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Gestalt Contours, Polarity and Construction-specific Phonology in Gaahmg

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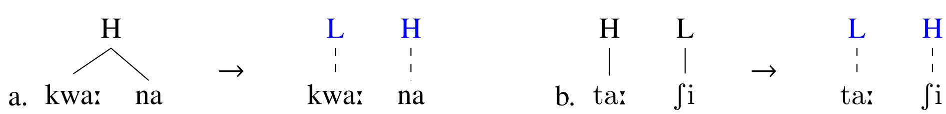
In this paper, I provide a new type of evidence for sub-tonal features (Yip 1980, 2002; Bao 1999) from the Eastern Sudanic language Gaahmg (Stirtz 2011): Gestalt contour formation where specific morphological categories change the tone of a base word to a falling contour, but with different absolute tone values (High-Mid, Mid-Low, and High-Low) depending on the input tone. I show that the three different Gestalt contours in Gaahmg can be captured succinctly via feature affixation using Register Tier Theory (Snider 1990, 1998, 1999), and that this analysis receives independent support by other general patterns in the morphophonology of the language. Thus, following McPherson (2017) and Meyase (2021), the paper undermines the major objection against tonal feature geometries that they lack broad support in language-specific tonal grammars (Hyman 2010; Clements, Michaud & Patin 2011). By developing a virtually complete tone-affixation analysis of Gaahmg's tonal morphology in Autosegmental Colored Containment Theory (Trommer 2015; Zaleska 2020; Paschen 2021), the paper also provides evidence for the viability of this formalism in the context of the Generalized Nonlinear Affixation (GNA) program to reduce all productive non-concatenative morphology to affixation of partial phonological representations (Bermúdez-Otero 2012).

Keywords: *tone; feature geometry; non-concatenative morphology*

1 Introduction

Cases of complete and unconditional tonal overwriting have played an important role in theoretical discussions of tonal morphology (see e.g., Inkelas 1998, 2014, 2018; Hyman & Olawsky 2004; McPherson & Heath 2016; Rolle 2018). For example, in Hausa, the imperative is formed by imposing a L(ow)H(igh) melody on verbs of any underlying tone (e.g. /kwáːná/ → [kwàːná] 'spend the night!', /táːʃì/ → [tàːʃí] 'get up!', Newman 2000:262–263):

(1)


The type of tonal morphology I discuss here may also be understood as a type of overwriting by a fixed pitch contour, but at a more abstract level. Underlying base tones are replaced by a specific pitch contour, but this contour cannot be captured by fixed tonal values. Thus Causative formation in Gaahmg uniformly

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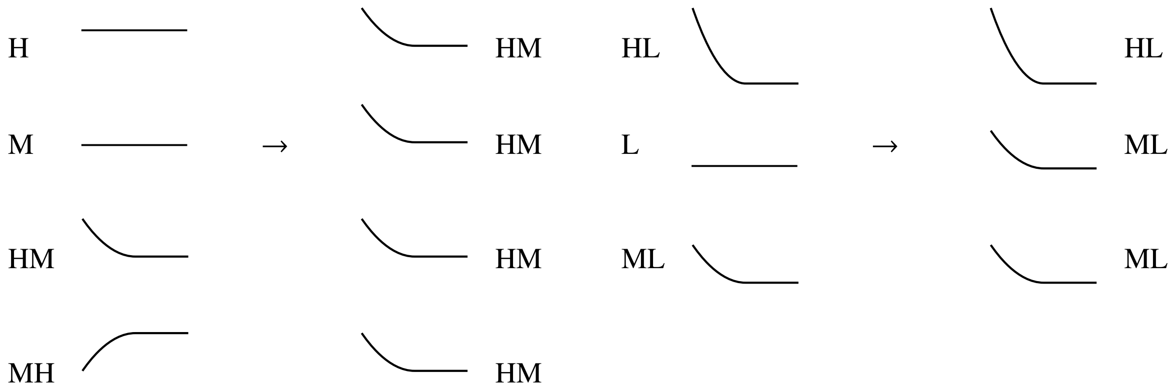
transforms the lexical tone melodies of verbs into falling contour tones. However, the specific resulting contour is either High-Mid, High-Low or Mid-Low depending on the underlying base tone:

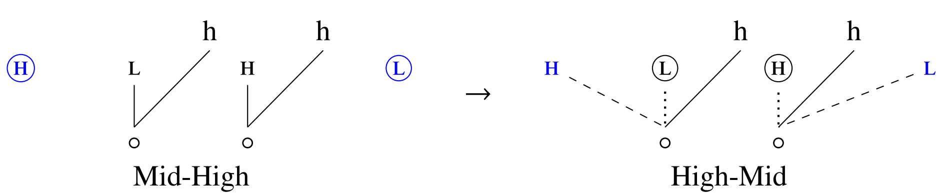
(2) Gaahmg Causative tone change



Unlike the Hausa case, overwriting here is neither complete nor unconditional. It is sensitive to, and shows traces of the underlying base tones since intuitively higher-register inputs (e.g. /H/) lead to higher-register outputs ([HM]), and lower inputs to lower outputs (e.g. /L/ to [ML]). This type of tonal morphology which I will call in the following *Gestalt Contour Formation* has to my best knowledge remained unnoticed in the theoretical literature so far.[1] Here, I will argue that it provides a new type of evidence for sub-tonal features in a tonal feature geometry where the register features (l(ow)/h(igh)), melody features (L(OW)/(H)IGH) and tonal root nodes are located on separate tiers and 'full tones' (i.e., the phonetically observable H and L tones) are composites of a tonal root node with 'subtones' (i.e., melody and register tones) as assumed in Register Tier Theory (Snider 1999).

For the Causative, I will show in section 4 that it falls out from a tonal H- -L circumfix which overwrites (and partially extends) the melody tones of the base. This is illustrated for a MH verb in (3) and a HL verb in (4), where Low amounts to the combination [L,l], High to [H,h], and [L,h] is a Mid tone (tiers are indicated by different vertical alignment, inserted association lines by dashing, and deleted association lines by dotting). Thus in (3), replacing the L melody tone of the Low by H results in a High, whereas supplanting melody H in the following High by L creates a new Mid (unassociated floating sub-tones are indicated by circles and not pronounced):

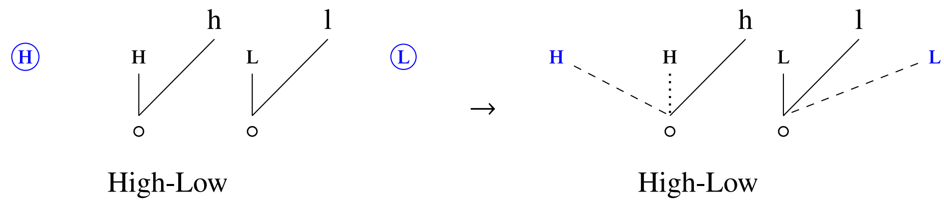
(3) Causative overwriting (MH-verb)



For an underlying HL-melody, attaching H and L is vacuous under the assumption that multiple identical melody tones on a single root nodes have the same phonetic interpretation as a single melody tone:

[1]The use of the word *Gestalt* (originally German: 'pattern, shape') here loosely follows its interpretation in Gestalt psychology (see Ellis 2013 for an synopsis), where it is used to designate global patterns of perception which cannot be captured in terms of the units which constitute the pattern. Similarly, the Gaahmg tone patterns discussed here have a characteristic shape that cannot be simply described by a combination of H, L and M.

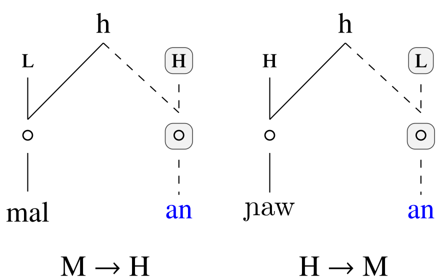
(4) (Vacuous) Causative overwriting (HL-verb)



Building on the analysis for the Causative, I demonstrate that this approach can be extended to two other global contours in Gaahmg, the non-rising (Mid level or Mid-Falling) shape of Verbal Nouns (section 4.2) and a partially polar falling pattern with a fixed final Low (Mid-Low or High-Low) in the Genitive (section 5.3) under the assumption that they combine full-tone and sub-tone affixation.

Going beyond Gestalt contours, the paper provides several additional types of support for subtonal features. I show that the assumed tonal representation also accounts for general tonal alternations in the language as well as for additional polarity patterns. Thus the Antipassive suffix -[an] systematically exhibits different tones after singleton verb tones (M after H and L, and H after M). This can be captured by the assumption that the suffix receives an epenthetic tonal root node which shares the register of the stem tone, but receives a melody tone which is the opposite of the one carried by the stem tone (H after L, and L after H) establishing a similar kind of subtonal polarity as established by Meyase (2021) for Tenyidie. I illustrate this in (5) for the verbs [māl] 'gather' and [ɲáw] 'request' (cf. [māl-án-sá] '(s)he gathers' and [ɲáw-ān-sá] '(s)he requests'; Stirtz 2011:205):

(5) Subtonal polarity



Moreover, the feature geometry explaining Gestalt contours and polarity also accounts for cases of construction-specific phonology in the Subjunctive (section 6.1) and Incompletive paradigms (section 6.2). These alternations can be derived as Emergence of the Unmarked effects (McCarthy & Prince 1994), triggered not by construction-specific constraints, but by the availability of affixal subtonal features which allow for exceptional constraint repairs and remain unrealized otherwise. Thus in the Incompletive, a marked Mid-High contour is repaired by lowering the H (e.g., the Incompletive 3SG /cɔ̄r/ 'help'+ /H/ 3SG → cɔ̄r+M = [cɔ̄r] '(s)he helps'; Stirtz 2011:195) whereas MH is apparently freely allowed in nouns and other verb paradigms (e.g., the Continuous Past 3SG which contains two consecutive MHs: [kə̄ə̄́-ə̄ń] '(s)he strikes'; Stirtz 2011:196). The morphological conditioning of the H-lowering pattern is captured by a melody L suffix specific to the Incompletive which replaces the H of the High, but only if it is triggered by the relevant markedness constraint against Mid-High sequences. More generally, the paper provides a further crucial type of evidence for sub-tonal representations: An important argument against tonal feature geometries of the influential papers by Hyman (2010) and Clements et al. (2011) has been that analyses using them in the previous literature are based on isolated phenomena for any given language, and lack independent language-specific evidence. But since feature geometries are not specific to a particular phonological construction or alternation we would expect that it emerges throughout the phonological system of a given language wherever relevant. As I will show, Gaahmg, in line with recent work by McPherson (2017) and Meyase (2021), provides just this: The geometry used for Gestalt contours also accounts for subtonal polarity and other morphophonological processes and is fully compatible with the analysis of general phonological alternations such as Chain Lowering (see section 3.2). To establish this point, the paper thus also provides a comprehensive formal analysis for the tonal morphology of Gaahmg integrating all morphological categories expressed by tone and the big majority of tonal alternations in the language. in the framework of Autosegmental Colored Containment Theory (Trommer 2015, 2022; Zaleska 2020; Paschen 2021).

Finally, since all morphophonological effects (Gestalt Contours, polarity and construction-specific phonology) are achieved without any morpheme-specific phonology, the paper also provides additional evidence for the viability of the Generalized Nonlinear Affixation (GNA) program to reduce all productive non-concatenative morphology to concatenative affixation of defective (partial) phonological representations (Bermúdez-Otero 2012). As I will show in section 7, Gaahmg employs all types of defective structure predicted by the tonal feature geometry—underspecified tonal root nodes and underspecified TBUs (as in the polar patterns in section 5), floating subtonal features (as in the Causative analysis shown in (3) and (4)) and floating full tones (see section 3.1 on tonal subject agreement).

The paper is structured as follows: Section 2 provides basic theoretical background on subtonal features and the version of Optimality Theory employed in the analysis, Autosegmental Colored Containment Theory. Section 3 applies this framework for an analysis of full-tone affixation in Gaahmg and the concomitant major subtonal alternation in Gaahmg, Chain Lowering. Based on these foundations, section 4 develops the account of the two monotonic Gestalt patterns in the language in Causative and Verbal Noun formation. Section 5 extends the analysis to a Gestalt pattern in the Genitive which exhibits additional polarity effects and integrates it with a more general account of polarity and dissimilation phenomena in the language. That the analysis also accounts for construction-specific phonological alternations is shown in section 6. Section 7 relates the Gaahmg data to a broadly similar case in Guébie, and shows that affixation of subtonal features provides a better approach to both languages than full tone affixation, scalar features and construction-specific phonology.

2 Background

2.1 The phonological system of Gaahmg

Gaahmg (also referred to as Ingessana, Gaam and Tabi, Ethnologue code [tbi]) is an Eastern Sudanic, Nilo-Saharan, language spoken in the Blue Nile Province in Sudan, close to the border to Ethiopia. The only detailed description of the language is the recent grammar by Stirtz (2011), which is also the source of all data discussed in this paper. The two most pervasive segmental alternations visible in the data discussed in this paper are the weakening of consonants and vowel harmony. Stops are lenited to glides intervocalically (e.g., /àb/ 'sit' → [àw-án] '(s)he was sitting (INC.CONT)', cf. [àb̥ː] 'to sit', and /káɟ/ 'bring' → [káj-án] '(s)he was bringing (INC.CONT)', cf. [káɟ̊ː] 'to bring'; Stirtz 2011:176).[2] Syllable-finally, non-geminate stops and glides vocalize (e.g. /àb/ 'sit' → [àɔ̄] '(s)he was sitting (INC)' [àɔ̄-d̪ɔ̄] '(s)he would sit (SBJ)', /káɟ/ 'bring' → [káɛ́] '(s)he was bringing (INC)', and /kɔ́j/ 'cook' → [kɔ́ɛ̄] '(s)he was cooking (INC)' cf. [kɔ́jː] 'to cook'; Stirtz 2011:176,182). The vowel inventory of Gaahmg is a symmetric 6-vowel system with 3 [+ATR] ([i], [ə], [u]) and 3 [-ATR] vowels ([ɛ], [a], [ɔ]). There is exceptionless [ATR]-harmony in prosodic words based on dominance of [+ATR] morphemes (e.g. /[cīg-sá]/ → [cīg-sə́] '(s)he did wear (COMP)', /wár-ì/ → [wə́r-ì] '(s)he takes him'; Stirtz 2011:58). There is also frequent rounding harmony triggered by roots on suffixes (/[lɔ̀f-sá]/ → [lɔ̀f-sɔ́] '(s)he does magic'; Stirtz 2011:186) but with lexically conditioned exceptions (e.g., [cɔ̄r-sə́] '(s)he helps'; Stirtz 2011:194).

[2] I use the following glosses for Gaahmg examples: COMP = Completive, CONT = Continuous, INC = Incompletive, O = object.

Stirtz (2011) shows in detail that the morphophonology of Gaahmg distinguishes three different word (or sub-word) domains: ① lexical roots ② lexical roots combined with derivational and inflectional affixes and ③ combinations of bare or affixed roots with clitics such as object markers and copulars. Stirtz (2011) refers to these domains as roots, stems and words. Here I will assume that they rather correspond to the three standard strata of Stratal Optimality Theory (Bermúdez-Otero 2018): ① Stem Level ② Word Level and ③ Phrase Level where the fact that clitics undergo partially the same phonological processes as affixes (e.g., ATR-harmony) follows from the assumption that they form a Phonological Word together with the morphosyntactic words to which they attach. The phonological difference between affixation and cliticization can be illustrated with lengthening of subminimal roots: Monosyllabic roots with open short vowels undergo vowel lengthening in forms without segmental affixes (e.g., the root /pā/ 'guard' in [pāː] '(s)he guards (INC)'). Adding affixes blocks lengthening (e.g., [pā-d̪] 'to guard' and [pā-án] 's(he) guarded (INC.CONT)'), but cliticization applies to the lengthened form ([pāː-ɛ́̄] '(s)he guards him/her (INC)'; Stirtz 2011:176). This follows directly if the Infinitive suffix -[d] and the Continuous suffix -[an] are added at the Word Level where lengthening applies, whereas the 3SG object clitic -[ɛ] is added postlexically after lengthening of the subminimal root.

In the description given by Stirtz (2011:44), Gaahmg has three contrastive level tones H(igh), M(id), and L(ow) (cf. the minimal triplet [ə́ːr] 'tree, bark', [ə̄ːr] 'anger', [ə̀ːr] 'sheep'). However, I will show below that phonologically there are two types of Mid tones in underlying forms and as the effect of morphological and phonological processes which behave systematically differently in the morphophonology of the language. Instrumental acoustic evidence will have to show whether this distinction is also reflected in the acoustic signal or phonetically fully neutralized. H, M and L can in principle be freely combined to form two-tone and three-tone contours on single syllables, but again with specific restrictions on different stratal domains. Thus simplex roots (stems) can only have a lexical two-tone contour whereas tonal affixation often results in three tones (e.g., /[kə̄ə̄́]/ 'strike' + [-3] Mid → kə̄́ə̄ 'I am striking' in Stirtz 2011:195). In section 3, I will argue that also the two different M tones obey specific restrictions in their cooccurrence with other tones in roots.

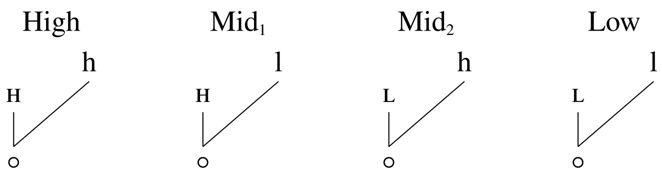
The central tonal alternations in Gaahmg are a major focus of this paper and will be introduced step-by-step below. There are only three areas of Gaahmg tonal morphophonology not addressed in detail in this paper since they seem to be largely independent from the processes discussed here: regular noun plurals (Stirtz 2011, section 6.3), specific contour simplification processes which emerge only in the context of the Continuous suffix (because it is the only segmental affix with an underlying contour tone; Stirtz 2011, section 9.8.6), and the tonal behavior of clitics (Stirtz 2011, sections 9.7 and 10.42).

2.2 Subtonal Features: Register Tier Theory

For languages with three or more tones, it is a natural assumption that tones are not only independent from segments (i.e., 'autosegmental'), but also just like segments composed of features on different autosegmental tiers, i.e., have subtonal features. Subtonal features allow a succinct formalization of alternations where tones form natural classes. Thus, as pointed out by van der Hulst & Snider (1993), tone features account for the fact that in some languages downstep is triggered not only by Low, but also by Mid tones while in others Mid tones (but not Low tones) may undergo downstep just like High tones. Subtonal features also capture partial tone assimilation such as in Babanki (Akumbu 2011; Nformi 2018), where a Low tone is raised to a Mid tone before a High tone, or cases of tone fusion where High and Low tones merge into Mid tones. The approach to subtonal features I will adopt here is the one by Snider (1999), Register Tier Theory (RTT), which unifies subtonal representation with an explanatory account of register, in particular downstep and upstep phenomena. A specific advantage of this formalism for a Containment-based approach to tone is that non-automatic downstep is not represented by floating Low tones (Pulleyblank 1986), which would run counter to the basic Containment assumption that floating material is inherently unpronounced (invisible to phonetic interpretation, see section 2.3 below). Instead downstep is captured uniformly by register features associated to tonal root nodes. Since Gaahmg doesn't have downstep or upstep, I will not discuss this aspect of the theory here. However, the conception of register features as operating recursively on the register of pitch in a given utterance will be shown to be crucial for the extension of RTT to Gestalt-like patterns in other languages in section 7.1.

