assuming that the difference between *-ment* and *-al* (and between non-cyclic and cyclic affixes in general) is arbitrarily specified on each exponent, by a diacritic: '[W]hether a given constituent is or is not cyclic is a purely idiosyncrative (lexical) matter' (Halle 1998:554). The effect of this diacritic is to send a special instruction to apply the Main Stress and Edge-Marking rules immediately upon vocabulary insertion. Whether there is precedent for this kind of diacritic marking, and whether the rules in question could be treated as a type of readjustment instead (see §5), are questions I leave open for future work.

For the sake of concreteness, let us consider what a non-autosegmental, non-piece-based treatment of grammatical tone might look like. Stump (2016:135-139) uses the rules of exponence in (26) (as well as a correspondence rule and a set of rule blocks) to analyze the Twi data in (27). The idea is that the negative perfect and affirmative past share property *D* (thus accounting for the addition of the final [ɔ̀], while only the affirmative past has the property *aff D* (thus accounting for the L tone on the first [ɔ̀]).

(26) CVX, Verb, {aff, D} → CV̀X
X[Y sonorant], Verb, {D} → XYỲ

(27) Present: tɔ́ 'buys'
Aff. past: tɔ̀ɔ̀ 'bought'
Neg. perfect: ǹ- tɔ́ɔ̀ 'has not bought'

Rules of exponence in PFM are essentially phonological—even when they add new content, this content is interpreted as the product of phonological insertion rather than as the exponence of a particular morpheme. Notice furthermore that the rules in (26) do not require autosegmental representations. Tones could be construed here as features of segments; e.g. V → V̀ could be viewed on par with V → [+back].

The trouble with extending this kind of approach to *all* grammatical tone is that, as we have seen, grammatical tone does not always surface on its 'source' word. In Igbo [SUB], for example, H surfaces sometimes on the preceding subject and sometimes on the following verb (repeated from (18)):

(28) a. H
èŋw**ó** **Ø** àtàà yá
[[monkey] [**SUB** [eat 3PL]]]
'lest a monkey eat them' (< èŋw**ò**)

b. H
Ø **ô-gbùò éghú**
[**SUB** [3SG-kill leopard]]
'lest he kill a leopard' (< **ò**-gbùò)

To analyze this pattern without autosegments in PFM, the tone alternations on *èŋwó* in (28)a and on *ô-gbùò* in (28)b would need to be attributed to phonological processes triggered by the feature [SUB], as in the hypothetical rules of exponence below:

(29) a. XV, Noun, {SUB} → XV́
b. (C)VX, Verb, {SUB} → (C)V̌X

Significant problems with these rules are readily apparent. Probably most egregious is the presence of [SUB] as a feature in a noun paradigm; this is wholly unexpected, since nouns do not normally host features like [SUB]. Even if [SUB] were considered a possible feature on nouns, we would need to explain why it only sometimes shows up on nouns and otherwise shows up on verbs.

Moreover, the fact that the *last* syllable of the subject *èŋwó* gets H while the *first* syllable on the verb *ô-gbùò* gets H would be an unexplained coincidence. In the piece-based autosegmental analysis in §2.3, this distribution falls out automatically from the hypothesized syntactic locus of [SUB] between the subject and the verb. In (29), however, H is phonologically inserted when the feature [SUB] appears in a word paradigm, without reference to the syntactic locus of [SUB]. As such, the rule in (29)a could just as easily replace XV with XV̂ (*èŋw**ô***) or or XVV (*èŋw**òò***), etc., as with XV́ (*èŋw**ó***).

To be clear, PFM rules of exponence can in principle include autosegments. A rule of exponence that treats Igbo H as an autosegment would solve the problems noted above:

(30) (C)VX, Verb, {SUB} → $\overset{\text{H}}{\text{(C)}}$VX

But the success of this fix simply underscores the main point of this section: Autosegments are independently required by both piece-based and non-piece-based theories, so the mere *existence* of suprasegmental morphology cannot be viewed as a challenge to DM (*pace* Boutin 2009 (2)).

In the rest of this chapter I take up some more complex case studies in grammatical tone, and show how they too can be handled by the model laid out in §§1-2. We will see that there are instances in which a *genuine* piece-or-process question arises, and that this question can be handled via the same mechanisms as those that have been proposed for segmental morphology.

4. Allomorphy with tonal exponents

For the remainder of the chapter, I will be using the following notation in place of tier diagrams: *mú, kà*, etc. for pre-linked segment+tone exponents (§2.1); *mu*$^{(\text{H})}$, *ka*$^{(\text{L})}$, etc. for non-linked segment+tone exponents (§2.2); and Ø$^{(\text{H})}$, Ø$^{(\text{L})}$ for tone-only exponents (§2.3). In other words, superscripted (T) will represent a floating tone.