In RTT, tones are composites of the melody tones H and L and the register elements h and l on different tiers linked by association to tonal root nodes ("○") on a third independent tier, resulting maximally in a 4-tone system as shown in (6):

(6) Tone in Register Tier Theory (RTT) (Snider 1999)



Since the effects of this geometry are most transparent in a system with four tones, I will illustrate its application with an example from the Tibeto-Burman language Tenyidie (Meyase 2015, 2020) which has phonemic Low, Mid, High and Extra-High tones. Many suffixes in Tenyidie such as the present continuous affix -[bɑ] show register harmony with the tone of the preceding verb base. If the root has a final higher-register tone (i.e., Mid or Extra High), the suffix is also higher, i.e., has an Extra High tone (7a,b); On the other hand if the root has a final lower register tone (High or Low), the suffix tone is High (7c,d).

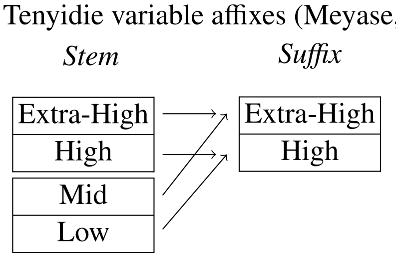
(7) Tenyidie subtonal assimilation (Meyase 2015:67)

a. pētɑ̋	'drive'	pētɑ̋-bɑ̋	'drive'-PRES.CONT
b. rəd̄ī	'change'	rədī-bɑ̋	'change'-PRES.CONT
c. rəlí	'rest'	rəlí-bɑ́	'rest'-PRES.CONT
d. pēl	'believe'	pēlè-bɑ́	'believe'-PRES.CONT

		Register	
		low	high
Melody	High	V́	V̋
	Low	V̀	V̄

The challenge this pattern poses to any theory where tones have no internal structure is that tonal change doesn't target a fixed output tone for all input tones. Moreover, it is also not a chain shift, which could be captured by shifting each tone to a higher one by one degree in a scalar representation (Mortensen 2006; Sande 2018). Thus with High and Extra-High tones on the base the suffix tone is identical to the base tone, whereas base Low and Mid tones result in affix tones which would be two steps higher:

(8) Tenyidie variable affixes (Meyase, 2016:21)



On the other hand, under the Register-Tier representation in (8), the height assimilation can be simply captured as spreading of the register feature of the stem to a suffix which is unspecified for register:

(9) Tenyidie variable affixes (Meyase, 2016:21)

a. Low+affix → Low+High b. Mid+affix → Mid+Extra-High

The range of tonal systems which can be captured by the inventory of two melody and two register features depends on further assumptions on constraints governing their combinatorics and possible phonetic interpretations. With Snider (1999), I assume that two-tone systems (without downstep) either completely abstain from the use of register features altogether or eschew their specific use in Mid tones. For surface three-tone (H, M, L) systems I assume three possible representations. Either the language lacks Mid_1 or Mid_2, or it has phonological representations corresponding to Mid_1 and Mid_2, but the difference between the Mid tones is phonetically neutralized. As shown by Snider (1999) this possibility follows under the natural assumption that both melodies and registers roughly contribute specific amounts of pitch raising and lowering on a language-specific basic. Hence these amounts can also be identical in specific languages, which would result in a system where Mid_1 and Mid_2 are phonologically different, but phonetically indistinguishable. Ahland (2012) provides detailed instrumental acoustic evidence from the Omotic language Mao that this kind of system is in fact attested. Two Mid tones which behave systematically differently in phonological processes show no significant differences in pitch realization. In this paper, I will argue that Gaahmg is a further possible case of a phonetic merger of two phonologically distinct Mid tones, pending acoustic verification of the auditory categorization by Stirtz (2011).[3] In section 7.2, I discuss the possibility that multi-tone languages which use tone in a more scalar way than Tenyidie and Gaahmg might be best described as systems which are limited to the use of register tones that cumulatively determine the pitch of a given tonal root node.

2.3 Autosegmental Colored Containment Theory and Generalized Nonlinear Affixation

The central goal of this paper is to show that Gaahmg Gestalt contours fall out from a representational assumption: Autosegmental Phonology embracing a subtonal feature geometry. This makes it methodologically critical to restrict the computational machinery in the developed analysis. I will therefore adopt a substantially restricted implementation of Optimality Theory—Colored Containment Theory (van Oostendorp 2008; Trommer 2011; Zaleska 2020; Paschen 2021) under the conceptual assumption of the Generalized Nonlinear Affixation (GNA) approach (Bermúdez-Otero 2012). Colored Containment is a conservative extension of the original implementation of OT in Prince & Smolensky (1993) with a more limited set of possible structural changes than Correspondence Theory—restricting them to insertion and marking for non-pronunciation— and principled modularity restrictions on the phonology-morphology interface. I will first discuss the notions of color and containment, and then turn to their integration into a GNA framework.

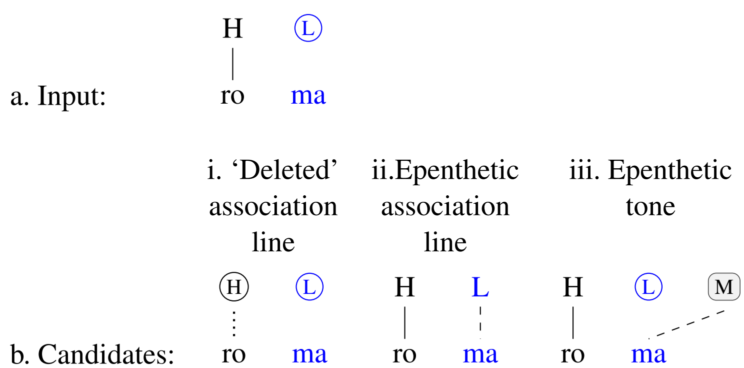
Color: Colored Containment Theory limits access of phonology to morphosyntactic information to 'colors', an encoding of morphemic affiliation, especially useful for autosegmental representations. I illustrate this with a toy example in (10). In the structure in (10a), color identifies the floating Low tone as part of the same morpheme as the syllable [ma] (and distinct from [ro] and its High tone) with a different color,

[3] An anonymous reviewer raises the concern that phonetic neutralization of phonologically different tones might be problematic for learnability. However, as shown by Nazarov (2016), from a learnability perspective, this kind of ambiguity is not substantially different from other cases where underlying contrasts are neutralized on the surface (i.e. where an underlying segment *S* in a lexeme *L* is not realized faithfully in any surface realization of *L*). As shown by recent work on computational learning, this kind of abstractness can be effectively learned from distributional data (Rasin & Katzir 2018; Rasin, Shefi & Katzir 2020; Rasin, Berger, Lan, Shefi & Katzir 2021, see also O'Hara 2017).

even though they do not form a coherent phonological object, a fact which would be difficult to capture by morpheme boundaries. The second crucial function of color is to distinguish underlying (= morphological = colored) and epenthetic (= non-underlying = colorless) material. Thus the notation used here for the lack of morphological colors, dashing of association lines as in (10b-ii,iii) and shaded boxes for tones (10b-iii), directly encodes their status as epenthetic material in output representations (circles are used, as usually, to highlight tones which are not phonetically associated to a TBU, hence are ‘floating’).

Containment: The Containment requirement of the theory states that input structure can never be literally deleted in possible outputs. The representation of deletion is instead by diacritically marking input association lines as phonetically invisible, graphically indicated by dotting (10b-i). By assumption, phonetic interpretation universally disregards phonological structure not phonetically associated to higher nodes. Thus the High tone in (10b-i) is not pronounced. Crucially, there is no candidate where tones (or segments) would be literally removed from possible phonological output representations. Thus inputs and their modifications performed by GEN are fully reconstructable from outputs, obviating input-out comparisons and indices as in Correspondence Theory. Hence, (10b) illustrates *all* possible types of tonal changes to the input candidate in (10a). Besides full deletion of a tone, changing a tone (say from High to Low), splitting a tone, or tone metathesis are in principle excluded.

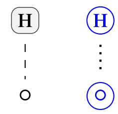
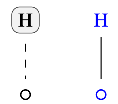
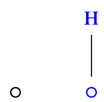
(10) Autosegmental representations in Colored Containment Theory



Containment allows optimality-theoretic markedness constraints to still access structure which is floating or marked as phonetically invisible. This is also a conservative aspect of the theory directly inherited from derivational Autosegmental Phonology. See the classical autosegmental literature on tone (e.g., Pulleyblank 1986 on Tiv, and Clements & Ford 1979 on Kikuyu) for extensive evidence for floating (unpronounced) tones, which are still capable of triggering overt effects like downstep and the blocking of otherwise expected tone spreading processes. Basic markedness constraints may appear in two versions (‘clones’), a standard ‘phonetic’ one which only evaluates phonetically visible structure (marked by underlining), and a general(ized) one which also takes into account material ultimately not pronounced (without special marking).

This is illustrated in (11) with a constraint which will play an important role in the analysis of polarity effects in section 3.3 below, the ban on adjacent identical melody tones, a version of the well-known Obligatory Contour Principle (Leben 1973; Myers 1997). The general version is abbreviated as OCP τ and its phonetic clone as <u>OCP</u> τ. The input representation (11c) violates neither constraint, whereas (11b), where a melody-H is inserted to associate to the unspecified tonal root node violates both. The crucial contrast between the two versions of the constraint emerges in (11a) where the second tone and its root node are ‘deleted’ (rendered phonetically invisible). Since the second melody-H is invisible for the phonetic constraint version <u>OCP</u> τ, this is not violated here. In contrast, the generalized constraint clone OCP τ evaluates the full phonological representation and is hence violated by (11a), just like by the visible tone in (11b). In effect, as shown in detail in section 3.3, a tone can opaquely trigger dissimilation on an adjacent tone even if it is deleted itself.

(11) Phonetic and general constraints: The OCP for melody tones

Input: c.	<u>OCP</u> τ	OCP τ
a. 		*
b. 	*	*
c. 		

Generalized and phonetic constraint versions will also play a crucial role for a central constraint in the analysis of tonal overwriting, Contiguity ∘ (see sections 3.3 and 4.1 below).

Generalized Nonlinear Affixation and the Concatenativist Hypothesis: A natural conceptual framework for Colored Containment Theory is the Generalized Nonlinear Affixation program (GNA) of Bermúdez-Otero (2012), a research program which generalizes the tradition of Autosegmental Phonology (Goldsmith 1976; McCarthy 1979; Marantz 1982) and Prosodic Morphology (McCarthy & Prince 1996), where tonal and templatic exponence is interpreted as affixation of partially specified phonological material (e.g. floating tones or moras) to all productive cases of nonconcatenative morphology in line with the concatenativist hypothesis in (12) :

(12) *The Concatenativist Hypothesis:* Morphology = Concatenation + Phonology

An important further assumption of Bermúdez-Otero (2012) adopted here is a strong version of the Indirect Reference Hypothesis (Nespor & Vogel 1986; Selkirk 1986; Inkelas & Zec 1995), which disallows direct reference to morphosyntactic information in phonological rules and constraints. Morphologically sensitive constraints as in indexed-constraint approaches (Pater 2007) or the assumption of different Cophonologies for specific morphological constructions (Orgun 1996; Inkelas 2014) undermine the empirical content of the Concatenativist Hypothesis: They allow phonology to perform most of the operations usually assumed in approaches to morphology employing spellout constraints or rules (Anderson 1992; Xu & Aronoff 2011) in a morphologically distinctive way. I will therefore assume following Trommer (2022) that the possible effects of morphological information on phonological computation is minimal and restricted by the principle in (13):

(13) *Color Map Hypothesis:* The only morphological information visible to phonology
are presence and difference of morphological color

Thus, OT-constraints may refer to whether a phonological element is epenthetic or not, and whether two phonological elements are tautomorphemic or not (a non-linear equivalent to morpheme boundaries), but cannot invoke *specific* colors, i.e., particular morphemes.

The combination of Generalized Nonlinear Affixation and Register Tier Theory predicts that tonal affixes may consist either of floating full tones (i.e., tonal root nodes associated to melody and register tones), or unassociated subtonal features (e.g., a single melody feature), or bare tonal root nodes without tonal specification, or combinations of these (e.g., an affix containing both full tones and melody tones). Strikingly, Gaahmg appears to make use of all of these options (see section 7 for discussion). In section 6, I will show that subtonal affixation also goes beyond nonconcatenative morphology proper and accounts for apparently morphologically conditioned phonological alternations in Gaahmg.

3 Full-Tone Morphology, Chain Lowering and the Representation of Gaahmg Tone

Before we turn to Gaahmg subtonal morphology, I will analyze full-tone affixation in the language. This serves two purposes: *First*, full-tone affixation shows especially transparently the effects of Chain Lowering, the most pervasive tonal sandhi process in Gaahmg, which provides independent evidence for the featural Register Tier decomposition I assume. *Second,* as we will see in subsequent sections, the analytic techniques and constraint types used in full-tone morphology transfer directly to subtonal morphology demonstrating that subtonal features allow for a unified account of both.

3.1 Full-Tone Suffixation in Finite Subject Agreement

The most straightforward and transparent case of tonal morphology in Gaahmg is the marking of subject agreement via tonal suffixation. Thus the Completive paradigm has the toneless aspect suffix -[sə], and additional tones on this affix not found in the Infinitive, High for 3SG, Low for 3PL subjects and Mid for all 1st and 2nd person forms. These show up transparently after Mid and High base tones. Tones in parentheses indicate tones whose presence is phonetically ambiguous (thus MM on a single syllable would be realized in the same way as just M), and boxed tones are the result of general tone alternations, mostly of the Chain Lowering process discussed immediately below in section 3.2. Note that verb roots in Gaahmg—in contrast to nouns—are generally monosyllabic.With Stirtz (2011) I assume that the syllable is in all cases the TBU. However, to enhance readability, I am marking contour tones with a Mid component by separate tonal diacritics on vowel and coda consonant (or on the length mark "ː").

(14) Completive verbs with subject agreement (Stirtz 2011:194)

(Inf)		1SG + M		3SG + H		3PL + L		
a. fír	H	fír-sə̄	H-M	fír-sə́	(H)-H	fír-sə̀	H-L	'to smell'
b. bɛ́l̄	HM	bɛ́l̄-d̪ā	H(M)-M	bɛ́l̄-d̪á	HM-H	bɛ́l-d̪à	H[L]-L	'to name'
c. kə̄ð́	MH	kə̄ś-sə̄	MH-M	kə̄ś-sə́	M(H)-H	kə̄ś-sə̀	MH-L	'to strike'
d. cɔ̄r	M	cɔ̄r-sə̄	(M)-M	cɔ̄r-sə́	M-H	cɔ̄r-sə̀	M-L	'to help'
e. d̪ùr	L	d̪ùr-sù	(L)-[L]	d̪ùr-sū	L-[M]	d̪ūr-sù	[M]-L	'to bury'
f. dɔ̄ː̀s	ML	dɔ̄ː̀s-sɔ̀	M(L)-[L]	dɔ̄ː̀s-sɔ̄	ML-[M]	dɔ̄ː̀s-sɔ̀	M(L)-L	'to stand'
g. pə̂r	HL	pə̂r-sə̀	H(L)-[L]	pə̂r-sə̄	HL-[M]	pə̂r-sə̀	H(L)-L	'to attach'

That tonal agreement morphology is not specific to the Completive or its suffix is shown by the Incompletive which lacks a suffix, but shows the same additional tones:

(15) Incompletive verbs with subject agreement (Stirtz 2011:195)

(Inf)		1SG + M		3SG + H		3PL + L		
a. fír	H	fír̄	H-M	fír	(H)-H	fîr	H-L	'to smell'
b. bɛ́l̄	HM	bɛ́l̄	H(M)-M	bɛ́l̄́	HM-H	bɛ́l	H(M)-L	'to name'
c. kə̄ð́	MH	kə̄́ð̄	MH-M	kə̄ð́	M(H)-H	kə̄́ð̀	MH-L	'to strike'
d. cɔ̄r	M	cɔ̄r	(M)-M	cɔ̄r	M-[M]	cɔ̄r̀	M-L	'to help'
e. d̪ùr	L	d̪ùr	(L)-[L]	d̪ùr̄	L-[M]	d̪ūr̀	[M]-L	'to bury'
f. dɔ̄ː̀s	ML	dɔ̄ː̀s	M(L)-[L]	dɔ̄ː̀s̄	ML-[M]	dɔ̄ː̀s	M(L)-L	'to stand'
g. pə̂r	HL	pə̂r	H(L)-[L]	pə́ŕ	H[M]-H	pə̂r	H(L)-L	'to attach'

A minimal concatenative analysis is to assume that morphology directly adds the suffix tone at the end of the tonal tier. That it is associated follows then from the constraint ranking in (16) in phonology.

(16) Constraints

a. τ ⊳ σ — Assign ∗ to every tone which is not associated to a syllable

b. *CONT(OUR) — Assign ∗ to every syllable which is associated phonetically with two different tones

c. MAX | — Assign ∗ to every morphological association line which is not phonetic

τ ⊳ σ enforces association of the floating affix tone, as shown in (17i). Since in Gaahmg MAX | is ranked above *CONTOUR, the affix tone is simply added to the underlying tone of the base, whereas the higher ranking of *CONTOUR would lead to phonetic deassociation of the underlying Mid. (17ii) illustrates a case of phonetically vacuous tone association:

(17) Tone suffixation

(i) fír + 1SG Ⓜ → fí̄r 'I smell' (15-a)

Input: = c.	τ ⊳ σ	MAX |	*CONT
a. fīr (Ⓗ ┆ M, H dotted, M dashed)		*!	
☞ b. fí̄r (H | M, M dashed)			*
c. fír (H | Ⓜ floating)	*!		

(ii) cɔ̄r + 1SG Ⓜ → cɔ̄r 'I help' (15-d)

Input: = c.	τ ⊳ σ	MAX |	*CONT
a. cɔ̄r (M ┆ M, M dotted, M dashed)		*!	
☞ b. cɔ̄r (M | M, M dashed)			
c. cɔ̄r (M | Ⓜ floating)	*!		

3.2 Chain Lowering and the Representation of the Gaahmg Three-Tone System

I turn now to the sub-tonal representation I will posit for Gaahmg, and show that it accounts for the major parts of tonal alternations in tonal subject agreement. Recall from section 2.2 that Gaahmg phonology employs all four basic tones of Register Tier Theory, H, L, M_1, and M_2, although with specific restrictions on the occurrence of the different Mid tones, as shown in (18) :

(18)

[H,h]	H	
[H,l]	M_2	(in underived ML and derived M)
[L,h]	M_1	(in underived M, MH, HM)
[L,l]	L	

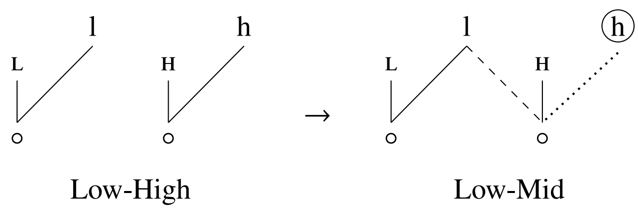
In line with the assumption that lexical roots in Gaahmg are Stem-Level domains in a stratal architecture (see section 2.1), the restriction of underlying root morphemes to M_2 in ML contours and to M_1 in other contexts can be derived as the result of an early optimization cycle at this level. Thus the combinatorics of Mid tones in contours posited in (18) correspond to a phonologically natural generalization at the subtonal melody level: The excluded *M_1L = [L,h][L,l] has two adjacent melody-L's whereas unattested *HM_2 = [H,h][H,l] and *M_2H = [H,l][H,h] have adjacent melody-H's. Hence what seems to be excluded are OCP-violations for melody tones. As we will see in section 5.1 Gaahmg also exhibits a productive alternation of this type at the Word Level (restricted to melody L-tones). In addition, the Stem Level apparently has an undominated constraint blocking syllables exclusively associated to M_2.[4] Thus the tonal agreement suffixes introduced in section 3.1 are represented as 1SG (non-third person) = M_1 ([L,h]), 3SG = H ([H,h]), and 3PL = L ([L,l]). Assuming two different Mid tones allows for a natural analysis of a central chain-shifting process in Gaahmg phonology that is found in Incompletive and Completive repeated in (19). Chain-shifting Lowering lowers non-low tones immediately following a Low by one degree, High to Mid (visible in the 3SG column after all root tones ending in L) and of Mid to Low (visible in the same contexts in the 1SG column). Low after Low as in the 3PL forms remains unchanged (see section 5.2 on the dissimilation of *root*-L in this context).