As noted in §1, a vocabulary item can have multiple exponents that compete for insertion, a situation we recognize as contextual allomorphy. The English past-tense is a much-cited example:

(31) T[+PAST] ↔ -t / √MEAN, √FEEL …__
-Ø / √PUT, √DIG, √SING …__
-(ə)d

In §2 I demonstrated that VI operates in the same way with tonal morphology as with segmental morphology, the only difference being that exponents in tone languages have an additional tonal tier. As such, there is no *a priori* reason why tonal exponents should not compete allomorphically too. Moreover, we should expect *any* of the various types of exponents reviewed in §2 to be able to compete allomorphically with any other type—so in addition to the familiar cases where segment-only exponents compete with each other (e.g. English past-tense (31)), we should also find:

(32) Types of allomorphy involving tonal exponents
- a. pre-linked segment+tone exponents competing with each other, e.g. *bú~à*
- b. non-linked segment+tone exponents competing with each other, e.g. *bu*$^{(\text{H})}$~a$^{(\text{L})}$
- c. tone-only exponents competing with each other, e.g. Ø$^{(\text{H})}$~Ø$^{(\text{L})}$
- d. any of the above competing with a segment-only exponent, e.g. *bú~ke*, *bu*$^{(\text{H})}$~*ke*, Ø$^{(\text{H})}$~*ke*
- e. any of the above competing with a null exponent, e.g. *bú*~Ø, *bu*$^{(\text{H})}$~Ø, Ø$^{(\text{H})}$~Ø
- f. any exponent of type (a)-(c) competing with another type, e.g. *bú~a*$^{(\text{L})}$, *bú*~Ø$^{(\text{H})}$, *bu*$^{(\text{H})}$~Ø$^{(\text{L})}$

Paster & Beam de Azcona (2004) describe a potential case of type (32)f from a dialect of Mixtepec Mixtec, where the [1SG] suffix is *-yù* (pre-linked segment+tone) iff the preceding root ends with L, otherwise floating L (tone-only). I have provided a VI in (34) that could account for this pattern.

(33)	cháì ~ cháì-**yù**	‘chair/my chair’
	tutù ~ tutù-**yù**	‘paper/my paper’
	nàmá ~ nàmá**à**	‘soap/my soap’

(34) [1SG] ↔ -yù / …V̀ +___
-Ø$^{(L)}$

An example of type (32)e allomorphy is found in the Logoori negative subjunctive (Odden 2018, Pak 2019). Like many Lacustrine Bantu languages (Ebarb et al. 2014), Logoori has two verb classes that show distinct tonal patterns throughout the tense-mood-aspect (TMA) system. Some of these distinctions can be attributed in part to allomorphic competition at the TMA suffix (‘M’ below). In the negative subjunctive, for example, the suffix is a floating-H for one verb class and Ø with the other. (The floating-H suffix is eventually linked to the first two moras of the verb root by general tier-association rules; see §5.1.)

(35) a. *bʊrʊk*-class verbs:
ù-tà-**búrúk-**à ‘you shouldn’t fly’
ù-tà-**váríz-**à ‘you shouldn’t count’

b. *karaang*-class verbs:
ù-tà-**kàrààng-**à ‘you shouldn’t fry (it)’
ù-tà-**dèèk-**à ‘you shouldn’t cook’

(36) M ↔ -Ø$^{(H)}$ / X + __, where X belongs to *bʊrʊk*-class[7]
-Ø

With respect to the contextual conditioning of allomorphy, I once again adopt the null hypothesis: that the various types of allomorphy in (32) are conditioned by the *same* factors and constraints as segmental allomorphy. Of course, as noted in §1, the exact nature of these factors and constraints remains an open question (see Embick 2010; Gouskova & Bobaljik, this volume). In all the cases proposed here, the information that is visible to the morpheme at VI is assumed to have been previously spelled out within its (c-command) domain. I do not yet have strong evidence from suprasegmental morphology to support or refute finer-grained locality conditions under discussion—e.g. linear adjacency, visibility of morphosyntactic vs. phonological features, etc. This is an important question for further empirical work.

To help guide this kind of work, I want to address a potential source of terminological confusion. The term *tonal allomorphy* is often used in the literature in the restricted sense (37)b rather than in the broader sense (37)a:

(37) Different definitions of TONAL ALLOMORPHY:
a. allomorphy involving at least one exponent with tone; any of the types listed in (32)a-f
b. allomorphy involving a specific subset of cases of type (32)a—namely, cases where the propopsed allomorphs have identical segmental content but distinct tones (e.g. *bú~bù, ká~kà*)

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[7] Instead of being conditioned by verb-class, this alternation could be phonologically conditioned—by an underlying H on *karaang*-verbs, which shows up in the infinitive but is independently deleted or lowered in certain TMAs (including negative-subjunctive). See §5 and Pak 2019 for more details.