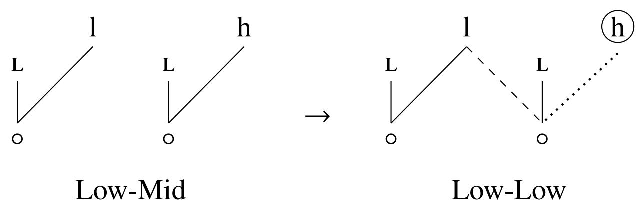
(19) Completive verbs with subject agreement (Stirtz 2011:194)

(Inf)		1SG + M		3sg + H		3PL + L		
a. fír	H	fír-sə̄	H-M	fír-sə́	(H)-H	fír-sə̀	H-L	'to smell'
b. bɛ́l̄	HM	bɛ́l̄-d̪ā	H(M)-M	bɛ́l̄-d̪á	HM-H	bɛ́l-d̪à	H L -L	'to name'
c. kə̄ə̋	MH	kə̄ś-sə̄	MH-M	kə̄ś-sə́	M(H)-H	kə̄ś-sə̀	MH-L	'to strike'
d. cɔ̄r	M	cɔ̄r-sə̄	(M)-M	cɔ̄r-sə́	M-H	cɔ̄r-sə̀	M-L	'to help'
e. d̪ùr	L	d̪ùr-sù	(L)- L	d̪ùr-sū	L- M	d̪ūr-sù	M -L	'to bury'
f. dɔ̄ɔ̀s	ML	dɔ̄ː̀s-sɔ̀	M(L)- L	dɔ̄ː̀s-sɔ̄	ML- M	dɔ̄ː̀s-sɔ̀	M(L)-L	'to stand'
g. pə̂r	HL	pə̂r-sə̀	H(L)- L	pə̂r-sə̄	HL- M	pə̂r-sə̀	H(L)-L	'to attach'

The feature system in (18) allows for a simple unified implementation of this pattern: Chain-shifting Lowering is spreading of register-l from a Low-tone to any following tone, as shown in (20) :

(20) Chain Lowering by spreading of register-l





[4]Note that the question of tonal morpheme structure constraints in OT is not a specific problem of the distribution of Mid tones. Thus verbs in many Bantoid languages (see, e.g., Trommer 2022 on Tiv and Chichewa) allow only a single H or L underlyingly, but multiple H tones in derived forms. Also Gaahmg shows additional categorial constraints on possible tone melodies in single morphemes. Thus there are no LH or LM melodies on morphologically simplex verbs, although LM results from tonal affixation (see below). All these patterns can not be derived in Standard Optimality Theory embracing Richness of the Base without substantial additional assumptions. Conversely, whatever specific solution to tonal morpheme structure constraints is adopted (e.g. strata, output-output constraints as in McCarthy 1998, or iterative lexicon optimization as in van Oostendorp 2014), it is likely to extend to the distributions in (18).

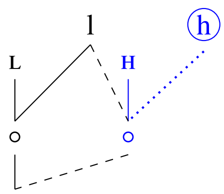
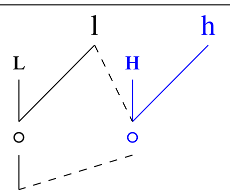
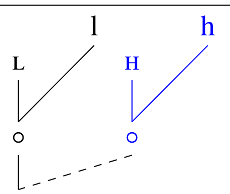
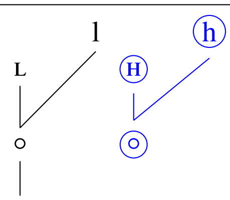
The constraints which achieve this are stated in (21), where <u>SHARE</u> l captures the requirement to spread the low register and $*_{\mathrm{H}\underline{\circ}\mathrm{L}}$/$*_{\mathrm{h}\underline{\circ}\mathrm{l}}$ the incompatibility of high and low elements on the same subtonal tier.[5]

(21) <u>SHARE</u> l A full phonetic L-tone (i.e., a [L,l] tone) should share its register-l with a right-adjacent tone

(22)
a. $*_{\mathrm{H}\underline{\circ}\mathrm{L}}$ Assign $*$ to every tonal root node which is phonetically associated to H and L
b. $*_{\mathrm{h}\underline{\circ}\mathrm{l}}$ Assign $*$ to every tonal root node which is phonetically associated to l and h

(23) shows the application of these constraints to the 3sg of a Low-tone verb. <u>SHARE</u> l triggers spreading of the low-register of the Low tone, and $*_{\mathrm{h}\underline{\circ}\mathrm{l}}$ enforces deassociation of the h-register in the following H since contradicting register values as in (23b) are nonlicit:

(23) Tone suffixation: 3SG of d̪ur 'bury'

Input: = d.	τ ⊳ σ	$*_{\mathrm{h}\underline{\circ}\mathrm{l}}$	<u>SHARE</u> l	MAX	*<u>CONT</u>
 ☞ a. d̪ur (LM₂)				*	*
 b. d̪ur (L?)		*!			*
 c. d̪ur (LH)			*!		*
 d. d̪ur (L)	*!		*		

[5]As predicted by (21), Chain Lowering is in principle iterative, as in a Low-root with a following 1SG subject Mid and the 2PL object clitic -[uːgːú] with a final High, where the medial Mid is lowered to Low and in turn lowers the following High to Mid: /d̪ùr + Ⓜ + uːgːú/ → [d̪ùr-ùːgːū] 'I bury you (pl.)' (Stirtz 2011:229).

Note that the specifics of the constraint ranking assumed in (23) and many of the following tableaux are mostly motivated by the role these constraints play in the analysis of other phenomena in Gaahmg discussed later in the paper. See appendix A.1 for the full constraint ranking for the overall analysis and appendix A.2 for the specific ranking arguments justifying it.

3.3 Double Body Part Plurals

Beside tonal morphology for subject agreement—which is concatenative addition of a full tone to a base tone that is preserved (modulo minor phonological alternations like Chain Lowering)—Gaahmg also has a morphological construction which is replacive in completely supplanting the underlying tonal shape of the base with a fixed tone pattern. This is the tonal exponent of noun inflection of body parts where both the noun and the possessor are plural (i.e., forms like [ìl-ə̄gː] 'their horns'). I will call this construction for short 'Double Body Part Plurals'. (24) shows representative examples. The singular has just a single form used in isolation or a (singular or plural) possessor. The simple plural form used without or with singular possessors, adds the segmental suffix -(V)[gː], but does not modify the tone of the noun root. This is simply the regular plural form in Gaahmg also found in nouns not denoting body parts, ("–" indicates gaps in the Stirtz 2011 corpus). In contrast, the Double Body Part Plural overwrites the underlying tone of nouns by a Low-Mid melody for polysyllabic nouns (24b,c) and by Low throughout for monosyllabic nouns (24a) in addition to the segmental plural suffix. Here I will show that the alternation between Low and Low-Mid, which Stirtz (2011) treats as a kind of allomorphy is in fact just a special case of Chain Lowering.

(24) Tonal overwriting in Double Body Part Plurals (Stirtz 2011:123,124)

		Singular	*Simple Plural*	*Double Body Part Plural*			
a.	H	cíl	–	cìl-g	L	'spine'	
	M	fīː-d̪	fīː-gː	fìː-gː	L	'feathers'	
	L	d̪ɔ̀l	–	d̪ùl-g	L	'penises'	1σ
	HM	ɲíī-d̪	ɲíī-gː	ɲìːgː	L	'teeth'	
	ML	sūù-d̪	–	sùː-g	L	'hairs'	
b.	MM	kāːlā-d̪	–	kə̀ːlə̄-g	LM	'tongues'	
	HL	îl	íl-ə̀gː	ìl-ə̄gː	LM	'horns'	
	ML	bāsːà-d̪	bāsːà-gː	bàsːā-gː	LM	'intestines'	2σ
	LM	ə̀mə̄ː	–	ə̀mə̄ː-gː	LM	'livers'	
c.	MMH	kūsūm-íː	kūsūm-íːgː	kùsùm-īːgː	LLM	'knees'	3σ
	HLM	d̪ɔ́gːɔ̀lɟā	d̪ɔ́gːɔ̀lɟā-gː	d̪ɔ̀gːɔ̀lɟā-gː	LLM	'ankle(s)'	1σ
	LLM	càŋàld̪ā	càŋàld̪ā-gː	càŋàld̪ā-gː	LLM	'tricepses'	

Complete Overwriting seems to pose a fundamental challenge to a purely affixational approach to tone morphology, but, as shown in Trommer (2022), it naturally follows from tonal circumfixation and phonological contiguity effects. For the Double Body Part Plural, I will posit the lexical entry in (25), i.e., a full-tone circumfix consisting of a Low prefix and a Mid_l suffix.

(25) 

Tonal overwriting is now achieved by a morphological contiguity constraint rendering circumfixal tones adjacent in the output. This is formalized in (26) in a form slightly generalized from Trommer (2022) as

Contiguity ∘ to cover also overwriting triggered by subtonal features (see Trommer 2015, 2022 for discussion on the interaction of circumfixation and Contiguity constraints across different phonological features, and Landman 2002 on the role of Contiguity in segmental phonology).

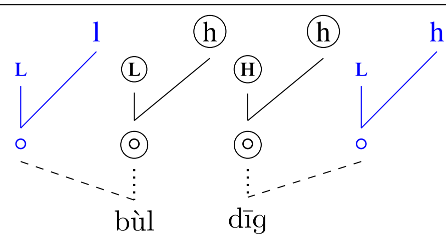
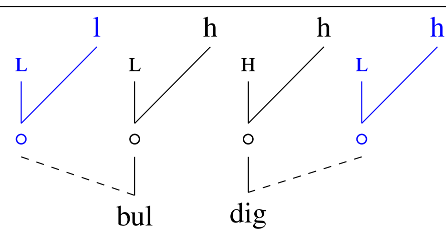
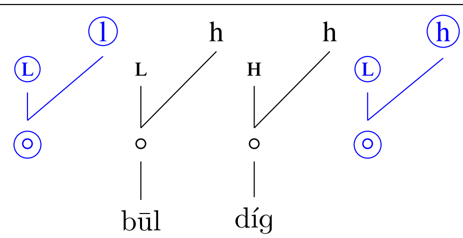
Tonal element is used here as a cover term for tonal melody features, register features and tonal root nodes, and dominance is conceived as reflexive such that a tonal root node dominates not only the melody and register features to which it is associated but also itself (see Partee, ter Meulen & Wall 1990 on more formal details on dominance as a reflexive relation, '$\trianglelefteq$' marks dominance and '$\ll$' linear adjacency).

(26) Contiguity ∘ (Ctg ∘)

Tautomorphemic tonal elements must be phonetically contiguous in terms of adjacent tonal root nodes	≈	Assign $*$ to every pair of tautomorphemic tonal elements T_1, T_2 on the same tier for which $\nexists$ two phonetic tonal root nodes R_1, R_2 such that $T_1 \trianglelefteq R_1$, $T_2 \trianglelefteq R_2$ and $R_1 \ll R_2$

Double Body Part Plurals exemplify the simplest case of applying Contiguity ∘; here it simply requires that two tautomorphemic tonal root nodes are adjacent (since by reflexivity of dominance a root node dominates itself). The crucial effect of Ctg ∘ is shown in (27) disregarding for the moment potential subtonal alternations and the constraints triggering them. Whereas $\tau \triangleright \sigma$ enforces association of the embracing affix tones, this isn't sufficient to capture full overwriting since contour tones on single syllables are in principle licit in Gaahmg, hence we would expect outputs like (27b). However Ctg ∘ can only be satisfied by phonetic non-realization of the intervening tones leading thus to full replacement of the base tones as in (27a):[6]

(27) Double Body Part Plurals: Simplified evaluation (/MH/ → [LM])

Input: = c.	Ctg ∘	$\tau \triangleright \sigma$	Max |
☞ a.  (LM_1)			**
b.  (LM_1HM_1)	*!		
c.  (M_1H)	*!	*!*	

[6]Note that the subtonal features of the deleted tonal root nodes cannot be "saved" by reassociation to the affix root nodes since this would either violate undominated $*_{\text{H}\underline{\circ}\text{L}}$ or lead to additional violations of Max | (by deassociating the corresponding affix features).

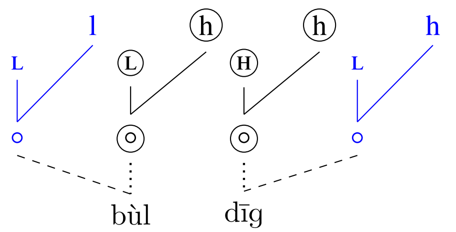
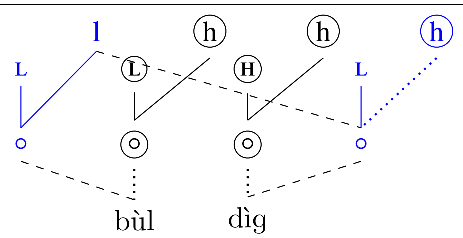
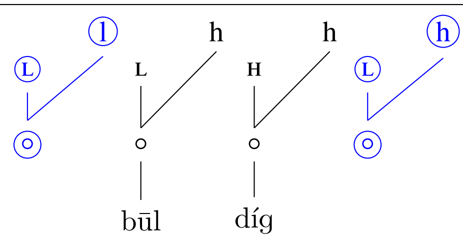
There are two apparent problems for the analysis in (27): *First*, we would expect incorrectly that Chain Lowering applies in the example in (27), and *second*, monosyllabic roots are not assigned LM, but Low instead. Both problems can be solved by slightly elaborating the analysis of Chain Lowering developed in section 3.2 through the constraints in (28). $*\mathrm{X}^{\mathrm{t}}_{\circ}$ formalizes the classical constraint against crossing association lines for tonal root and register nodes in its generalized version (penalizing also the crossing of intervening structure which is phonetically unrealized, see the discussion of (11)). (Sʜᴀʀᴇ l)$_\sigma$ is a version of Sʜᴀʀᴇ l specific to syllable domains reflecting the well-established insight that phonological restrictions in smaller domains should be more stringent (see e.g. Archangeli & Pulleyblank 2002; Kim & Pulleyblank 2009):

(28) a. $*\mathrm{X}^{\mathrm{t}}_{\circ}$ Assign $*$ to every two association lines between tonal root nodes R_1, R_2 and register nodes r_1, r_2 which are crossing (i.e., R_1 is associated to r_2, R_2 is associated to r_1, where $R_1 \prec R_2$ and $r_1 \prec r_2$)

b. (Sʜᴀʀᴇ l)$_\sigma$ A full phonetic L-tone (i.e., a [ʟ,l] tone) should share its register-l with a right-adjacent phonetic tone **in the same syllable**

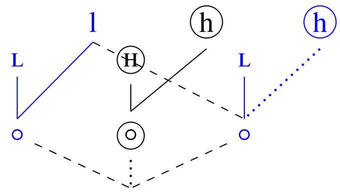
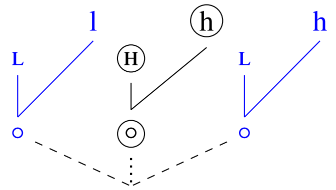
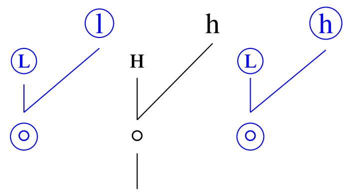
The crucial effect of $*\mathrm{X}^{\mathrm{t}}_{\circ}$ emerges in polysyllabic nouns where it enforces a violation of Sʜʀ l:

(29) Double Body Part Plural: Polysyllabic noun (/MH/ → [LM])

Input: = c.	Cᴛɢ ∘	τ ⊳ σ	(Sʜʀ l)$_\sigma$	$*\mathrm{X}^{\mathrm{t}}_{\circ}$	Sʜʀ l	Mᴀx |
☞ a.  (LM$_1$)					*	**
b.  (LL)				*!*		***
c.  (M$_1$H)	*!	*!*				

On the other hand, for a mono-syllabic base, (Sʜʀ l)$_\sigma$ applies and enforces the violation of $*\mathrm{X}^{\mathrm{t}}_{\circ}$ and application of Chain Lowering by the prefix on the suffix tone:

(30) Double Body Part Plural: Monosyllabic noun (/H/ → [L])

Input: = c.		CTG ○	τ ⊳ σ	(SHR l)$_σ$	*X$^t_○$	SHR l	MAX |
☞ a.  cìlg	(LL)				*		**
b.  cìlḡ	(LM$_1$)			*!		*	*
c.  cílg	(H)	*!	**				

There is one further aspect of the data we need to address. Whereas the constraints introduced up to this point uniquely determine the outcome for monosyllabic and bisyllabic base nouns, CTG ○ for a polysyllabic noun could be satisfied by any candidate where any two adjacent syllables are associated to the affix tones, no matter how the remaining syllables are associated. Instead what we find is that the last syllable is deterministically associated to the suffixal M and all remaining syllables to the prefix-L of the tone circumfix. I derive this pattern by the three constraints in (31) (see Trommer 2022 on detailed motivation for (31c)).

(31) a. σ ⊳ τ — Assign ∗ to every syllable which is not phonetically associated to a tone

b. DEP ○ — Assign ∗ to every phonetic tonal root node which is not morphological

c. $*\cdots\tau_\omega$ — Assign $n-1$ ∗'s to a tone span S with n phonetic association lines on the ○-σ plane if S contains the last phonetic tone association line on this plane

The tableau in (32) shows the derivation of a polysyllabic noun, omitting sub-tonal structure to make the representations more transparent. CTG ○ again enforces deletion of all intervening base tones (eliminating (32f)). σ ⊳ τ and DEP ○ lead to association of all base syllables to the tones of the circumfix (eliminating (32c,d,e)), and $*\cdots\tau_\omega$ favors multiple association of the initial over the final circumfix tone (disfavoring (32b)):

(32) Double Body Part Plural: Multiple association in a polysyllabic noun (/MMH/ → [LLM])

Input: = f.	Ctg ○	σ ⊳ τ	τ ⊳ σ	$*\cdots\tau_\omega$	Dep ○	Max |
☞ a. L Ⓜ Ⓗ M — kù sū mīː (LLM)						***
b. L Ⓜ Ⓗ M — kù sū mīː (LMM)				*!		***
c. L Ⓜ Ⓗ M L — kù sū mìː (LML)					*!	***
d. L Ⓜ Ⓗ M — kù sū miː (LMØ)		*!				***
e. Ⓛ Ⓜ Ⓗ Ⓜ — ku su miː (ØØØ)		*!**	*!*			***
f. Ⓛ M H Ⓜ — kū sū míː (MMH)	*!		*!*			

We will see independent evidence for the generality of this pattern in the Genitive Gestalt discussed below in section 5.3.

4 Monotonic Gestalt Patterns in Gaahmg

The derivation of morphotonological Gestalt patterns is now a transposition of the analysis for full unconditional overwriting in Body Part Plurals to the sub-tonal level. Subtonal circumfixes impose a unitary contour on their bases via Contiguity. In contrast to full-tone circumfixation, register features of the base partially survive and thus ensure different specific output tones. The Causative illustrates this in a pure form, affixation of a circumfix consisting only of subtonal features (section 4.1). In Verbal Noun formation, subtonal affixation is combined with the affixation of a full tone (section 4.2), another pattern expected in a GNA account with tonal decomposition.

4.1 The Causative Falling Gestalt

The following tables provide representative Causative data from the Infinitive (33), the Completive 3sg (34) and the Incompletive 3sg (35)—recall that verb roots in Gaahmg are generally monosyllabic. My discussion will be based mainly on the finite Completive and Incompletive forms which have additional tonal affixation for person and number, but for which Stirtz (2011) provides more extensive data:

(33) Causative Infinitives (Stirtz 2011:208)

Underived Infinitive			*Causative Infinitive*		
a. H	múðː	'meet'	múd̪̄-d̪	'gather'	HM
b. H	kɔ́rː	'speak'	kúr̄-d̪	'read'	HM
c. M	māːrː	'buy'	mə́r̄-d̪	'sell'	HM
d. M	t̪írː	'die'	t̪ír̄-d̪	'kill'	HM

(34) Causative Completive verbs (with subject agreement) (Stirtz 2011:194,210)

(Inf)		3SG (+ H)		Caus 3SG (+ H)		
a. fír	H	fír-sə́	(H)-H	fír̄-sə́	HM-H	'to smell'
b. bɛ́l̄	HM	bɛ́l̄-d̪á	HM-H	bíl̄-d̪ə̄	HM-H	'to name'
c. kə̄ə̋	MH	kə̄ś-sə́	M(H)-H	kə́s̄-sə́	HM-H	'to strike'
d. cɔ̄r	M	cɔ̄r-sə́	M-H	cúr̄-sú	HM-H	'to help'
e. d̪ùr	L	d̪ùr-sū	L-[M]	d̪ūr̀-sū	ML-[M]	'to bury'
f. dɔ̄ɔ̀s	ML	dɔ̄ː̀s-sɔ̄	ML-[M]	dūː̀s-sū	ML-[M]	'to stand'
g. pə̂r	HL	pə̂r-sə̄	HL-[M]	pə̂r-sə̄	HL-[M]	'to attach'

(35) Causative Incompletive verbs (with subject agreement) (Stirtz 2011:195,210)

(Inf)		3SG (+ H)		Caus 3SG + (H)		
a. fír	H	fír	(H)-H	fír̄-d̪ə́	HM-H	'to smell'
b. bɛ́l̄	HM	bɛ́l̄́	HM-H	bíl̄-d̪á	HM-H	'to name'
c. kə̄ə̋	MH	kə̄ə̋	M(H)-H	kə́s̄-sə́	HM-H	'to strike'
d. cɔ̄r	M	cɔ̄r	M-[M]	cúr̄-d̪ú	HM-H	'to help'
e. d̪ùr	L	d̪ùr̄	L-[M]	d̪ūr̀-d̪ū	ML-[M]	'to bury'
f. dɔ̄ː̀s	ML	dɔ̄ː̀s̄	ML-[M]	dūː̀s-d̪ū	ML-[M]	'to stand'
g. pə̂r	HL	pə́ŕ	H[M]-H	pə̂r-d̪ə̄	HL-[M]	'to attach'

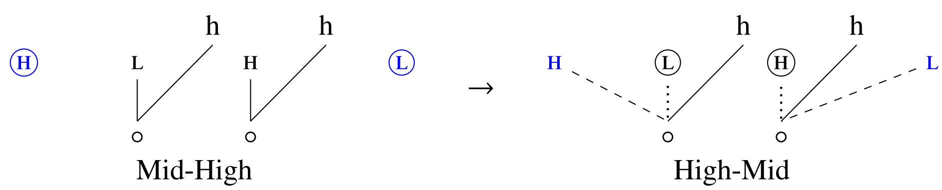
Overall, Causative forms in Gaahmg are characterized by a combination of several exponents ① a change of [-ATR] stem vowels to [+ATR] (e.g., [kɔr] → [kur] in (33-b)), ② a partially different distribution of segmental TAM-suffixes shown schematically in (36), and ③ the tonal falling Gestalt of interest here.[7]

(36) Distribution of segmental suffixes in (Non-)Causative verbs

	Infinitive	Subjunctive	Incompletive	*Completive*
Underived Verb	-C	-d̪-V	-Ø	-s-V
Causative Verb	-d	-d̪-V	-d̪-V	-s-V

Given the independent motivation for the tonal subanalysis in Chain Lowering (section 3.2), uniformly falling Causative overwriting can now be captured as a melodic H- -L circumfix. This is illustrated for the most drastic effect of overwriting by this affix where it converts an underlying rising Mid-High into a falling High-Mid verb (37) :

(37) Causative overwriting (MH-verb)



[7]Since none of the suffixes in (36) appears exclusively in the Causative, I conclude that there is no segmental Causative morpheme, and that these affixes are TAM affixes with complex allomorphic conditioning by the Causative and other categories. The Causative affix itself would thus comprise only a floating [+ATR] autosegment and the tonal circumfix proposed here. In any case, segmental affixation and vowel changes don't seem to interact in any relevant way with tone, hence I will not discuss it here any further.

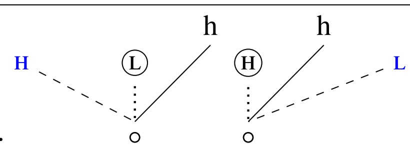
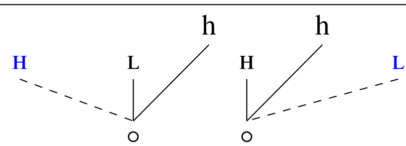
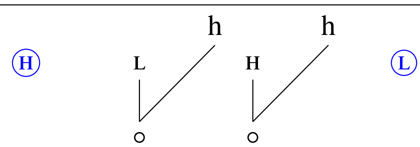
The OT-analysis builds again on CONTIGUITY ∘ repeated in (38).

(38) CONTIGUITY ∘ (CTG ∘)

Tautomorphemic tonal elements must be phonetically contiguous in terms of adjacent tonal root nodes	≈	Assign $*$ to every pair of tautomorphemic tonal elements T_1, T_2 on the same tier for which $\nexists$ two tonal phonetic root nodes R_1, R_2 such that $T_1 \trianglelefteq R_1$, $T_2 \trianglelefteq R_2$ and $R_1 \lll R_2$

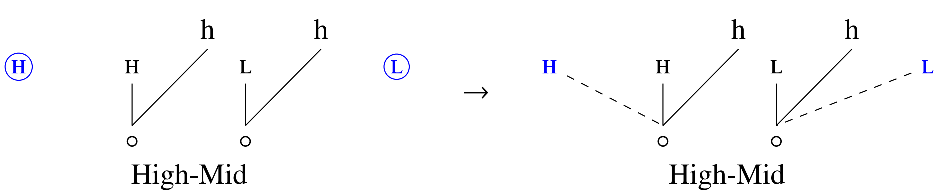
Ranking of CTG ∘ and the ban on overt melodic contour tones $*_{\mathrm{H}\underline{\circ}\mathrm{L}}$[8] above the faithfulness constraint protecting underlyingly associated melody tones enforces replacement of the underlyingly associated melody tones by the melody tones of the Causative circumfix:

(39) Tonal overwriting in Causative formation (/MH/ → [HM])

Input: = c.	CTG ∘	$*_{\mathrm{H}\underline{\circ}\mathrm{L}}$	DEP ∘	MAX |
☞ a.  (HM₁)				**
b.  (FF)		*!*		
c.  (M₁H)	*!			

The subtonal analysis also provides a natural explanation for cases where overwriting doesn't result in overt changes. This is illustrated in (40) for an underlying High-Mid verb. Since the first tone of the contour already has a melody-H, and the second one a melody-L, adding the same tonal elements results in vacuous 'overwriting':

(40) Causative (vacuous) overwriting (HM-verb)



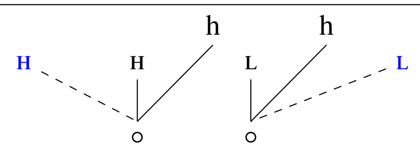
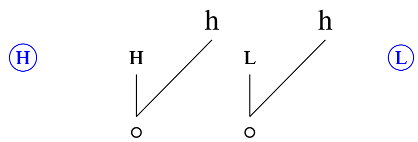
The intuition behind the constraint-based analysis I propose is that CTG ∘ is exceptionlessly fulfilled—with a minimum of insertion and deassociation. Technically this intuition is captured by the faithfulness constraints DEP ∘, MAX |, DEP t and DEP T (41):

[8]Note that structures as in (39b) are probably not universally excluded since it describes unitary contour tones which behave as single units for processes such as spreading (Yip 1989, 2000), common in South Asian, but rare in African languages (see Gjersøe 2019 for a potential case in Nilotic).

(41) a. DEP t Assign ∗ to every epenthetic register tone
(i.e., every phonetic register tone which is colorless)
b. DEP T Assign ∗ to every epenthetic melody tone
(i.e., every phonetic melody tone which is colorless)

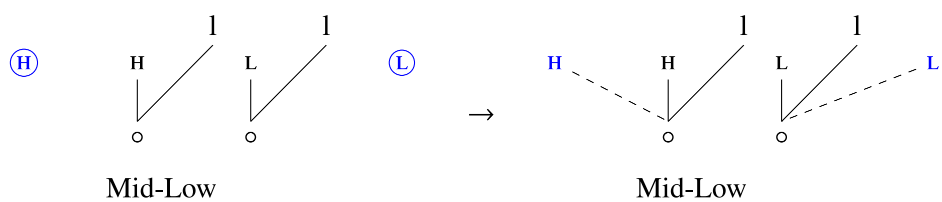
For Mid-High bases only the lowest-ranked faithfulness constraint MAX | is violated, as shown in (39). For High-Mid bases (40) these constraints can all be satisfied without conflict, explicitly shown in the tableau in (42):

(42) Causative (vacuous) overwriting (/HM/ → [HM])

Input: = b.	CTG ○	$*_{\text{H}}\underline{\circ}_{\text{L}}$	DEP ○	DEP t	MAX |
☞ a.  (HM$_1$)					
b.  (HM$_1$)	*!				

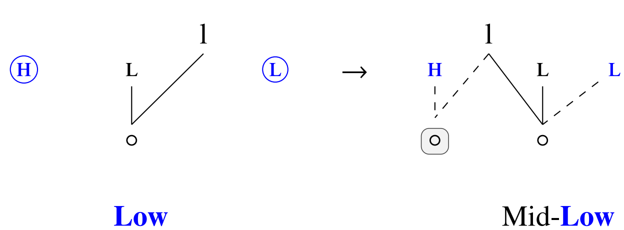
The same reasoning holds for underlying Mid-Low verbs. Recall that the Mid tone here is Mid$_2$, i.e. [H,l]. Thus again, the Causative tone circumfix can dock without overtly changing the already associated tones:

(43) Causative (vacuous) overwriting (ML-verb)



For verbs which have underlyingly a single (non-contour) tone, I assume that the floating melody tones trigger insertion of an additional tonal root node as shown in (44) for an underlying Low. For convenience, I am graphically switching the order of register- and melody-tone in the output here and in other forms with leftwards association of register tones. Since melody and register tones are on different tiers, they are inherently unordered, thus this reordering doesn't change the formal representation, it is just a different way to visualize the same tridimensional representation in a two-dimensional diagram (the graphical line crossing which would otherwise appear is thus also not line crossing in the technical sense):

(44) Tonal overwriting in Causative formation (L-verb)



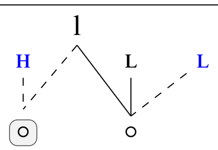
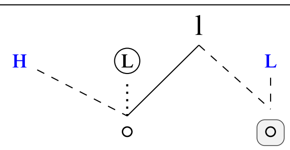
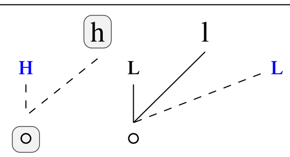
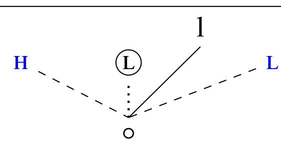
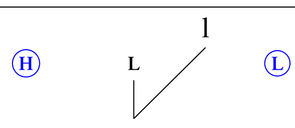
Mono-tonal inputs and epenthesis lead of course to more options for creating falling contours. The two central constraints to derive the correct outcomes are Max | and Dep t. Max | ensures that affix-h associates to base High-tones, and affix-l to underlying Low and Mid tones, while the remaining melody component of the Causative circumfix associates to the epenthetic tonal root node. Dep t implements the intuition that higher-register base tones (H and M) lead to higher-register contours (HM) while base-L tone results in lower-register ML. This results here simply from the fact that high-ranked Dep t blocks insertion of an additional register feature for the epenthetic tonal root node which is consequently forced to share the register feature of the full base tone.

To show that the overall ranking is consistent, I include the constraint *<u>Mid</u> here since it will be shown below to play an active role in Gaahmg. It captures the intuition that Mid tones are disfavored over peripheral tones (accounting for the fact that Mid tones are only found in languages which have also High and Low tones, Pulleyblank 1986):

(45) *<u>Mid</u> Assign $*$ to every phonetic Mid tone
(i.e., every tonal root node which is associated to high and low values on different tiers)

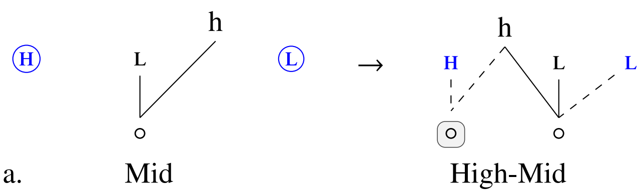
Epenthesis itself is a result of conflicting Ctg ○ and $*_{\text{H}}\underline{\circ}_{\text{L}}$. Since the affixal melody tones must be associated to root nodes, but cannot *both* target the single underlying one (46d), at least one ○-node must be inserted. As argued above, Max | blocks association of h to the underlying verb tone (46b), and Dep t ensures register sharing (46a) over register epenthesis (46c):

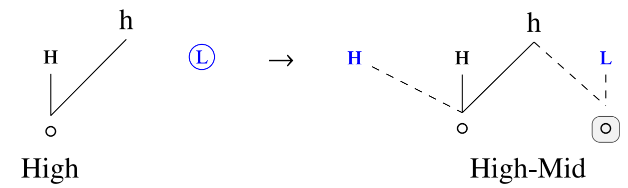
(46) Tonal overwriting in Causative formation (/L/ → [ML])

Input: = e.	Ctg ○	$*_{\text{H}}\underline{\circ}_{\text{L}}$	Dep ○	Dep t	*<u>Mid</u>	Max |
☞ a.  (M_2L)			*		*	
b.  (M_2L)			*		*	*!
c.  (HL)			*	*!		
d.  (F)		*!				*
e.  (L)	*!					

The same constraint mechanics leads to insertion of tones for underlying Mid and High verbs, which both become High-Mid:

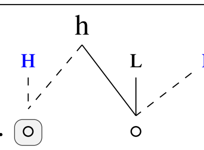
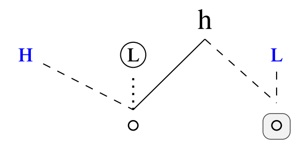
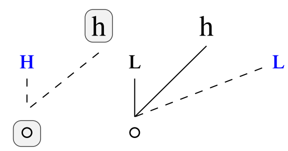
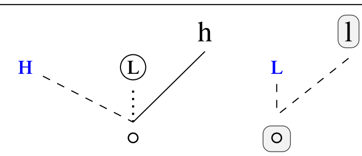
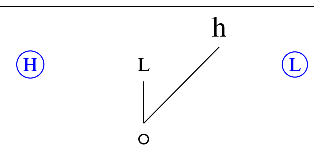
(47) Tonal overwriting in Causative formation (Mid- and High-verbs)

a. 

b. 

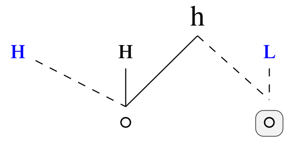
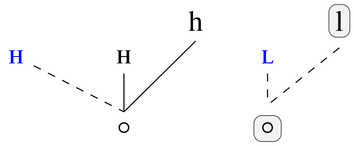
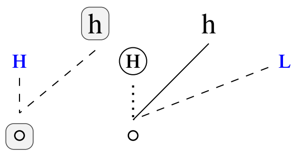
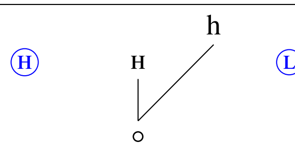
Underlying Mid-tone verbs show again the effect of Dep t (48c,d). Melody-L not -H must associate to the underlying root node to avoid a Max | violation (48b), and register-h is shared due to Dep t:

(48) Tonal overwriting in Causative formation (/M/ → [HM])

<table>
<tr><th>Input: = e.</th><th>Ctg ○</th><th>*H○L</th><th>Dep ○</th><th>Dep t</th><th>*Mid</th><th>Max |</th></tr>
<tr><td>☞ a.  (HM1)</td><td></td><td></td><td>*</td><td></td><td>*</td><td></td></tr>
<tr><td>b.  (HM1)</td><td></td><td></td><td>*</td><td></td><td>*</td><td>*!</td></tr>
<tr><td>c.  (HM1)</td><td></td><td></td><td>*</td><td>*!</td><td>*</td><td></td></tr>
<tr><td>d.  (HL)</td><td></td><td></td><td>*</td><td>*!</td><td></td><td>*</td></tr>
<tr><td>e.  (M1)</td><td>*!</td><td></td><td></td><td></td><td>*</td><td></td></tr>
</table>

For an underlying H, the H-prefix associates to the base-○ whereas the melody-L docks to an epenthetic root node. Again this minimizes violations of Dep t and Max |:

(49) Tonal overwriting in Causative formation (/H/ → [HM])

Input: = d.	CTG ○	$*_{\mathrm{H}}\underline{\circ}_{\mathrm{L}}$	DEP ○	DEP t	*$\underline{\text{MID}}$	MAX |
☞ a.  (HM₁)			*		*	
b.  (HL)			*	*!		
c.  (HM₁)			*	*!	*	*
d.  (H)	*!					

Summarizing, undominated CTG ○ and $*_{\mathrm{H}}\underline{\circ}_{\mathrm{L}}$ guarantee that for all inputs the affixal H- -L tones will appear on distinct adjacent tonal root nodes, where CTG ○ ensures adjacency and $*_{\mathrm{H}}\underline{\circ}_{\mathrm{L}}$ that the melody tones cannot associate to one and the same root node. Lower-ranked faithfulness constraints bring about that epenthesis of an additional root node is restricted to bases with a simple verb tone (DEP ○) and that the resulting Fall incorporates the register features of the base thus creating the particular Gestalt pattern. In the next section we will see that this analysis generalizes directly to a slightly different Gestalt contour in Verbal Noun formation.