Archangeli & Pulleyblank 2015 (henceforth A&P) use the term *tonal allomorphy* in the restricted sense (37)b,[8] to refer to L~H alternations on Kinande verb and noun prefixes (38)a. Under their analysis, *rì* and *rí* (among others) are suppletive allomorphs, whose selection is conditioned by the presence of a 'H-selecting' diacritic on the following root. I have provided a VI that achieves this effect in (38)b.

(38) a. Kinande infinitive *rì~rí*:
ɛ̀-**rì**-hʊ̀m-à 'to hit,' ɛ̀-**rì**-sɛ̀k-à 'to mock'
ɛ̀-**rí**-tʊ̀m-à 'to send,' ɛ̀-**rí**-sàk-à 'to incise' (H-selecting verb roots)
(Similar pattern in *tà~tá* ('merely'); *mʊ̀~mʊ́* (3SG.OBJ); *kʊ̀~kʊ́, ká~kà* (noun classes), etc.)
b. VI (allomorphic analysis)
[INFINITIVE] ↔ rí- / __+ X, where X belongs to *-class[9])
rì-

A&P frame their analysis as an explicit rejection of treatments that derive *rí* from *rì* phonologically, as a reflex of H-spread from the verb root:

(39) Phonological analysis of Kinande *rì~rí*

UR	ɛ-ri-hʊm-a 'to hit'	ɛ-ri-tʊ́m-a 'to send'
Non-iterative H-spread	---	ɛ-r**í**-tʊ́m-a
Delink rightmost	---	ɛ-rí-tʊm-a
Default L	ɛ̀-rì-hʊ̀m-à	ɛ̀-rí-tʊ̀m-à

A&P reject this phonological treatment because it requires the 'stipulation of non-iterativity in the grammar': 'if the spreading results from some sort of pressure to extend the tone's domain leftwards, then why doesn't the domain extend as far leftwards as it can?' (p. 81) While their allomorphic treatment keeps the phonology highly regular and predictable, its disadvantage is that it requires a nontrivial number of nearly-identical forms to be stored as suppletive allomorphs. The phonetic similarity between *rì* and *rí, kà* and *ká,* etc., becomes entirely accidental.

As this example shows, defining 'tonal allomorphy' in the narrower sense in (32)b serves as a direct gateway to a long-standing debate in DM:

(40) If a morpheme has two surface forms that are phonetically very similar, is it better to
(i) store the two forms as suppletive allomorphs, or
(ii) store a single underlying form and derive the alternation phonologically?

This is a classic piece-or-process question; see Chen 2018 on Taiwan Southern Min tone sandhi, Embick & Shwayder 2018 on German umlaut, Mackenzie 2012 on English auxiliary contraction, Pak 2008:ch6 on French liaison, Pak 2016a on English *a/an* and *the,* Sande 2017:117 on Guébie scalar tone, Welmers 1973:132, Zimmermann 2016, among many others. Factors considered in these studies include:

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[8] Rolle 2018 also defines *tonal allomorphy* in this way (p. 45), but rejects A&P's proposal on independent grounds (pp. 247-248).

[9] Like Logoori, Kinande has two verb classes with distinct tonal properties.

(41) a. How many morphemes are affected by the alternation—one, ten, hundreds? How many forms would end up needing to be stored as suppletive allomorphs under (i)? How costly are these additions perceived to be within the theory or sub-theory?
b. Under (ii), how irregular or idiosyncratic would the phonological rule(s) or process(es) need to be? Are the necessary rules or processes allowed by the theory or sub-theory? (For example, some versions of DM allow for morphophonological readjustment while others eschew it.)
c. Does the alternation meet hypothesized *locality conditions* on allomorphy (i) or phonology (ii)?

A&P articulate a stance where redundancy in the lexicon is viewed as less costly than irregularity in the phonology. But the model laid out here is neutral on these questions, meaning that it can accommodate either an allomorphic treatment (38)b or a phonological treatment (39) of Kinande *rì~rí*. Moreover—to reiterate—cases like Kinande *rì~rí* represent only one subset of one of the many types of allomorphy listed in (32)a-f, all of which are automatically available once DM and autosegmental phonology are unified. To invoke any of these other kinds of 'tonal allomorphy' in an analysis no way implies an endorsement of A&P's particular stance on the piece-or-process question.

5. Replacive tone and process-based morphology

In §2, I presented a series of cases of grammatical tone (GT) that yield to a two-step analysis: VI + general phonology. However, many cases of GT cannot be analyzed with these two steps alone because they involve irregular modification of tones (where *irregular* means 'not predicted by the general phonology of the language'). Such cases, arguably, implicate some kind of phonological change or process, on par with English *sing~sang, keep-kept*. This idea is well-established in the descriptive literature on grammatical tone, where **affixal tone** is distinguished from **replacive tone** as potentially involving process-based morphology: '[T]he concept of 'replacives'…smacks of 'process' description' (Welmers 1973:132).

Consider the Logoori infinitive~consecutive alternation below (shown earlier in (1)c). As in many Lacustrine Bantu languages (Ebarb et al. 2014), verb roots in Logoori belong to one of two classes. The *bʊrʊk*-class verbs in (42)a are L-toned in the infinitive, but have H on the first two moras in the consecutive. The *karaang*-class verbs in (42)b, on the other hand, have H on the first vowel (underlined) in the infinitive, and a LH pattern in the consecutive.

(42) a. i. kʊ̀-bʊ̀rʊ̀k-à ~ -bʊ́rʊ́k-à 'to fly / and then flew'
ii. kʊ̀-vàrìzà ~ -váríz-à 'to count / and then counted'
b. i. kʊ́-kárààng-à ~ -kàrááng-á 'to fry / and then fried'
ii. kʊ́-déèk-à ~ -dèèk-á 'to cook / and then cooked' (Odden 2018, Pak 2019)

The alternation with *karaang*-class verbs is our challenge: some tones go from H to L while others go from L to H, so this cannot be a case of simple tonal affixation.

Odden (2018) explains this pattern—and other tense-mood-aspect forms (TMAs) in Logoori—with the assumptions in (43)a-e. I have formalized his proposal to fit the DM framework here but preserve its core. The relevant tone alternations are achieved by a combination of H-tone affixation (43)b and a *morphophonological* H-lowering rule (43)c.

(43) Derivation of Logoori infinitive and consecutive (adapted from Odden 2018)

	INFINITIVE		CONSECUTIVE	
a. *bʊrʊk*-class verbs are toneless; *ka̲raang*-class has underlying H on first vowel.	-bʊrʊk-a	-ká̲raang-a	-bʊrʊk-a	-ká̲raang-a
b. CONSECUTIVE morpheme is a floating-H suffix. INFINITIVE does not insert a tone.	---	---	-bʊrʊk-a-Ø$^{(H)}$	-ká̲raang-a-Ø$^{(H)}$
c. Underlying H of *ka̲raang*-verbs lowers to L in CONSEC. (but not INFIN.).	---	---	-bʊrʊk-a-Ø$^{(H)}$	-kà̲raang-a-Ø$^{(H)}$
d. A floating tone docks on µ2 if that vowel doesn't already have a tone, otherwise on the final vowel.[10]	---	---	-bʊrʊ́k-a	-kà̲raang-á
e. An H tone spreads leftward through toneless vowels until it hits another tone, by a general phrasal rule (44)a.	---	---	-bʊ́rʊ́k-a	-kà̲rááng-á
f. Toneless vowels get default L.	-bʊ̀rʊ̀k-à	-ká̲ràànġ-à	-bʊ́rʊ́k-à	---

The H-lowering effect in (43)c is *morphosyntactically* constrained. It applies in only some TMAs, e.g. consecutive, negative subjunctive and indefinite future but not infinitive, remote future or recent past (Odden 2018). Moreover—despite initial appearances—H-lowering does not reflect a general HH dissimilation strategy in Logoori. In phrasal contexts, HH sequences are resolved by downstep of H_2, not lowering of H_1:

(44) Logoori leftward H-spread and downstep (Odden 2018:73)
  a. kʊ-gʊra 'to buy' + macú̲unga 'oranges' → kʊ́-gʊ́rá mácú̲ùngà 'to buy oranges'
  b. kʊ-vʊ̲́gʊra 'to receive' + macú̲unga 'oranges' → kʊ́-vʊ̲́ꜜgʊ́rá mácú̲ùngà 'to buy oranges'

Even in word-internal contexts, HH sequences are not always resolved by lowering H_1. For example, if H_1 is pre-linked to an object prefix and H_2 to a verb root, it is H_2 that becomes L: *kʊ + vá̲ + vá̲riza → kʊ́-vá̲-và̲rìzà* 'to count them' (Meeussen's rule, Odden 2018:73-74). Furthermore, H-lowering sometimes applies even in the absence of a 'triggering' H_2. In the negative subjunctive, for example, *ka̲raang*-class verbs do not get a floating-H suffix but the H on their first vowel lowers anyway. Consequently, they surface as L-toned throughout: *ù-tà-kà̲ràànġ-à* 'you shouldn't fry (it).'