4.2 Verbal Nouns: The Non-Rising Pattern

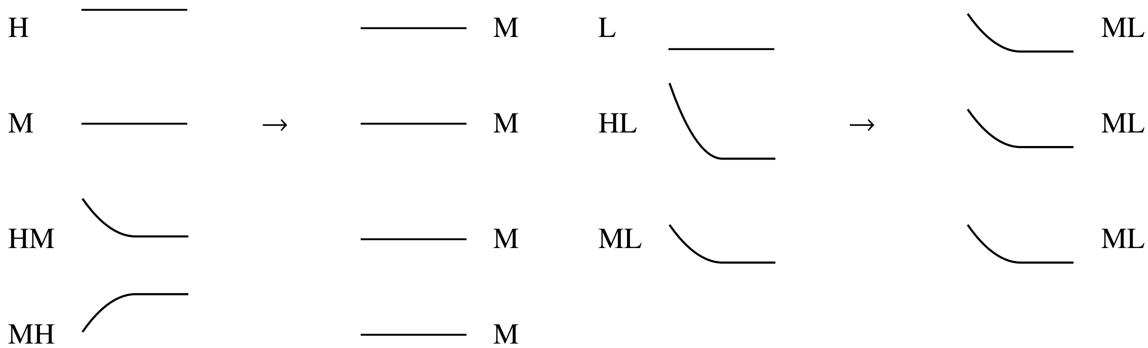
Verbal nouns are characterized tonally by what I will call the 'Non-Rising Pattern'. They uniformly start with a Mid tone which falls to Low for bases with an underlying Low (50e-g). Otherwise, the initial Mid tone extends to the end of the nominal form (50a-d):

(50) The Verbal Noun Non-Rising Gestalt: Data (Stirtz 2011:256)

		Infinitive	Verbal Noun		
a.	H	pál	pāl	M	'cut'
b.	HM	bɛ́l̄	bɛ̄l	M	'to name'
c.	MH	kɔ̄ɔ̃	kɔ̄n	M	'to strike'
d.	M	bɛ̄l	bɛ̄l	M	'to possess'
e.	L	fɛ̀l	fɛ̄l̀	ML	'to bury'
f.	ML	dɔ̄ːs-sɔ̄	dɔ̄ːs(-ɔ̀g)	ML	'to stand'
g.	HL	pîr	pīr̀	ML	'to deceive'

(51) shows the input-output mappings in Verbal Noun formation again graphically as idealized contours:

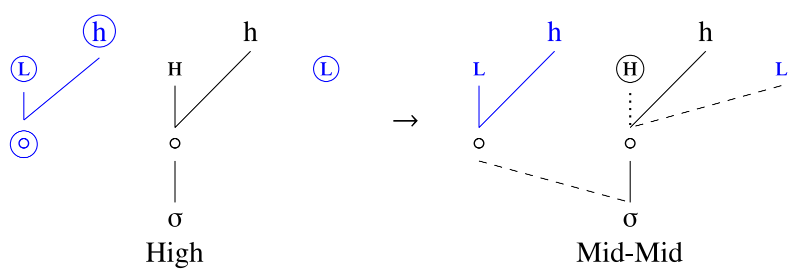
(51) Gaahmg Verbal Noun Non-Rising Contour



The global Gestalt nature of the non-rising pattern is less obvious than in the falling shape of the Causative. One might object that it simply falls out from adding a full Mid-tone prefix, where most base tones are deleted due to tonal crowding or illicit contours, and underlying Low tones survive due to special faithfulness or markedness requirements. The problem with this alternative however is that a Mid tone prefix would create perfectly licit contours even in monosyllabic Verbal Nouns. Thus adding M- to a H or MH base should result in MH, which is attested not only as a lexical tone in roots, but also on affixes, as the suffix in the Continuous Past, (e.g., [fír-ə̄ń], 'she was smelling'; Stirtz 2011:196), where it is plausibly the result of associating a floating Mid tone expressing Past Tense to a High-toned affix (cf. the corresponding Present Continuous form which is otherwise identical, but lacks the Mid tone [fír-ə́ń], 'she is smelling'; Stirtz 2011:199). Since the Verbal Noun melodies also extend to multisyllabic plural forms, crowding on a single TBU can also hardly be the decisive factor in neutralizing underlying base tones.

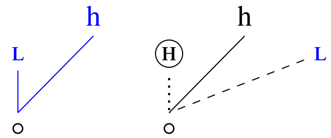
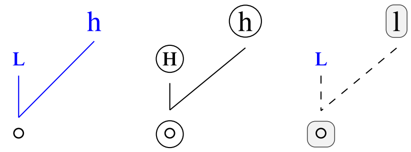
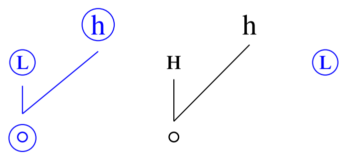
The analysis I propose here takes up the idea of a full-tone Mid prefix, but combines it with a bare melody L-suffix into a circumfixal structure, as illustrated in (52) for a H-toned verb base where the second melody-L overwrites the melody-H resulting in a Mid tone. The full M-prefix also associates to the stem syllable resulting in a sequence of two Ms, which is again phonetically interpreted as a simple M. As in section 3.3, this analysis relies on the standard autosegmental assumption that association to two identical full tones is phonetically indistinguishable from association to a single tone of the same height:

(52) Verbal Noun overwriting (/H/ → [M])



Overwriting is again triggered by CTG ∘ since the Verbal Noun circumfix contains two morphologically adjacent melody tones which are separated by the base tone, as shown in (53). For reasons of space, I omit the syllable tier here and in the following, and association of tonal root nodes is only marked by the absence of floating (indicated by the circle notation). Epenthesis of a root node with concomitant deletion of the intervening base tone is not an option since it would violate high-ranked DEP ∘. The derivation here also shows that *MID and MAX | must be ranked below the DEP constraints because otherwise (53b) would become optimal:

(53) Tonal overwriting in Verbal Noun formation (/H/ → [M])

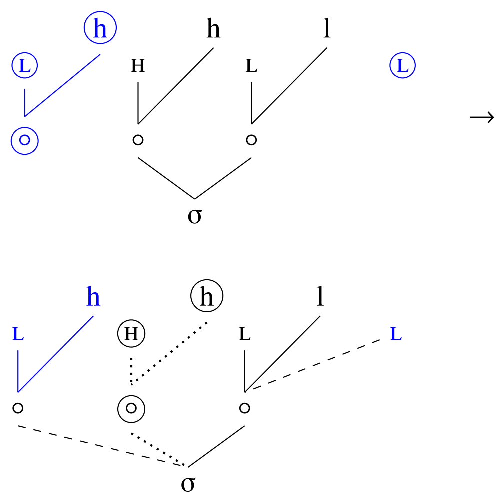
Input: = c.	CTG ○	$*_{H}\underline{\circ}_{L}$	DEP ○	DEP t	*<u>MID</u>	MAX |
☞ a.  $(M_{\vert}M_{\vert})$					**	*
b.  $(M_{\vert}L)$			*!	*	*	*
c.  (H)	*!					

Thus final base-H's are changed to Mid whereas bases with a final Mid or Low simply keep this because the melody-L is vacuously added to an existing L in the final base tone. This is illustrated in (54) and (55) for a HL-verb:

(54) Verbal Noun overwriting (HL-verb)

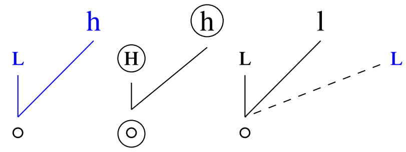
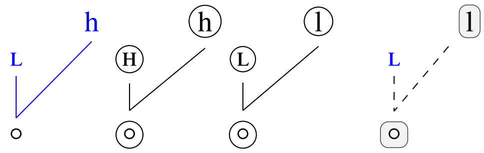
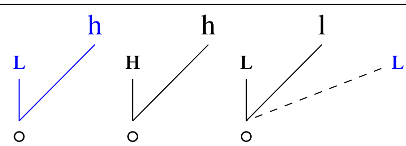
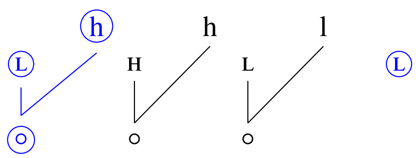
High-**Low**

Mid-**Low**



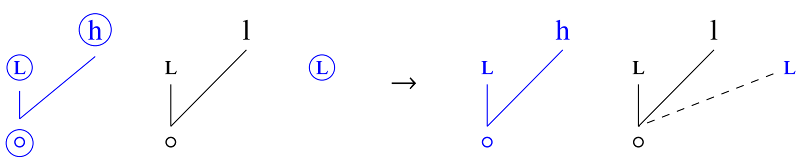
That not all base tones survive (not even in melodically modified form) is again—as in Double Body Part Plurals—a consequence of CTG ○ which can only be satisfied under deassociation of intervening tones. This is shown for (54) in (55):

(55) Tonal overwriting in Verbal Noun formation (/HL/ → [ML])

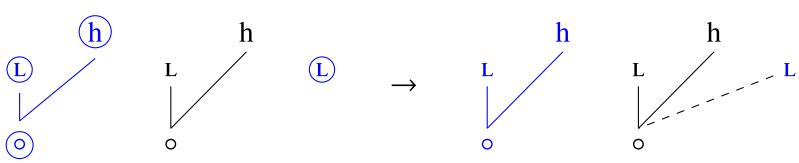
Input: = d.		Ctg ○	$*_{H\underline{○}L}$	Dep ○	Dep t	*Mid	Max |
☞ a. 	(M_1L)					*	*
b. 	(M_1L)			*!	*	*	**
c. 	(M_1HL)	*!				*	
d. 	(HL)	*!					

(56) and (57) show that the analysis also extends straightforwardly to single Low and Mid-tone verbs:

(56) /L/ → $[M_1L]$



(57) $/M_1/ \rightarrow [M_1M_1]$



(58) summarizes the mappings for all attested verb tone shapes, where number indices indicate the correspondence between input and output tones for the tones of the verbal base, and color the correspondence to affixal tone material. Thus M_2 in the output of (58c): is the result of integrating the floating affix Ⓛ and H_2:

(58) Summary of tone mappings in Verbal Noun tone

a. High	Ⓜ +	H_1	+ Ⓛ	→	MM_1	*Final /H/ or /M/ → [M]*
b. Mid	Ⓜ +	M_1	+ Ⓛ	→	MM_1	
c. Mid-High	Ⓜ +	M_1H_2	+ Ⓛ	→	M$Ⓜ_1M_2$	
d. High-Mid	Ⓜ +	H_1M_2	+ Ⓛ	→	M$Ⓗ_1M_2$	
e. Low	Ⓜ +	L_1	+ Ⓛ	→	ML_1	
f. High-Low	Ⓜ +	H_1L_2	+ Ⓛ	→	M$Ⓗ_1L_2$	
g. Mid-Low	Ⓜ +	M_1L_2	+ Ⓛ	→	M$Ⓜ_1L_2$	

5 Polarity and Global Falling Contours

In the Genitive, a Global Falling contour introduces an element of polarity: nominal tones are overwritten by HL if the underlying tone melody starts with an M-tone, but by ML if the base melody starts with a H. I will argue here that this results from the second type of defective representation predicted by GNA and the featural decomposition of tones: affixes containing unspecified tonal root nodes— the logical complement of subtonal features lacking a root node. But before I turn to an account of the Genitive pattern, I will first discuss two dissimilatory patterns in the language that apply outside of Global Gestalt morphology, polarity in the Antipassive (section 5.1) and Low-Tone Dissimilation (section 5.2). In section 5.3, I will then show that the constraints independently established for these patterns also account for the Genitive polar Gestalt.

5.1 Antipassive Polarity

The Antipassive is described by Stirtz (2011) as exhibiting tonal changes of a similar type as the other morphological tones analyzed above—it also consistently creates tone contours— but the evidence suggests that it actually does not involve any specific tonal modification or tonal affixation. The Antipassive is consistently characterized by the segmental suffix -[an] which forms an independent syllable, but whose tone depends predictably on the underlying tone pattern of the verb root to which it attaches. If the verb has a contour tone (59d-g), the second tone of the contour shifts to the Antipassive suffix. On the other hand, if the verb has only a single tone, the suffix exhibits polarity: it is Mid after Low and High tones (59a,c), and High after Mid tones (59b).[9]

(59) Antipassive polarity: Data (Completive) (Stirtz 2011:205)

	3SG		3SG + Antipassive		
a. H	fír-sə́	H-H	fír-ə̄n-sə́	H-M-H	‘to smell’
b. M	cɔ̄r-sə́	M-H	cɔ̄r-ɔ́n-sɔ́	M-H-H	‘to help’
c. L	d̪ùr-sū	L-[M]	d̪ùr-ūn-sú	L-M-H	‘to bury’
d. HM	bɛ́l̄-d̪á	HM-H	bɛ́l-ān-sá	H-M-H	‘to name’
e. MH	kə̄ś-sə́	M(H)-H	kə̄s-ə́n-sə́	M-H-H	‘to strike’
f. ML	būɲ̀-sū	ML-[M]	būɲ-d̪-ùn-sū	M-L-M	‘to make-big’
g. HL	pə̂r-sə̄	HL-[M]	pə́r-ə̀n-sə̄	H-L-M	‘to attach’

H	→	HM
M	→	MH
L	→	LM
HM,MH,ML,HL	→	(no change)

I will adopt here a classical representational approach to polarity phenomena: underspecification (see, e.g., Pulleyblank 1986; Antilla & Bodomo 2000; Meyase 2020). Assuming that true spreading in Gaahmg

[9]Polarity is typically defined with respect to two-tone languages as a pattern where an affix carries the tone opposite to an adjacent base tone (H in the context of L, and L in the context of H, see Yip 2002:159). Here I follow Meyase (2021) in generalizing the notion to phenomena in tone systems with more than two tones such that the emerging affix tone is required to be different from the triggering base tone.

is excluded by the undominated constraint *Spread in (60), the only way to provide the suffix syllable with a tone after a single base tone is to insert a different tone. Note that *spreading* in the definition of (60) is conceived as a special case of feature *sharing* where the shared tone feature is underlyingly (and overtly) associated to an underlying TBU. Thus the multiple association of floating tones in Double Body Part Plurals (see section 3.3) does not violate *Spread ∘ since the involved tones are underlyingly floating.

(60) *Spr(ead) ∘ Assign ∗ to every epenthetic association line of a tonal root node N to a syllable S_2 if N is also phonetically and morphologically associated to a syllable S_1, $S_1 \neq S_2$

The Gaahmg pattern provides striking new evidence for an underspecification-based analysis of tone polarity. Whereas the better-known cases of polarity in Margi (Pulleyblank 1986) and Dagaare (Antilla & Bodomo 2000) involve polarity in all contexts. Gaahmg suspends polarity with contour tones where it applies contour simplification instead. Under an optimality-theoretic perspective, this is a classical example of a phonologically motivated rule conspiracy: the same markedness violation (a toneless TBU) is repaired in different ways according to phonological context. In an approach to tone polarity which invokes morpheme-specific rules or constraints explicitly stipulating tone dissimilation for particular affixes (Cahill 2004; Kouneli & Nie 2021), this would be an accident.

Now before we turn to the full analysis, we have to address a further unusual property of Gaahmg. While polarity in Margi and Dagaare is housed in two-tone-systems where avoiding H leads unambiguously to Low and vice versa, Gaahmg has a three-tone system where identity avoidance could be resolved in different ways. Thus after a H tone, a Mid as well as a Low tone would avoid complete identity.

The subsegmental approach to tone offers a natural solution to this problem. The polarity effect can be understood as avoidance of identical adjacent *melody* tones as formulated in the OCP constraint in (61):

(61) OCP τ Assign ∗ to every pair of adjacent identical melody tones

The following two tableaux show representative cases for contour simplification (62) and polarity (63), putting aside for the moment subtonal representations, to focus on the overall structure of the analysis. With an input contour, the second component tone of the contour is shifted (deassociated and reassociated) to the suffix (62a), which in contrast to spreading (reassociation without deassociation) as in (62b) doesn't violate *Spr ∘. Applying polarity, i.e. insertion of a distinct tone (62c) is ruled out because it involves an unnecessary Dep ∘ violation:

(62) Antipassive: HM-base

Input: = d.	σ ⊳ τ	*Spr ∘	Dep ∘	Max |
☞ a. H M / bɛ́l ān				*
b. H M / bɛ́l̄ ān		*!		
c. H M (H) / bɛ́l̄ án			*!	
d. H M / bɛ́l̄ an	*!			

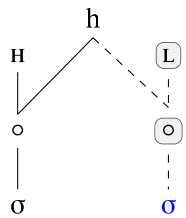
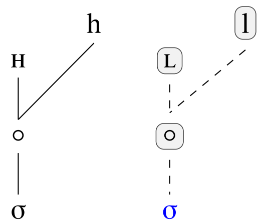
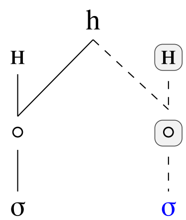
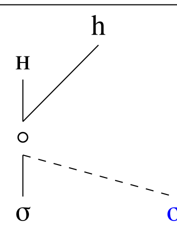
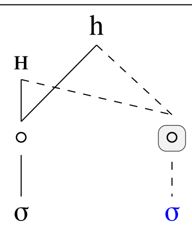
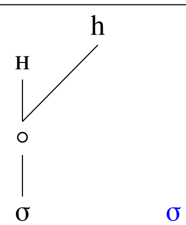
On the other hand, if the base verb contains just a single tone, shifting (63c) is harmonically bounded because it would also just shift the lack of tonal specification to the stem syllable, spreading (63b) again violates *Spr ∘. Thus only full-tone insertion (63a) remains as a viable option to satisfy undominated <u>σ ⊳ τ</u>:

(63) Antipassive: H-base (/H/ → [HM])

Input: = d.	<u>σ ⊳ τ</u>	*Spr ∘	Dep ∘	Max |
☞ a. fír ān (H linked to fír; inserted M linked to ān)			*	
b. fír án (H linked to fír, spread to án)		*!		
c. fír án (H delinked from fír, shifted to án)	*!			*
d. fír an (H linked to fír)	*!			

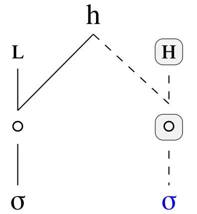
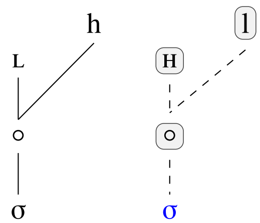
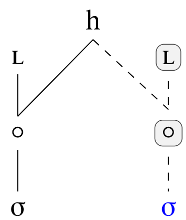
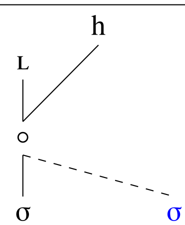
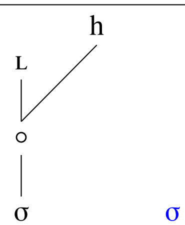
(64) spells out the subsegmental details of how epenthetic Mid is chosen over Low and High in (63). I assume that sharing of melody tones is categorically excluded in Gaahmg by the undominated constraint *Share t (‘Assign $n-1$ ∗’s to every melody tone which is associated to n tonal root nodes’) eliminating candidate (64e). Since full-tone spreading is also blocked by undominated *Spr ∘ excluding (64d), at least a tonal root node and a melody tone must be inserted as in (64a,b,c). OCP t ensures that the epenthetic melody tone is l, not h as in (64c). Finally, the contrast between (64a) and (64b) reveals an important parallel to Causative formation: spreading of the register tone of the base is preferred over register insertion to satisfy Dep t. Thus the concatenative subtonal analysis allows for capturing crucial phonological generalizations across different constructions.

(64) Antipassive: /H/ → [HM]

Input: = f.	σ ⊳ τ	*Spr ○	*Shr T	Dep T	Dep ○	OCP T	Dep t	*Mid	Max |
☞ a.  (HM$_1$)				*	*			*	
b.  (HL)				*	*		*!		
c.  (HH)				*	*	*!			
d.  (HH)		*!							
e.  (HH)			*!		*				
f.  (H)	*!								

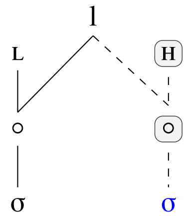
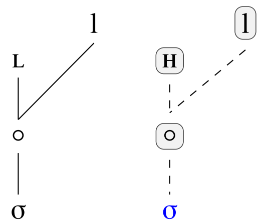
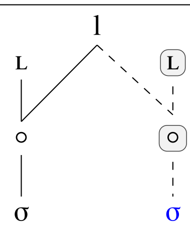
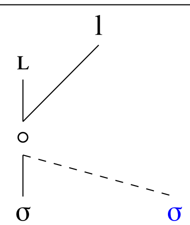
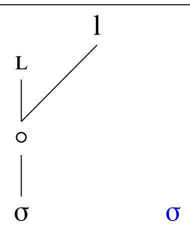
The derivation for a Mid-tone base is essentially the mirror image for the H-tone case. h-register is shared and melody-L on the stem triggers melody-H on the suffix:

(65) Antipassive: /M/ → [MH]

Input: = e.	σ ⊳ τ	*Spr ○	Dep T	Dep ○	OCP T	Dep t	*Mid	Max |
☞ a.  (M$_1$H)			*	*			*	
b.  (M$_1$M$_2$)			*	*		*!	**	
c.  (M$_1$M$_1$)			*	*	*!		**	
d.  (M$_1$M$_1$)		*!					*	
e.  (M$_1$)	*!						*	

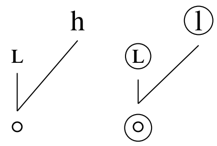
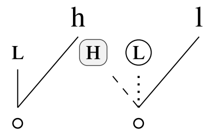
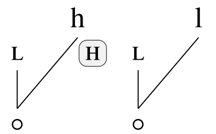
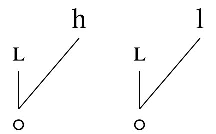
With Low-verbs the combination of register sharing and dissimilatory melody insertion results in a Mid$_2$-tone on the suffix, providing further support for the assumption that phonetic Mid-tones in Gaahmg instantiate two distinct phonological categories:

(66) Antipassive: /L/ → [LM]

Input: = e.	σ ⊳ τ	*Spr ○	Dep T	Dep ○	OCP T	Dep t	*Mid	Max |
☞ a.  (LM$_2$)			*	*			*	
b.  (LM$_2$)			*	*		*!	*	
c.  (LL)			*	*	*!			
d.  (LL)		*!						
e.  (L)	*!							