How do we deal with cases of morphosyntactically constrained phonology like Logoori H-lowering? In §5.1 I present an analysis that uses **readjustment**, the same kind of operation that is hypothesized to be responsible for e.g. *sing~sang, ke̲e̲p-ke̲pt*, etc. in Halle & Marantz 1993, Embick & Noyer 2001 and others).

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[10] Goldsmith 1991 explains this 'µ2/FV' tone-attraction pattern with metrical-grid principles (see also Pak 2019). Simplifying somewhat: A line-2 accent is added to µ2 of the metrical grid iff there is no line-2 accent already on µ1. Suffixal floating tones are attracted to the vowel with the highest accent on the metrical grid, then to the final vowel.

Then I present two alternative DM-based analyses of replacive GT that do not use readjustment (§§5.2-5.3). There are no doubt additional possibilities beyond these; this is an active area for future research.

5.1 Irregular GT as Readjustment

Since its earliest instantiations, DM allows for a class of **readjustment** rules (i.e. morphophonological rules), which render phonological changes in morphologically limited contexts. Probably the best-known examples of readjustment rules (RRs) are those that produce vowel alternations in the English past tense (*sing~sang*, *keep~kept*, *mean~meant*, etc.). Additional examples from Embick & Shwayder 2018 include:

(45) a. English fricative voicing (e.g. shel**f** ~ shel**v**e (*n/v*), wol**f** ~ wol**v**-es (SG/PL))
  b. German umlaut (e.g. f**u**s ~ f**y**s-e 'foot.SG/PL')
  c. Spanish diphthongization (e.g. p**e**ns-ar ~ p**je**ns-o 'to think/I think')

RRs are assumed to apply after VI but still relatively early in PF, before the general phonology (see (6)). In the updated analysis (from (43)) below, a RR achieves the H-lowering effect from (43)c:

(46) a. Vocab. insertion: [CONSECUTIVE] ↔ -Ø$^{(H)}$ -bʊrʊk-a-Ø$^{(H)}$ -káraang-a-Ø$^{(H)}$
  b. Readjustment: H → L / [… __] + [CONSECUTIVE][11] --- -k**à**raang-a-Ø$^{(H)}$
  c. Gen. phonology: tier-association, H-spread, default L -bʊ́rʊ́k-à -kàrááng-á

Notice the parallelism between the derivation in (46) and the derivation of the past-tense of English *mean* below. This parallelism is of course expected under the assumption that suprasegmental morphology undergoes the same PF operations as segmental morphology.

(47) a. Vocab. Insertion: T[+PAST] ↔ -t / X + __, X = √MEAN, √FEEL, √SPILL… [min]-**t**
  b. Readjustment: i → [-high -tense] / [... __ ...]$_X$ + [PAST],
   X = √MEAN, √READ, √MEET… [m**ɛ**n]-t
  c. Gen. phonology: flapping, glottalization, etc. I [mɛ**ɾ̃**] it.

Notice also the parallelism between the RRs in (46)b and (47)b. These look like ordinary phonological rules up to the slash; then we see that they are arbitrarily restricted to specific morphosyntactic contexts. There is no synchronically apparent reason *why* H should lower in the consecutive and negative-subjunctive but not the infinitive or remote-future, nor any reason why [i] should become non-high in [+PAST] but not [-PAST] (or in *mean* and *keep* but not *wean* or *seep*). RRs are a means of representing this kind of arbitrary conditioning, while still treating the alternation itself as a phonological change rather than full suppletion.

Readjustment represents a mechanism for *limited* process-based morphology in a primarily piece-based theory. It does not represent a free pass to invoke morphophonology at any point in an analysis. Since RRs are hypothesized to apply early in PF, as subwords are undergoing phase-cyclic spell-out and linearization, they are subjected to strict locality conditions; see Embick & Shwayder 2018 for one proposal. H-lowering in the Logoori consecutive does appear to apply locally: its trigger [CONSECUTIVE] is a TMA morpheme that can 'see' H on the verb from the previous cycle. Moreover, H → L itself is a well-precedented phonological rule, with counterparts in many two-tone Bantu languages (Hyman & Katamba 1993, Odden 2015).

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[11] The condition for this RR is read as: '…iff H is the rightmost tone in the spellout domain of [CONSECUTIVE].' The H exponent of [CONSECUTIVE] itself is not affected by this RR.

Still, it is always worth asking if readjustment is necessary for a given analysis. Readjustment represents something extra for the speaker to learn; in this way RRs are unlike vocabulary-insertion rules, which have to be learned for every morpheme as a matter of course. Thus, '[a]ll other things being equal, a piece-based analysis is preferred to a Readjustment Rule analysis when the morpho-syntactic decomposition justifies a piece-based treatment' (Embick & Halle 2005:29).

Can the Logoori pattern be analyzed without RRs? The answer appears to be: up to a point, and with potential drawbacks. The reanalysis would involve treating *all* verb tones, including initial H on *ka̱raang*-class verbs, as exponents of TMA suffixes. This will enable the H~L alternation on *ka̱raang*-verbs to be treated allomorphically rather than phonologically.

To start, instead of having underlying H, *ka̱raang*-class verbs could be distinguished by an underlying accent on the first mora; this accent will effectively override the default µ2 tone-attraction pattern (cf. (43)d). Then we can use allomorphy (conditioned by verb class) to explain why *karaang*-class and *bʊrʊk*-class verbs surface with different tones. A derivation is shown below.

(48) Revised derivation of Logoori infinitive and consecutive, with no RRs

	INFINITIVE		CONSECUTIVE	
a. *Karaang*-class has UR accent on µ1; *bʊrʊk*-class does not.	-bʊrʊk-a	-ka͓raang-a	-bʊrʊk-a	-ka͓raang-a
b. Vocabulary insertion (49)	-bʊrʊk-a-Ø	H -ka͓raang-a-Ø	H -bʊrʊk-a-Ø	LH -ka͓raang-a-Ø
c. Metrical grid construction; tier-association (see note 10)	---	H -ka͓raang-a-Ø	H -bʊrʊk-a-Ø	LH -ka͓raang-a-Ø
d. H-spread; default L	-bʊ̀rʊ̀k-à	-kárààng-à	-bʊ́rʊ́k-à	-kàrááng-á

(49) Vocabulary items under revised 'no-RR' analysis:

a. [INFINITIVE] ↔ -Ø$^{(H)}$ / X + __, where X has line-2 mark on the metrical tier
-Ø

b. [CONSECUTIVE] ↔ -Ø$^{(L)(H)}$ / X + __, where X has line-2 mark on the metrical tier
-Ø$^{(H)}$

While this reanalysis works so far, it is important to note that it requires us to treat L as a *phonemic* tone—a base form in the exponent of CONSECUTIVE (49). This is potentially problematic, since it has been argued elsewhere that L tone is always derived in Logoori (Marlo 2008:155, Odden p.c.). If L were phonemic, we would expect it to be more freely distributed through the vocabulary than it is. See also Hyman 2000.

Another problem is that this no-RR analysis does not work straightforwardly across the full range of TMAs. Crucially, there are a few TMAs where the distinction between the two verb classes is neutralized, and suffixal H surfaces in an unexpected position in both classes. In the remote past, for example, both *karaang*-class and *bʊrʊk*-class verbs get H on their first syllable, whether that syllable is a short or long vowel:

(50)		*Remote past*	*cf. Consecutive*
	a.	nd-áá-**várìz**-à ‘I counted’	**-váríz**-à ‘and then counted’
		nd-áá-**sóóm**-à ‘I read.PAST’	**-sóóm**-à ‘and then read’
	b.	nd-áá-**káràànɡ**-à ‘I fried’	**-kàráánɡ**-á ‘and then fried’
		nd-áá-**déék**-à ‘I cooked’	**-dèèk**-á ‘and then cooked’

This exception to the usual tone-association pattern suggests that Logoori metrical-grid and tone-association principles are tweaked in TMA-specific contexts. The trouble is that the requisite tweaking—e.g. deleting or shifting the underlying accent on *karaang*-class verbs, invoking a TMA-specific instruction to assign accent (or tone) to σ1 instead of μ1 or μ2—end up essentially being just another kind of RR. It seems that morphosyntactically restricted phonology is inescapable here. See Pak 2019 §4 for more potential problems with this ‘no-RR’ reanalysis.

I am aware of two DM-based proposals that analyze replacive tone without readjustment: Rolle 2018 and Sande et al. 2020. As pointed out in footnote 2, while these proposals adopt some core DM assumptions (e.g. cyclic spellout of morphosyntactic structures, postsyntactic VI), they diverge significantly from the architecture in (6).

5.2 Irregular GT as a cophonology inducing paradigm uniformity (Rolle 2018)

In common with the current proposal, Rolle (2018) assumes cyclic spellout of morphosyntactic structures with VI driving piece-based morphology. His analysis of affixal tone (like the cases we saw in §2, which he calls *non-dominant GT*) does not differ radically from mine: these tones are added by VI, and are placed as expected given the general phonology of the language.