A final important point on the functioning of OCP T is that it doesn't trigger dissimilatory effects outside of underspecified input structures as in the Antipassive. This is illustrated with a generic Mid-Low input in (67), which is instantiated for example by Incompletive Mid-tone verbs with a 3Pl suffix (e.g., (15-d) [cɔ̄r̀] M-L 'they are helping') where both input tones surface faithfully. One major reason why OCP T is inert in such configurations is that Dep T is ranked higher excluding insertion of an intervening H-melody tone as in (67c). Since input tones in Containment can never be truly modified 'changing' one of the tones to a different one, as in (67b), Low to Mid is just the combination of the same thing (H-epenthesis) and deassociation, and excluded by the same token. Finally also a repair of the L-L configuration by deassociation/'deletion' alone as in (67a) is excluded on principled grounds in Containment since OCP T is a generalized markedness constraint (cf. section 2.3), and the second melody-L is still visible and incurring a violation even though it is marked as phonetically invisible:

(67) No general OCP τ repairs (/ML/ → [ML])

Input: = d.	Max ○	Dep τ	Dep ○	OCP τ	Dep t	*<u>Mid</u>	Max |
a.  (M₁)	*!			*		*	*
b.  (M_1M_2)		*!				**	*
c.  (M_1L)		*!				*	
☞ d.  (M_1L)				*		*	

5.2 Low-Tone Dissimilation (LTD)

A second process crucial to the understanding of the Genitive polar Gestalt is a general dissimilation process which raises Low tones to Mid before other Low tones as shown in (68) (repeated with minor changes from (14)) for the Completive of a L-root before the 3PL L-suffix (68e).[10]

(68) Low-Tone dissimilation (Completive) (Stirtz 2011:194)

		1SG + M		3SG + H		3PL + L		
a. fír	H	fír-sə̄	H-M	fír-sə́	(H)-H	fír-sə̀	H-L	'to smell'
c. kə̄ə̋	MH	kə̄ə́-sə̄	MH-M	kə̄ə́-sə́	M(H)-H	kə̄ə́-sə̀	MH-L	'to strike'
d. cɔ̄r	M	cɔ̄r-sə̄	(M)-M	cɔ̄r-sə́	M-H	cɔ̄r-sə̀	M-L	'to help'
e. d̪ùr	L	d̪ùr-sù	(L)-L	d̪ùr-sū	L-M	d̪ūr-sù	M-L	'to bury'
f. dɔ̄ː̀s	ML	dɔ̄ː̀s-sɔ̀	M(L)-L	dɔ̄ː̀s-sɔ̄	ML-M	dɔ̄ː̀s-sɔ̀	M(L)-L	'to stand'
g. pə̂r	HL	pə̂r-sə̀	H(L)-L	pə̂r-sə̄	HL-M	pə̂r-sə̀	H(L)-L	'to attach'

As Chain Lowering, Low-Tone Dissimilation (LTD) happens across all paradigms independently from segmental affixation (cf., e.g., the 3SG Incompletive, /d̪ùr-sù/ L-L → [d̪ūr-sù] M-L 'to bury', see (15) for the full paradigm).

I capture Low Tone Dissimilation by the constraints in (69). Note that, just as the constraint <u>OCP τ</u> discussed for (11) in section 2.3, <u>OCP L</u> is the phonetic clone of the constraint and hence evaluates only material which is phonetically realized.

[10] I assume that Low-Tone Dissimilation also applies to HL and ML verbs when followed by the 3PL-L resulting in /HL-L/ → [HML] and /ML-L/ → [MML]. This is another case where phonetic interpretation plausibly neutralizes. Thus the acoustic contour for HLL and HML would in both cases involve continuous falling from High to Low through a Mid pitch region.

(69) a. OCP L Assign ∗ to every unconnected pair of adjacent phonetic full Low tones

b. $*\circ_{2l}$ Assign ∗ to every tonal root node associated to more than one l-register feature

In line with the standard autosegmental interpretation of OCP-constraints (see e.g. Kenstowicz 1994 on Shona, and Hayes 1986 on Toba Batak), OCP L doesn't penalize two adjacent L-tone syllables per se, but only two L-tone syllables linked to fully distinct tones. Thus it doesn't apply to two consequent L-tones which have been generated by spreading a register-l to a Mid_1 tone (e.g., all cases of a Mid-suffix such as 1SG on a Low-tone verb base), where Low-Low is licit. The same holds for the Double Body Plural Low-Mid circumfix which on monosyllabic bases becomes Low-Low (see section 3.3). Undominated $*\circ_{2l}$ excludes the option that a configuration violating OCP L is repaired by simply spreading the register-l of the first Low tone phonetically vacuously to the second Low tone (or vice versa).[11]

This point is demonstrated in the example evaluation for Low Dissimilation in (70). OCP L requires some change to the input L-L configuration (70g), but $*\circ_{2l}$ excludes l-spreading as a cheap repair (70f). Since deletion of one of the tones (70e) is also excluded by a high-ranked constraint—MAX ○ ('Assign ∗ to every morphological tonal root node which is not phonetic'), all plausible candidates involve some subtonal modification for one of the Low-tones (70a-d). The ranking of DEP T above DEP t ensures that a register tone, not a melody tone, is inserted as in (70c,d). SHR l, independently motivated by Chain Lowering, which decides in favor of changing the register of the first tone (70a), not the second one (70b), demonstrating again the tight connectedness between phonological alternations in Gaahmg:

[11] Thus l-spreading in Chain Lowering only targets High and Mid_1 tones, but not Low tones.

(70) Low-Tone dissimilation: /LL/ → [ML]

Input: = g.	OCP L	*○$_{21}$	MAX ○	DEP T	SHR l	OCP T	DEP t	*MID	MAX |
☞ a. d̪ū rù (M_1L)						*	*	*	*
b. d̪ù rū (LM_1)					*!	*	*	*	*
c. d̪ù rū (LM_2)				*!				*	*
d. d̪ū rù (M_2L)				*!		*		*	*
e. d̪ù ru (LØ)			*!			*			*
f. d̪ù rù (LL)		*!				*			
g. d̪ù rù (LL)	*!					*			

5.3 The Global Genitive Contour: Polar Falling to Low

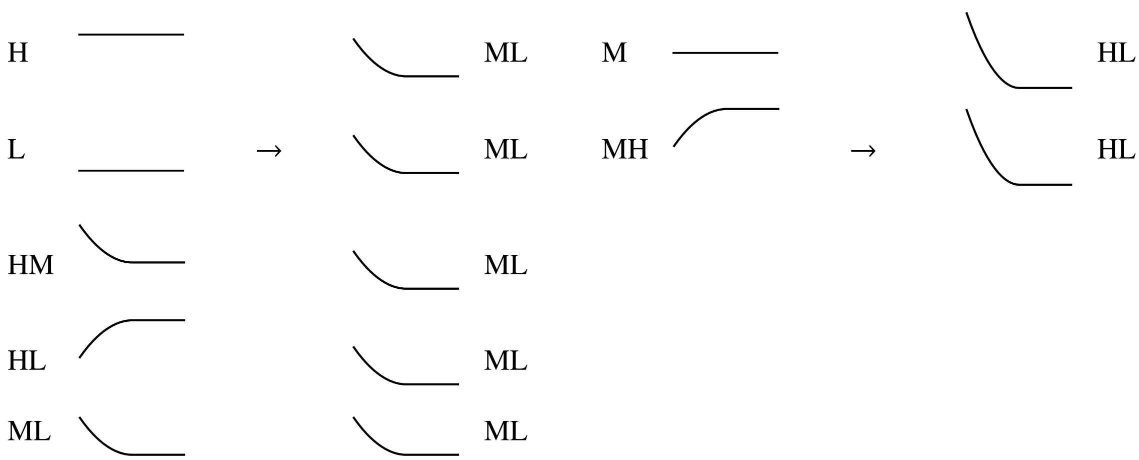
We are now in a position to address the third global Gestalt contour in Gaahmg, in the Genitive of nouns. As in the Causative, the resulting contour is consistently falling and dependent on (predictable from, but not systematically identical to) the input tone. However, in contrast to the latter, it is restricted to HL and ML, and contains an element of polarity fully in parallel to the Antipassive: Initial output Mid is found with bases that have an underlying initial High or Low (71a-d), and output High results from initial input Mid (71e,f). A final twist is that this doesn't hold for input Mid-Low which remains unchanged (71g):

(71) The Genitive Polar Falling Gestalt: Data (Stirtz 2011:125)

		Nominative	*Genitive*		
a.	H	t̪ɔ́ː	t̪ɔ̄̀ː	ML	'cow'
b.	HL	wírì	wīrī̀	ML	'bird'
c.	HM	súlə̄	sūlə̀	ML	'clan member'
d.	L	d̪ìː	d̪ī̀ː	ML	'rat'
e.	MH	tɛ̄nd̪ás	tɛ́nd̪às	HL	(bird type)
f.	M	mīː	mîː	HL	'goat'
g.	ML	ɲūːì	ɲūːì	ML	'leopard'

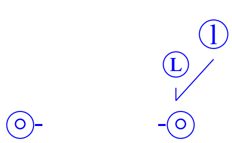
(72) shows again schematically the Gestalt nature of the overall pattern: all outputs are falling, but in different ways:

(72) Gaahmg Genitive tone change: Global Polar Falling



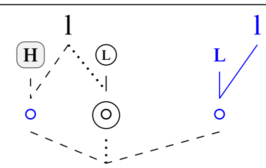
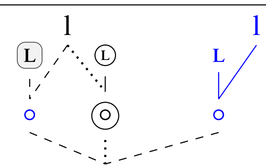
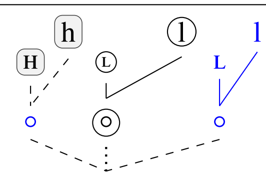
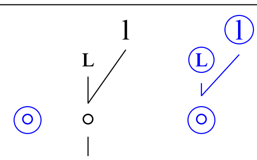
Polarity in the Genitive is unexpected as far as polarity in the Antipassive seems to be triggered by an unspecified syllabic suffix whereas the Genitive lacks any segmental affix, and is expressed purely by tonal means. The solution I propose here is to assume that the Genitive instead of an underspecified syllable introduces an underspecified tonal (prefix) root node which is epenthetically filled by distinctive ('polar') material to satisfy OCP-constraints. Thus just as the analysis of the global Causative Gestalt transposes the overwriting analysis of Body Part plurals to the subtonal level, the analysis of the Genitive replicates the Antipassive analysis in the subtonal domain. That the Genitive results also in a global Gestalt follows partially from a full-tone Low suffix, and partially from the fact that the OCP effects on the underspecified prefix root-node results in a preference for non-low tones. The underlying representation of the Genitive circumfix is thus as in (73):

(73)



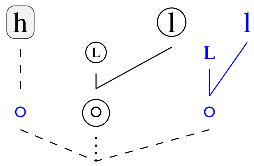
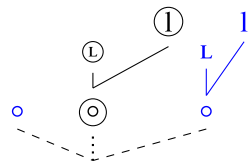
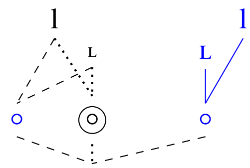
Given this representation, the Genitive Gestalt pattern now follows from the interaction of the constraints independently established for the Gestalt and polarity patterns above. This is illustrated with a Low-tone noun in (74). Overwriting is again driven by Ctg ○ since the circumfix contains two tautomorphemic tonal root nodes in parallel to Body Part Plurals separated by the base tone (74d). The additional complication here, in contrast to the earlier Gestalt patterns, is that the unspecified prefixal ○-node must be simultaneously associated to melody and register tones. As in the Causative, Dep t ensures that sharing the register of the first base's register tone is preferred over inserting a new register tone, as in (74c). Insertion of a H melody tone is preferred over L-insertion as in (74b) to avoid an <u>OCP L</u> violation, in parallel to the general L-dissimilation process discussed in section 5.2. Intuitively, a Mid (more specifically a Mid_2) tone is created because it employs the complementary melody tone to the base:

(74) Genitive overwriting: /L/ → [ML]

Input: d.	Ctg ○	τ ⊳ σ	<u>OCP L</u>	Max ○	Dep T	OCP T	Dep t	Max |
☞ a.  d̪ı̄̂ː (M_2L)				*	*	*		**
b.  d̪ìː (LL)			*!	*	*	**		**
c.  d̪îː (HL)				*	*	*	*!	*
d.  d̪ìː (L)	*!	**		**		*		

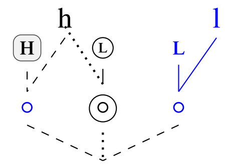
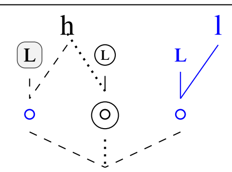
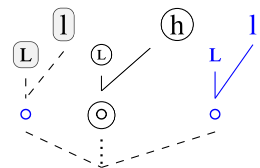
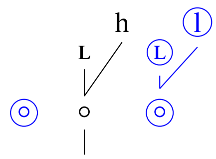
For the sake of completeness, the supplementary tableau for the same input in (75) shows some more possible outputs excluded by undominated constraints. <u>FullSpec</u> is the constraint requiring every tonal root node to be phonetically associated to a register and a melody tone, excluding incomplete tone specifications as in (75a,b) (the prefix-○ lacks a melody tone in (75a) and is fully underspecified for melody and register features in (75b)). As in the Antipassive (see the discussion of the tableau in (64)), *Share T excludes multiply associated melody tones like in (75c), where the melody-L of the first base-○ reassociates to the prefix-○ (since *Share T is a generalized markedness constraint, it penalizes double association even though the second association line is not pronounced). Together these constraints ensure that the prefix-○ must be filled by an epenthetic melody tone as in the winning candidate in (74a) :

(75) Genitive overwriting: /L/ → [ML]: More candidates excluded by undominated constraints

Input: (74d)	FULLSPEC	*SHARE T
a.  dḭ̀ː (XL)	*!	
b.  dḭ̀ː (XL)	*!*	
c.  dḭ̀ː (LL)		*!

For Mid and High-tone bases, OCP L conspires with OCP T to achieve the observed polarity pattern. This is illustrated for a Mid-tone verb in (76). A Low-Low sequence as in (76c) is again excluded by OCP L, as expected, but Mid-Low (76b) is also ruled out because inserting a melody-L would incur an additional violation of OCP T (76b) ((76b) has three adjacent melody-LS, the winning (76a) only two):

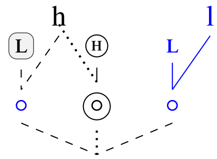
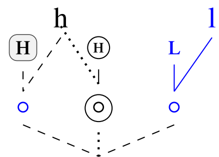
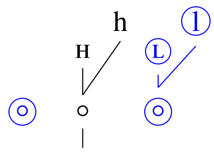
(76) Genitive overwriting: /M/ → [HL]

Input: d.	Ctg ○	OCP L	τ ▷ σ	Max ○	Dep T	OCP T	Dep t	Max |
 ☞ a. mî: (HL)				*	*	*		**
 b. mī̀: (M_1L)				*	*	**!		**
 c. mì: (LL)		*!		*	*	**	*	*
 d. mī: (M_1)	*!		**	**		*		

It is crucial for the understanding of this evaluation that OCP T is a generalized constraint under Containment (cf. section 2.3). Thus the ‘deletion’ (phonetic deassociation) of the root-L in (76a,b,c) does not avoid the OCP-violation for the two input-L-’s provided by the base and the suffixal part of the Genitive affix (and neither would deassociation of the suffixes melody-L). As already pointed out in the discussion of the Antipassive, the effect of OCP T only emerges for an underspecified structure as the input-○ where epenthesis of an identical melody tone incurs, and epenthesis of a different tone avoids violation of the constraint.

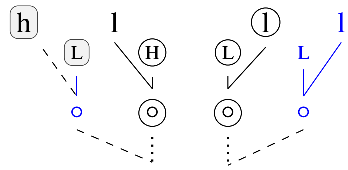
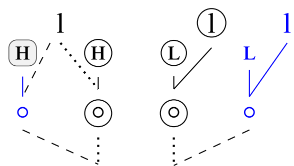
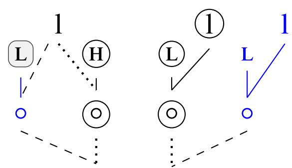
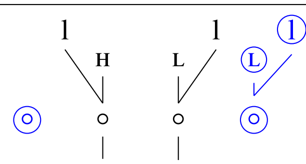
Underlying High tones provide roughly the mirror image to Mid-tone bases, as shown in (77): sharing of the High tone’s h-register and dissimilatory insertion of melody-L. The fact that both nouns with underlying Low and underlying High tone lead to Mid-Low Genitives provides further evidence for the systematic ambiguity of Gaahmg Mid tones. Whereas a Low-tone input results in [H+l]-L = Mid_2-L (see the tableau in (74)), underlying High results in surface Mid_1-L:

(77) Genitive overwriting: /H/ → [ML]

Input: c.	Ctg ○	τ ⊳ σ	<u>OCP L</u>	Max ○	Dep T	OCP T	Dep t	Max |
 ☞ a. t̪ɔ̄ː (M_1L)				*	*			**
 b. t̪ɔ̂ː (HL)				*	*	*!		**
 c. t̪ɔ́ː (H)	*!	**		**				

The phonological contrast between Mid$_1$ and Mid$_2$ also allows for a natural explanation of the fact that Mid-Low bases seem to thwart polarity by not exhibiting any change in the Genitive. Recall from section 2.2 that the Mid component of Mid-Low verbs is Mid$_2$ based on melody-H (78d). Inserting L as preferred by OCP T as in (78c) would result in two adjacent full Low tones, which is blocked by higher-ranked <u>OCP L</u>.Creating a new M_2 under register sharing (78b) incurs an unnecessary additional violation of OCP T. Thus epenthesis of both h and L establishing a M_1 becomes optimal (78a):

(78) Genitive overwriting: /ML/ → [ML]

Input: d.	Ctg ∘	τ ▷ σ	OCP L	Max ∘	Dep τ	OCP τ	Dep t	Max |
☞ a.  ɲùː ì (M_1L)				**	*	*		**
b.  ɲūː ì (M_2L)				**	*	**!		***
c.  ɲùː ì (LL)			*!	**	*	*		***
d.  ɲūː ì (M_2L)	*!	*!*		**		*		

Note also that Ctg ∘, as in the Causative, enforces the deletion of medial tones. Since nominal bases may be longer than verb roots this may affect multiple tones (e.g., HL [wírì-ìgː] → [wīrī-ìgː] 'birds'; Stirtz 2011:125). The usurped surplus syllables are filled by spreading the initial Mid tone of the syllable. See section 3.3 for an account for the directionality of spreading.