To analyze replacive tone (or *dominant GT*, as he calls it (approximately)), Rolle relies crucially on the assumption that the various PF operations in (2) take place in parallel via constraint rankings, rather than serially. In this hybrid ‘OT-DM’ approach, certain vocabulary items (namely, those that trigger replacive tone) can be specified with a special cophonology—a subranking that overrides the default constraint ranking of the language. More specifically, replacive-tone-triggering morphemes have cophonologies with a high-ranked output-output constraint inducing uniformity across a paradigm. The effect of this cophonology is to ‘extract the most common structure,’ meaning that no tones are preserved (p. 180).

The proposal can be illustrated with the Kalabari demonstrative (21) *mí*, which appears to wipe out the tones on its complement and replace them with a LH melody:

(51)	a.	námá	mí nàmá	‘meat/this meat’
	b.	pùlò	mí pùló	‘oil/this oil’
	c.	bélè	mí bèlé	‘light / this light’

The vocabulary item for the demonstrative in Rolle 2018 is specified with a paradigm-uniformity-inducing cophonology, whose effect is to preserve the root’s segments but not its tones (e.g. *nama, pulo, bele,* etc.). The phonological exponent inserted for the demonstrative consists of the segments [mi] pre-linked to H, followed by two floating tones:

(52) H (L)(H)
|
mi

The floating tones (L)(H) introduced by this VI are mapped to the now-toneless root according to general tone-association principles.

Aside from the significant architectural differences underlying Rolle 2018 and the model presented here, the proposals diverge in several ways. Based on a large empirical sample, Rolle argues that there is a general tendency for dominant GT to pattern as it does in Kalabari—erasing tones on the stem and inserting a new tonal melody—and his theory accounts for this tendency directly. Under my proposal, while tone-deletion could be effected by a RR, this deletion would be treated as an idiosyncratic language-specific rule; there would be no expectation that it would be cross-linguistically prevalent. On the other hand, the Logoori reanalysis at the end of §5.1 might be taken as a sign that replacive GT cannot always be reduced to extracting a most-common structure and inserting tonal affixes.

It is also worth noting that many of the cases examined by Rolle 2018 involve morphosyntactic conditioning across an apparent word boundary—e.g. a prenominal adjective or possessor inducing replacive-tone alternations on a following noun. This kind of alternation cannot be attributed to readjustment *per se* as it is envisioned in Embick & Noyer 2001, Embick & Shwayder 2018, etc., since readjustment applies only during spellout of the *internal* contents of complex heads (i.e. it is ‘M-word internal’). In Pak 2008 I offer a theory of phrasal phonology that allows some (‘Type 1’) rules access to morphosyntactic information; the tone-erasure effects described in Rolle 2018, as well as McPherson & Heath 2015, appear to follow the locality constraints I proposed for these Type 1 rules. The insertion of the new tonal melody could still be treated as VI with floating-tone exponents, as in (52).

Both proposals reviewed so far aim to maximize the use of piece-based morphology (tonal affixation with VI) and constrain the use of processes. A somewhat different approach is taken by Sande et al. 2020, addressed next.

5.3 Irregular GT as language-specific cophonology (Sande 2017, Sande et al. 2020)

Like Rolle 2018, Sande et al. 2020 adopt a hybrid OT-DM architecture with morpheme-triggered cophonologies. While Rolle uses cophonologies only to induce tone erasure via paradigm uniformity, Sande et al. allow cophonologies to introduce a wider range of process-based interactions.

Sande et al. describe (among other case studies) a scalar tone alternation involving the Imperfective in Guébie (Sande 2017). Guébie has four tones, 1=lowest and 4=highest. The Imperfective is usually realized by lowering the tone of the first syllable of the verb by one level:

(53)	ju^4 gb**a**$^{\mathbf{3}}$la^4 si^3	~	ju^4 gb**a**$^{\mathbf{2}}$la^4 si^3
	boy climb.PERF tree		boy climb.**IMPERF** tree
	‘A boy climbed trees.’		‘A boy climbed trees.’
(54)	e^4 li$^{\mathbf{3}}$ ɟa^3-ɓə^1	~	e^4 l**i**$^{\mathbf{2}}$ ɟa^3-ɓə^1
	I eat.PERF coconut		I eat.**IMPERF** coconut
	‘I ate a coconut.’		‘I am eating a coconut.’

If the verb already begins with tone 1 (i.e. the lowest tone available), then Imperfective is realized by *raising* the tone of the final syllable of the preceding *subject*—producing a displacement effect reminiscent of the Igbo subordinate-marker behavior described in §2.3.