6 Morphologically Restricted Raising and Lowering

We turn now to one more, independent, argument for subtonal features. Recall first that affixation of subtonal features in all Gestalt and polarity patterns discussed so far obviates the use of construction- or morpheme-specific constraints or constraint rankings assumed as crucial in many recent analyses of complex patterns of tonal morphophonology (see e.g. Jenks & Rose 2011, 2015 on Moro, Sande 2017, 2018 on Guébie, and Rolle 2018 on Izon). A central reasoning in this line of research is that minor phonological alternations (i.e., alternations restricted to specific morphosyntactic environments) require sensitivity of constraints or constraint rankings independently from non-concatenative morphology. But once we allow for construction-specific phonology, it also naturally accounts for nonconcatenative morphology, and the most parsimonious approach is to capture both phenomena in this way. This claim is encapsulated most clearly in what Sande, Jenks & Inkelas (2020) call *Inkelas' Generalization*:

(79) *Inkelas' Generalization:*(Sande et al. 2020:5)
Morphologically conditioned phonology and process morphology make reference
to the same phonological operations in terms of Substance, Scope, and Layering.

Here I will put the argumentation underlying Inkelas' Generalization upside down: We have already seen that by the use of subsegmental features the explanatory range of a purely concatenative approach to nonconcatenative morphology can be substantially extended, covering all Gestalt and polarity patterns in Gaahmg. This is in line with the radical alternative to a construction phonology approach to procedural morphology, the *Generalized Nonlinear Affixation* (GNA) approach of Bermúdez-Otero (2012) introduced in section 2.3. In GNA, all productive nonconcatenative morphology is captured as concatenative affixation of defective (segmentally unspecified) autosegmental or prosodic material which triggers independently motivated phonological processes. Here I will show that the same approach— defective autosegmental representations—also accounts for what are apparently minor phonological alternations.

Subtonal features are especially significant in the enterprise to derive (apparent) minor alternations via concatenation simply because they are so 'small'. They are likely to be deleted in many phonological environments since they are not protected by full tonal structure, and even when they are incorporated into the phonological representation of base tones they might fail to have an overt effect since the affected tone is already underlyingly specified for the same subtonal element. In the following, I will show that this accounts naturally for several cases of tone modifications in Gaahmg which Stirtz (2011) lists as arbitrary morphophonological alternations. The overall analysis developed here thus provides further support for the restrictive assumption that construction-specific phonology is ultimately unnecessary in general (Bermúdez-Otero 2012, see also section 7.2 for more discussion).

6.1 Subjunctive Mid Raising

The first minor tone process to be discussed here is the raising of Mid tones which applies to Mid-tone verbs in the Subjunctive (80e), but not in other paradigms such as the Completive (80e') and Incompletive (80e") (see section 6.2 for discussion of the H-Lowering in the 3SG form). Raising also doesn't affect the Mid tones in HM-roots (80b), MH-roots (80c), and ML-roots (80d). As (Stirtz 2011:195) puts it, "… Mid tone melodies … are replaced by High tone for unknown reasons.":

(80) Subjunctive Mid Raising

		1SG + M		3SG + H		3PL + L		
a. fír	H	fír̄	H-M	fír-rə́	(H)-H	fír-rə̀	H-L	'to smell'
b. bɛ́l̄	HM	bɛ́l̄	H(M)-M	bɛ́l̄-d̪á	HM-H	bɛ̂l-d̪à	H[L]-L	'to name'
c. kə̄ð̄́	MH	kə̄ð̄́	MH-M	kə̄d̪́-də́	M(H)-H	kə̄d̪́-də̀	MH-L	'to strike'
d. dɔ̄ː̀s	ML	dɔ̄ː̀s-sɔ̀	M(L)-[L]	dɔ̄ː̀d̪-d̪ɔ̄	ML-[M]	dɔ̄ː̀d̪-d̪ɔ̄	ML-L	'to stand'
e. cɔ̄r	M	cɔ́r̄	[H]-M	cɔ́r-rɔ́	[H]-H	cɔ́r-rɔ̀	[H]–L	'to help'
e'. cɔ̄r	M	cɔ̄r-sə̄	(M)-M	cɔ̄r-sə́	M-H	cɔ̄r-sə̀	M-L	'to help' (Completive)
e". cɔ̄r	M	cɔ̄r	(M)-M	cɔ̄r	M-[M]	cɔ̄r̀	M-L	'to help' (Incompletive)

In a Cophonology account, this could be naturally captured by assuming a markedness constraint against overt Mid tones, in our notation *MID, which is ranked high in the construction-specific Cophonology of the Subjunctive, but low in the general phonology of Gaahmg. On the other hand, positing a H-tone affix for the Subjunctive would be at odds with the fact that this H would only surface under highly restricted circumstances, and would in most cases result in configurations which are obviously licit in the language (e.g., H-L → HL). Thus Mid Raising seems to posit a substantial challenge to the concatenativist hypothesis.

The solution I propose here is that the tonal marker of the Subjunctive is indeed simply an affix, however not a full H-tone, but a H melody tone which is prefixed. Under this account, the observed tonal change can now in fact be covered as an Emergence of the Unmarked Effect driven by *MID, defined in (81a), in tandem with higher-ranked $*_{H}\underline{\sigma}_{H}$ (81b) to be discussed further below (note crucially that *MID penalizes both Mid_1

and Mid$_2$ tones). T ▷ ○ is dominated by all other relevant constraints so that floating melody tones per se do not associate if not triggered by additional markedness constraints:

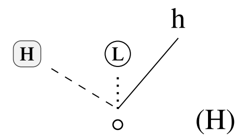
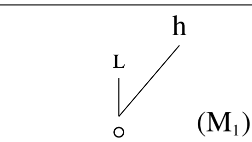
(81) a. *<u>Mid</u> Assign ∗ to every tonal root node which is phonetically associated to both low (l or L) and high (h or H) tone features

b. $*_{\text{H}}\underline{\sigma}_{\text{H}}$ Assign ∗ to every syllable which is phonetically associated to more than one High tone

c. T ▷ ○ Assign ∗ to every melody tone which is not associated to a tonal root node

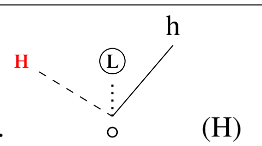
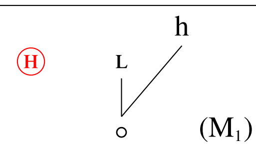
By assumption, *<u>Mid</u> and $*_{\text{H}}\underline{\sigma}_{\text{H}}$ are ranked rather low, and especially below Dep T (and Dep t), which in all environments outside the Subjunctive blocks their effects. This is illustrated in (82):[12]

(82) *No* raising of Mids outside the Subjunctive (/M/ → [M])

Input: = b.	Dep T	$*_{\text{H}}\underline{\sigma}_{\text{H}}$	*<u>Mid</u>	Max	T ▷ ○
a. 	*!			*	
☞ b. 			*		

The crucial effect of the Subjunctive prefix is thus that it provides a H-tone ‘for free’ (without epenthesis and consequent violation of Dep T). Subtonal affixation is thus directly feeding the TETU effect observed in Mid raising:

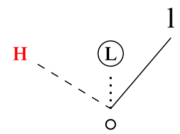
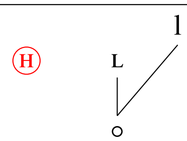
(83) Raising of Mids in the Subjunctive (M-Verb) (/M/ → [H])

Input: = b.	Dep T	$*_{\text{H}}\underline{\sigma}_{\text{H}}$	*<u>Mid</u>	Max	T ▷ ○
☞ a. 				*	
b. 			*!		*

For L-tone verbs, the melody-H stays afloat since associating it as in (84a) would create a Mid instead of avoiding it:

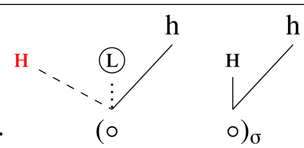
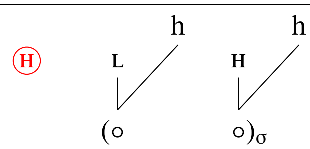
[12] By transitivity of ranking, this means that $*_{\text{H}}\underline{\sigma}_{\text{H}}$ is also ranked below τ ▷ σ and hence doesn't block affixation of a 3sg H-tone to a monosyllabic H-tone base (see section 3.1).

(84) *No* tonal overwriting in the Subjunctive (L-Verb) (/L/ → [L])

Input: = b.	DEP T	*$_{H}\underline{\sigma}_{H}$	*<u>MID</u>	MAX	T ▷ ○
a.  (M_2)			*!	*	
☞ b.  (L)					*

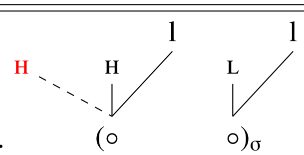
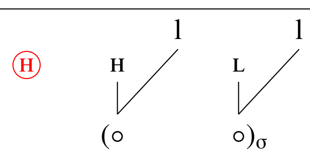
The only complication are MH-verbs where we might expect raising to HH (i.e. phonetically: H). I assume that this is blocked by higher-ranked *$_{H}\underline{\sigma}_{H}$:

(85) *No* Tonal overwriting—Subjunctive MH-verb (/MH/ → [MH])

Input: = b.	DEP T	*$_{H}\underline{\sigma}_{H}$	*<u>MID</u>	MAX	T ▷ ○
a.  (HH)		*!		*	
☞ b.  (M_1H)			*		*

For H-verbs and ML verbs (which start with Mid_2, not Mid_1), the melody-H associates vacuously to a root node which is already linked to a melody-H:

(86) Vacuous Tonal overwriting—Subjunctive ML-verb (/ML/ → [ML])

Input: = b.	DEP T	*$_{H}\underline{\sigma}_{H}$	*<u>MID</u>	MAX	T ▷ ○
☞ a.  (M_2H)					
b.  (M_2H)					*!

Notice how the analysis for Mid-tone raising builds on independently established assumptions of the overall account: The different reaction of the Mid tones in M-verbs and ML-Verbs to the prefix-H follows from the different phonological representation of these tone melodies also emerging in the Causative and the Genitive Gestalt (see sections 4.1 and 5.3) and also underlying the account of Chain Lowering (section 3.2). Note that this kind of exceptionality—a specific tone contour behaves special in *all* relevant lexical items—follows naturally from complex phonological representations, but cannot be modeled in other approaches to exceptional phonology where exceptions follow from arbitrary morphological and lexical factors. In contrast, under the approach to exceptionality developed here, it is closely interwoven with phonological detail. Thus for HM-verbs the prefix-ʜ cannot raise the second Mid-tone of the melody because of the general ban on crossing association lines. Thus these verbs show vacuous association to the first tonal root node of the verb just as in H and ML verbs. More generally, the fact that the ʜ-prefix has detectable effects in an extremely circumscribed context—only for M-tone verbs— follows from the fact that it is phonologically so small—just a molecular part of a complete simple tone—and thus many potential targets are already specified for the same melody tone. The same logic will also be crucial for the analysis of our second minor alternation, Incompletive High Lowering, in the following section.

6.2 Incompletive High Lowering

The second minor alternation we will discuss is restricted to the Incompletive and targets not a root but an affix tone, the 3rd singular High (87d). As Stirtz (2011:195) puts it: "For unknown reasons, final High tone in third singular forms with Mid root tone melody … does not surface." The 3sɢ-H shows up faithfully in the Completive (87d') and Subjunctive (87d"). Comparison with the latter example also shows that High Lowering is even more restricted than Subjunctive Mid Raising (which applies to forms with all tonal agreement suffixes) and is restricted to a single paradigmatic cell:

(87) Incompletive High Lowering (Stirtz 2011:195)

		1sɢ + ᴍ		3sɢ + ʜ		3ᴘʟ + ʟ		
a. fír	ʜ	fír̄	ʜ-ᴍ	fír	(ʜ)-ʜ	fîr	ʜ-ʟ	'to smell'
b. bɛ́l̄	ʜᴍ	bɛ́l̄	ʜ(ᴍ)-ᴍ	bɛ́l̄́	ʜᴍ-ʜ	bɛ̂l	ʜ(ᴍ)-ʟ	'to name'
c. kə̄ə̄́	ᴍʜ	kə́ə̄	ᴍʜ-ᴍ	kə̄ə̄́	ᴍ(ʜ)-ʜ	kə́ə̄̀	ᴍʜ-ʟ	'to strike'
d. cɔ̄r	ᴍ	cɔ̄r	(ᴍ)-ᴍ	cɔ̄r	ᴍ-[ᴍ]	cɔ̄r̀	ᴍ-ʟ	'to help'
d'. cɔ̄r	ᴍ	cɔ̄r-sə̄	(ᴍ)-ᴍ	cɔ̄r-sə́	ᴍ-ʜ	cɔ̄r-sə̀	ᴍ-ʟ	'to help' (Completive)
d". cɔ̄r	ᴍ	cɔ́r̄	[ʜ]-ᴍ	cɔ́r-rɔ́	[ʜ]-ʜ	cɔ́r-rɔ̀	[ʜ]–ʟ	'to help' (Subjunctive)

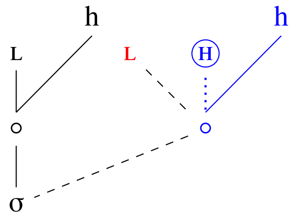
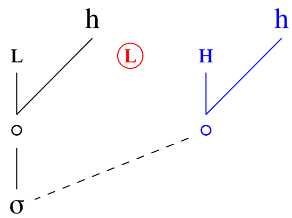
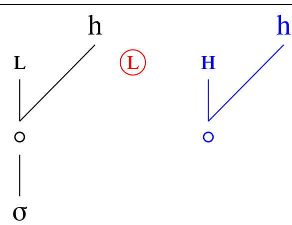
Lowering of High after Mid is again clearly not a general alternation in Gaahmg. Underlying MH-sequences surface intact (cf. the Infinitive of (87c)). Overt MH-syllables also occur on suffixes as on the Continuous Past suffix -[ən] in [fír-ə̄́n] '(s)he was smelling' (Stirtz 2011:196). On the other hand, suppletive allomorphy which would be sensitive to tonal properties of a base seems to be crosslinguistically virtually unattested (Paster 2006).

Thus I will again assume that this is a phonological alternation triggered by a relatively low-ranked markedness constraint, which is formulated in (88). Note that it is crucial that $*\underline{\sigma}_{\text{MH}}$ penalizes only two-tone contours, not Mid-High sequences in more complex contour tones. Thus … MH … is licit in Incompletive forms in HMH sequences as a result of combining a HM verb such as [bɛl] 'name' with the 3sɢ H-tone suffix (87b):

(88) $*\underline{\sigma}_{\text{MH}}$: Assign $*$ to every syllable which is phonetically exclusively associated with two tones T_1 = [ʟ,h] and T_2 = [ʜ,h] where T_1 precedes T_2

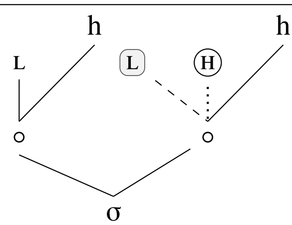
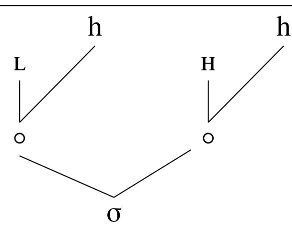
The analysis for Incompletive Lowering is now the exact mirror image of the one for Subjunctive Raising: Where the latter is triggered by a melody-ʜ prefix, the Subjunctive provides a melody ʟ-*suffix* which usurps a suffixal High tone and consequently lowers it:

(89) Incompletive Lowering: /MH/ → [MM]

Input: = c.	$\tau \rhd \sigma$	Dep τ	$*\underline{\sigma}_{MH}$	*Mid	Max |	τ ▷ ○
☞ a.  (M_1M_1)				**	*	
b.  (M_1H)			*!	*		*
c.  (M_1)	*!			*		*

The ranking of $*\underline{\sigma}_{MH}$ is fully parallel to the one of *Mid—below Dep τ. Consequently, in Infinitives an underlying MH on a single syllable is tolerated because changing the High into Mid would require inserting an epenthetic melody tone violating the higher-ranked faithfulness constraint.[13]

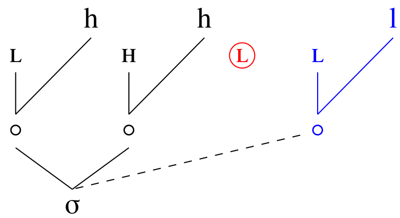
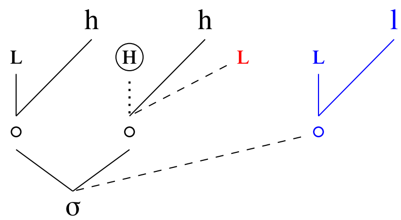
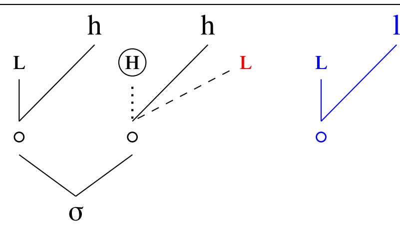
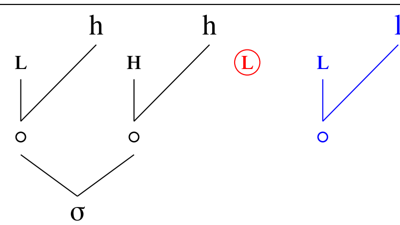
(90) No H-Lowering in Infinitives with MH-base (/MH/ → [MH])

Input: = b.	$\tau \rhd \sigma$	Dep τ	$*\underline{\sigma}_{MH}$	*Mid	Max |	τ ▷ ○
a.  (M_1M_1)		*!		**	*	
☞ b.  (M_1H)			*	*		

Underlying MH also apparently surfaces intact in the Incompletive. Here τ ▷ σ enforces association of the full agreement suffix L-tone. The output tone is hence a three-tone contour, which avoids the violation of $*\underline{\sigma}_{MH}$ (targeting only strictly two-tone contours). Association of floating Ⓛ as in (91b) is thus blocked by lower-ranked *Mid:

[13] Note that deleting/deassociating one of the involved full tones is also blocked—by Max ○. Full-tone deletion in Gaahmg can only be enforced by Ctg ○ under melody-tone circumfixation.

(91) No lowering in the Incompletive with underlying MH (/MH/ → [MHL])

Input: = d.	τ ▷ σ	Dep T	$*\sigma_{MH}$	*Mid	Max	T ▷ ○
☞ a.  (M_1HL)				*		*
b.  (M_1M_1L)				**!	*	
c.  (M_1M_1)	*!			**	*	
d.  (M_1H)	*!		*	*		*

7 Discussion

A major objection against tonal feature geometries has been that they are only motivated by single isolated patterns in any given language, but lack support by complete systems which make extensive use of the assumed subtonal structure (Clements et al. 2011). A central result of the Gaahmg analysis is thus that the same subtonal feature system accounts in a simple way for three independent hallmarks of Gaahmg morphotonology, Gestalt patterns, polarity, and minor construction-specific phonological alternations.

Adding this result to other recent in-depth investigations of tone-internal structure in single languages (Ahland 2012 on Mao, McPherson 2017 on Seenku, and Meyase 2020 on Tenyidie) makes it plausible that the alleged lack of language-wide evidence for feature geometries is due simply to the lack of detailed studies on the subject.

The overall system of Gaahmg is also instructive in another aspect: The Generalized Nonlinear Affixation approach assumed here embracing subtonal representations (see section 2.3) might seem to predict an unwarranted richness of possible defective representations. The sum of morphological patterns and minor alternations in Gaahmg demonstrates that this inventory is empirically fully justified, as shown in (92). Gaahmg has both underspecified 'skeletal' structure at the tonal and prosodic (syllabic) level (92a), and full-tone affixes, sub-tonal affixes, and combinations of both types on the tonal side (92):

(92) Inventory of defective representations

a. Tonally unspecified segmental and prosodic representations:

- Syllables (→ Antipassive, s. 5.1)
- Tonal root nodes (→ Genitive, s. 5.3)

b. Floating tonal representations:

- Full-tone suffixes (→ Subject Agreement, s. 3.1, Past (Continuous), s. 4.1)
- Full-tone circumfixes (→ Double Body Part Plurals, s. 3.3)
- Sub-tone suffixes (→ M-Raising, s. 6.1, H-Lowering, s. 6.2)
- Sub-tone circumfix (→ Causative Gestalt tone, s. 4.1)
- Full-Tone + sub-tone circumfix (→ Verbal Noun Gestalt, s. 4.2)

Thus Gaahmg demonstrates that all types of defective structure predicted by the combination of the GNA-approach and Register Tier Theory (cf. section 2) may be found alongside in the same language and can be captured in a unified analysis.