(55) ɛ̱$^{\mathbf{3}}$ ɓɔ^{1} ~ **ɛ̱**$^{\mathbf{4}}$ ɓɔ^{1}
it wither.PERF   it wither.**IMPERF**
‘It withered.’   ‘It withers.’

(56) ju^{4} [e^{4} ji^{2} ne̱^{2}] pa^{1} ~ ju^{4} [e^{4} ji^{2} n**e̱**$^{\mathbf{3}}$] pa^{1}
boy I know REL run.PERF   boy I know REL run.**IMPERF**
‘The boy that I know ran.’   ‘The boy that I know runs.’

If the verb underlyingly begins with tone 1 *and* the subject underlyingly ends with tone 4, the subject’s final 4 raises to a super-high tone 5, which does not occur anywhere else in Guébie.

(57) **e̱**$^{\mathbf{4}}$ pa^{1} ~ **e̱**$^{\mathbf{5}}$ pa^{1} ‘I ran/run’

Sande et al. 2020 argue that the Imperfective morpheme T[IPFV] triggers a cophonology that promotes the (otherwise relatively low-ranked) anti-faithfulness constraint PITCHDROP. Crucially, having PITCHDROP outrank the faithfulness constraints IDENT-T(R,φ) and IDENT-T, but still be outranked by 0* (‘no super-low tones’), enables the final tone of a subject to surface one step higher iff the verb is tone 1.

(58) PITCHDROP: ‘Assign one violation for each sequence of consecutive prosodic phrases whose shared edge is not associated with more of a pitch-drop in the output than in the input.’
>> IDENT-T(R,φ): An output tone at the right edge of a prosodic phrase boundary is identical to its corresponding input tone.
>> IDENT-T: An output tone is identical to its corresponding input tone.

The proposal leaves open just what kinds of constraints a morpheme-specific cophonology can promote. For example, PITCHDROP makes specific reference to the shared edge of two prosodic phrases, thus accounting for the fact that only those syllables are ever affected by T[IPFV]—but the fact that those two syllables are immediately adjacent to the *morpheme* T[IPFV] is a coincidence. The cophonology induced by T[IPFV] makes no reference to the syntactic locus of T[IPFV]; it refers only to prosodic phrases.

If the scalar tone-shifting effects seen here could be analyzed in a piece-based way, the pattern could be analyzed along the same lines as Igbo [SUB] (to which it bears a striking structural resemblance; see §2.3, §3). Floating-tone allomorphy (§4) might explain why T[IPFV] has a lowering effect in some contexts and a raising effect in others: the VI for T[IPFV] might, for example, insert a floating 4 (high) tone iff the following tone is 1 (low), and otherwise insert 1. Many facts would remain to be explained—e.g. why the inserted tones always induce a scalar (one-step) shifting effect, why derived 4+1 tones don’t *generally* surface as level-3 tones in Guébie (Hannah Sande, p.c.), and why the allomorphs dock in different directions (one leftward, one rightward). I reluctantly leave these questions for future work.

6. Summary and conclusion

The primary goal of this chapter has been to lay out an explicit model that DM practitioners can use to analyze suprasegmental morphology. I have focused primarily on grammatical tone, a widespread phenomenon that has until recently received little attention in the DM literature.

Over the course of the chapter I addressed two sub-goals. First I tried to dispel the misconception that suprasegmental morphology is by definition process-based and therefore problematic for piece-based theories like DM. Independently-motivated principles of autosegmental theory enable suprasegmentals to be analyzed in a piece-based way, and are easily folded into the DM architecture (§§1-3).

I then tested the model out on some more complex cases of grammatical tone, which arguably involve suppletive allomorphy (§4) or irregular 'replacive' tone (§5). Such phenomena raise a *bona fide* piece-or-process question: 'Do *certain cases* of suprasegmental morphology call for a process-based analysis, and if so, by what means is this to be achieved?' My goal here was to demonstrate how we can appeal to the same PF operations and principles to understand suprasegmental morphology as we do for segmental morphology—i.e., segmental and suprasegmental morphology are not qualitatively different and call for the same analytical tools. The success of this approach, compared with the somewhat different approaches taken by Rolle 2018, Sande et al. 2020, and others, is a question for future research.

Acknowledgements

Many thanks to the editors of this volume, my anonymous reviewer, David Embick, David Odden, and my audiences at LSA 2019, FLYM 5, LCUGA 5, and the 2020 Emory Linguistics Faculty Colloquium, for helpful feedback and discussion. I would also like to thank the Fall 2018 Field Methods in Linguistics class at Emory, my co-instructor Yun Kim, and our generous Logoori language consultant. All errors are of course my own.

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