Finally Gaahmg, adds a number of additional pieces of evidence to the substantial body of data favoring an autosegmental analysis of tonal morphophonology. Autosegmental representations directly account for the fact that Chain Lowering fails to apply in specific forms of Body-Part Plural Overwriting, which follows from intervention of floating stem material (section 3.3). They explain the emerging (counterfeeding) opacity in configurations with two adjacent Low-tone syllables. These are repaired in forms with two representationally distinct Low tones, but not for two adjacent Low tones derived by Chain Lowering where they exhibit double linking (section 5.2). Autosegmental subtonal representations also naturally capture the systematically different status of Mid-tones in Mid-Low contours across the language, which is derived by assigning to it a different feature structure than other underlying Mid tones in Gaahmg.

7.1 Beyond Gaahmg: Gestalt Contour Patterns in other Languages

Probably the closest counterpart to the Gaahmg Gestalt contours in other tone languages is the pattern of Imperfective Tone Marking in Guébie identified in work by Sande (2017, 2018, 2019). Guébie has an underlying 4-tone system (in Sande's notation 4 is the highest and 1 the lowest tone), and most tenses are expressed by auxiliaries immediately following the subject, with the verb in clause-final position:

(93) Guébie Future and Irrealis auxiliaries (Sande 2018:259)

a. e^{4} ji^{3} ɟa^{31} li^{3}
1SG.NOM FUT coconuts eat
'I will eat coconuts'

b. e^{4} ka^{3} ɟa^{31} li^{3}
1SG.NOM IRR coconuts eat
'I would eat coconuts'

In Perfective (94a) and Imperfective (94b) forms, there is no segmental auxiliary and the verb appears in the position immediately following the subject. While the Perfective is thus effectively zero-marked, the Imperfective is realized as a complex tonal modification. For most inputs the initial tone of the verb undergoes a chain shift, where every tone is lowered by one degree (4 → 3, 3 → 2, 2 → 1):

(94) Guébie: Imperfective verb tone lowering (Sande 2018:260)

a. e^{4} li^{3} ɟa^{3}-ɓə^{1}
1SG.NOM eat.PFV coconuts-SG
'I ate a coconut'

b. e^{4} li^{2} ɟa^{3}-ɓə^{1}
1SG.NOM eat.IPFV coconuts-SG
'I am eating a coconut'

The only exception are verbs with the lowest tone, 1, where—apparently to avoid a Superlow tone, there is instead raising of the final tone in the preceding subject (95b):

(95) Guébie: Imperfective subject tone raising (Sande 2018:263)

a. ɟaci$^{23.1}$ pa^{1}
Djatchi run.PFV
'Djatchi ran'

b. ɟaci$^{23.2}$ pa^{1}
Djatchi run.IPV
'Djatchi runs'

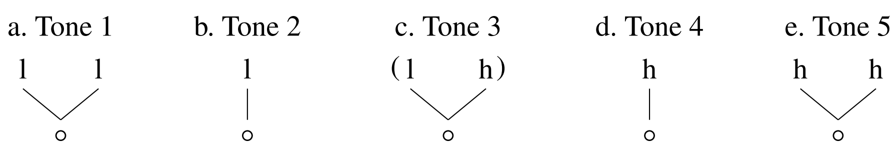
Just as verb lowering, subject raising is chain-shifting. Every tone is replaced by the next-higher tone in the inventory:

(96) Guébie tonal chain shifts (Sande 2019:468–469)

a. Verb tone lowering			b. Subject tone raising		
Underlying tone		Imperfective Tone	Underlying tone		Imperfective Tone
4		3	4		5
3	→	2	3	→	4
2		1	2		3
1		1	1		2

Guébie Imperfective tone is not uniformly creating falling configurations (as for example the Gaahmg Causative Gestalt). Thus an underlying rising configuration such as Subject^{2} Verb^{4} will still be rising after undergoing the lowering of the verb (resulting in Subject^{2} Verb^{3}). Still, the pattern uniformly serves to approximate (or maximize) falling, and is thus a distant relative to the Gaahmg patterns. It is hence striking that Sande (2018) discusses a simple and elegant concatenative analysis of these data much along the lines of the analysis developed here, representing the Guébie tone system purely by scalar (register) features. The Imperfective marker then amounts to a tonal auxiliary which, as expected, follows the subject, and consists of a sequence of register features (high-low), whose realization is driven by REALIZE MORPHEME. (Sande rejects this analysis in favor of one using morphologically triggered constraint rankings, see section 7.2.3 for critical discussion). I show here a slightly simplified version of this analysis adapted to my formal assumptions. The central idea is that multiple register features on a single root node are not interpreted as a temporal sequence, but as cumulative specifications of the same pitch target such that for example (97a) is lower than (97b), and l's and h's on the same root node cancel each other out. Hence Tone 3 might be equivalently represented as a bare tonal root node or as a combination of h and l as in (97c):

(97) Guébie tone in Sande (2018) (slightly adapted)



REALIZE MORPHEME (RM) ranked above faithfulness constraints barring epenthetic association lines now ensures that either the register-l (98i-a) or the register-h (98ii-a) associate, but never both (98i-b,ii-b).The standard constraint *SKIP blocks association of the floating features across its unassociated twin feature (98i-d/ii-d), restricting lowering to the following verb and raising to the preceding noun. The noun-verb alternation then follows from the interaction of *AS(SOCIATE)-L(EFT) and $*\circ_{31}$ ("Avoid association of a tonal root node to more than two l-register features"). The ranking of *AS-L above *AS(SOCIATE)-R(IGHT) effects association of ⓛ to the following verb as in (98i) in the default case. However, if this would lead to a violation of $*\circ_{31}$ (a Superlow tone as in (98ii-a)), leftwards association is chosen instead (98ii-c):

(98) Guébie analysis using register features

(i) Lowering of verb tone: /3 + 3/ → [3 +2]

Input: e.	RM	*SKIP	$*\circ_{31}$	*AS-L	*AS-R
☞ a. ⓗ l / ○ ○					*
b. h l / ○ ○				*!	*
c. h ⓛ / ○ ○				*!	
d. ⓗ l / ○ ○		*!		*	
e. ⓗ ⓛ / ○ ○	*!				

(ii) Raising of subject tone: /3 + 1/ → [4 +1]

Input: e.	RM	*SKIP	$*\circ_{31}$	*AS-L	*AS-R
a. ⓗ l l l / ○ ○			*!		*
b. h l l l / ○ ○			*!	*	*
☞ c. h ⓛ l l / ○ ○				*	
d. ⓗ l l l / ○ ○		*!		*	
e. ⓗ ⓛ l l / ○ ○	*!				

To be sure, this analysis of Guébie requires an extension to the range of possible crosslinguistic variation in tone inventories with respect to the possibilities originally envisioned by Snider (1999) for Register Tier Theory. It also implies that the structure of tone in Guébie is systematically different from tone in languages like Tenyidie and Gaahmg. Whereas the latter two languages ban recursive registers tones on the same root node, Guébie eschews the use of melody tones.[14] This predicts that in Guébie there should be no phonological processes relating tones that are non-adjacent in pitch. Given our current knowledge of the language, this seems to be correct: The only other tonal process reported in Sande (2017) which systematically relates different tones (i.e., not simply adds a tone or replaces/spreads all full tones on a par) is another tone shift which expresses Nominative/subject status on pronouns and raises them by one. Conversely, Tenyidie in the detailed description of Meyase (2021) shows no scalar effects comparable to the ones in Guébie. I will show immediately below in section 7.2.1 that Gestalt contours in Gaahmg are also incompatible with the geometry in (97).

7.2 Possible Alternative Analyses of Gestalt Contours

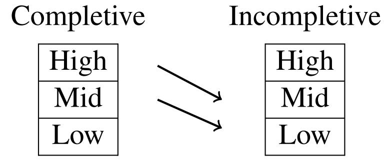
Gestalt contours have so far not been identified explicitly in the theoretical literature. Thus I will discuss here formal approaches which have been proposed for the empirical phenomenon which is intuitively closest to this kind of pattern, morphologically triggered tonal chain shifts (including the Guébie data discussed in

[14] I assume again that this is the result of morpheme structure constraints following from an Stem-Level optimization cycle (see section 2.1).

section 7.1). A simple instance of this is the Incompletive aspect in Day which shifts High-tone verbs to Mid, and Mid tone verbs to Low:

(99) Aspect in Day (Hyman 2010:8, Nougayrol 1979)

		[HIGH]	[LOW]
Completive	[high]	júː	jūː
Incompletive	[low]	jūː	jùː
		'put on, wear'	'drink'

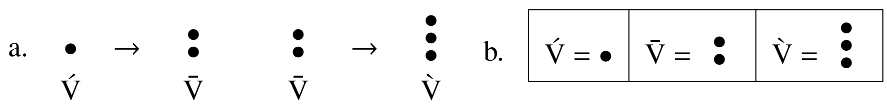


Chain shifts of this type, although not involving contours, also have a Gestalt flavor since they add a consistent tonal component (pitch height), which is inconsistent in terms of the resulting full tones in the output. Here I will discuss three major theoretical approaches to tonal chain shifts, based on Hyman (2010) and Sande (2018). Conversely, morphological chain shifts as in Day can also be captured succinctly by tonal feature geometries in parallel to purely phonological chain shifting in Gaahmg, as already indicated by the feature assignments in (99). Thus assume that the Completive exhibits the underlying verb tones (H = [HIGH, high] and M = [LOW,high]), and Day, as Gaahmg, phonetically neutralizes the contrast between the two Mid tones [LOW, high] and [HIGH, low]. The pattern in (99) then follows if the Incompletive is a floating register-[low] overwriting the [high]-specification of the base tone.

7.2.1 Scalar Height Affixation (Hyman 2010)

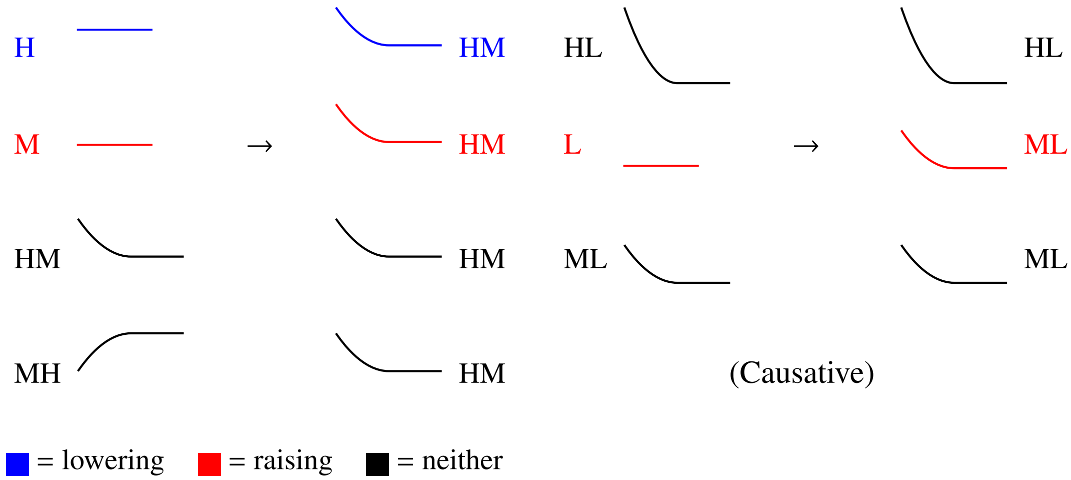
If pitch height is represented in a scalar way by grids such that High tone equals one grid mark, Mid two marks, and Low three (100b), the Day chain shift could be captured simply by encoding the Completive tone morphology as a floating grid mark as shown in (100):

(100) Day by scalar tone representations



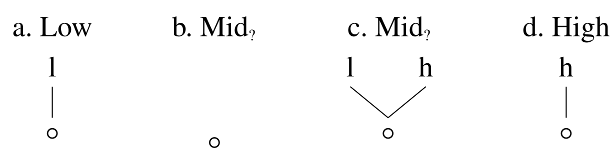
Scalar affixation has independent problems, e.g., for languages which show chain shifts in two directions (e.g., Guébie and Seenku, McPherson 2017). It is also not obvious how this account could be extended to Gaahmg Gestalt patterns since these are not uniformly raising or lowering with respect to their input tone. This is illustrated in (101) for the Causative Gestalt, where an output pattern is classified as lowering if it has at least one full tone which is lower than all input tones, higher if it has at least one higher tone, and 'neither' if it has the same tones. Crucially there is no identifiable tendency for raising or lowering:

(101) Gestalts are not uniformly lowering or raising



The bidirectionality dilemma might be in principle solved by adopting the scalar geometry discussed above for Guébie (97), which uses lowering and raising primitives without recursion and distinguishes the two Mid tones by representing one as a bare tonal root node and the other one as combining [l] and [h].

(102) Gaahmg tones in a bidirectional scalar representation



However, this implies other problems. Consider for example the Verbal Noun Gestalt (see section 4.2) which lowers final Hs to M, but leaves final Ms and Ls unchanged . This is captured naturally by an overwriting L melody suffix because both Low and Mid tones already contain a L component. This correctly predicts phonetically vacuous overwriting ([L,l] + L → [L,l], [L,h] + L → [L,h]). On the other hand, l-affixation to either of the representations in (102b,c) predicts lowering of Mid tones to Low. This cannot be excluded in general for Gaahmg since lowering of Mid to Low is observed in Chain Lowering, where it is due to register-l, not melody-L. The geometry containing both melody and register features allows a simple qualitative account of this difference not available in the strictly scalar system in (102).

The scalar geometry also makes wrong predictions for polarity (see section 5) where we would expect that L triggers H and H triggers L, whereas both tones in fact trigger a surface Mid. Finally, the geometry in (102) also seems to make it impossible to uniformly characterize the differences between the two types of Mid tones. Thus suppose that the Causative Gestalt (see section 4.1) is derived by a scalar h- -l circumfix. The M of MH contours should correspond to (102b) to capture the fact that it is raised to H ([ ] + h → [h] = High, whereas the Mid in ML stems should be (102c) to capture the fact that it remains unchanged ([l,h] + h → [l,h]). Singleton M should also correspond to (102c) since the combination of h- -l with (102b) (which contains no sub-tones) would incorrectly result in HL, not HM. The resulting prediction is thus that ML and M stems should pattern together in contrast to the exclusion of MH, but the evidence we have seen from polarity patterns and minor alternations is exactly the opposite grouping. Thus, whereas Gaahmg allows a limited amount of chain shifting, its overall morphotonology is best represented fully in parallel to Tenyidie.[15]

[15] As noted by an anonymous reviewer, deriving a chain shift from a phonetic merger of two Mid tones, cannot capture a ternary chain shift in a language with four basic tones. This—apparently correctly—excludes a four-tone language which mixes the char-

7.2.2 Full-tone affixation + Contour Simplification (Hyman 2010)

The analysis of Day which Hyman (2010) actually favors involves neither subtonal features nor scalar representations, but prefixation of a full-scale Low-tone which is then simplified to avoid a contour tone on a single syllable as shown in (103):

(103) Hyman's (2010) analysis of Day

			Affixation		Contour simplification
a.	H	→	L-H	→	M
b.	M	→	L-M	→	L

This approach is conceptually problematic since it requires arbitrary rewrite rules which are incompatible with Optimality Theory, but also restrictive versions of rule-based approaches (see e.g. Archangeli & Pulleyblank 1994). For Gaahmg, it would also face empirical problems. Note first that Gaahmg Gestalt patterns seem to be independent from prosodic size. This is illustrated with a minimal pair of Causative forms in (104). The base is monosyllabic in (104a) (modulo the Completive suffix), but bisyllabic in (104b) (due to the Antipassive suffix), but the change from MH to HM is exactly the same:

(104) Gestalt patterns are not dependent on prosodic size: Causative /MH/ → HM (Stirtz 2011:210)

	MH		HM
a. 1σ-Base	kə̄ś(-sə́) strike-3SG	→	kə́s̄(-sə́) strike:CAUS-3SG
b. 2σ-Base	māːr-án(-sá) buy-AP-3SG	→	mə́ːr-ə̄n(-sə́) buy:AP:CAUS-3SG

The same independence is found in the Genitive. The resulting tone patterns depend purely on the input tone melody, not on the syllable number of the base:

(105) Gestalt patterns are not dependent on prosodic size—Genitive (Stirtz 2011:125)

	Nominative		*Genitive*			
a.	H	t̪ɔ́ː	t̪ɔ̄̀ː	ML	'cow'	1σ
b.	HL	wírì	wīrī̀	ML	'bird'	2σ
c.	HM	súlə̄	sūlə̄̀	ML	'clan member'	2σ
d.	L	d̪ìː	d̪ī̀ː	ML	'rat'	1σ
e.	MH	tɛ̄nd̪ás	tɛ́nd̪às	HL	(bird type)	2σ
f.	M	mīː	mîː	HL	'goat'	1σ
g.	ML	ɲūːì	ɲūːì	ML	'leopard'	2σ

In contrast to Day, Gaahmg also relatively freely allows for contour tones, in derived contexts often even 3-tone contours (see, e.g., the Incompletive forms in (15)), thus Contour simplification couldn't be a general language-wide process, as it might be in Day. In fact, in many cases Gestalt patterns *create* contours such as in all Incompletive Causative forms with single-tone bases (i.e., /H/ → [H**M**], /M/ → [**H**M], /L/ → [**M**L]). Single-tone bases also lead to a further problem with a full-tone affixation analysis: this would require a H-prefix for M-bases, but an M-prefix for H-bases. Note finally that this discussion is closely related to the reasons why Hyman (2010) rejects a subtonal affixation analysis for Day. There are longer bases in

acteristics of Tenyidie or Gaahmg and of Guébie (e.g., the Guébie Imperfective chain shift and Tenyidie register spreading).

the language where additional full-tones show up (e.g., Completive ML [lāvɔ̀] → LML [làvɔ̄ɔ̀] 'to sweat', Nougayrol 1979:169). Gaahmg single-tone bases in the account provided here actually show the same effect: Subtonal affixation results in surface addition. This is achieved simply by epenthesis of a tonal root node to ensure association of a floating melody tone. Thus 'mixed' full-tone/sub-tone exponence is in principle not an obstacle to a sub-tonal analysis.

7.2.3 Scalar Representations + Arithmetic Constraints + Cophonologies (Sande 2018)

In Cophonology approaches, tonal overwriting is interpreted as an effect of construction-specific constraint ranking. Thus Inkelas & Zoll (2007) capture the LH-overwriting in the Hausa Imperative (1), simply by a constraint requiring LH-tone ('Tone = LH') for the domain, ranked above tonal faithfulness constraints (Ident-tone). This ranking is associated with the morphological Imperative construction, and thus limited to Imperative word forms.

Similarly, Sande (2018) ultimately rejects the feature affixation analysis of Guébie discussed above (section 7.1) in favor of a Cophonology by Phase account driven by the constraint in (106):

(106) PitchDrop (Sande 2018:272):
For each phonological word, x, which immediately follows another phonological word, y, assign one violation if the final tone level of y is not relatively higher than the initial tone level of x on the four-tone scale than it was in the input.

Input	*Output*
FST-IVT=n	FST-IVT=n+1

It is instructive to shortly consider Sande's comparison of the two approaches since the more recent CbP literature presents the 2018 paper as providing decisive evidence for the Cophonology analysis. In point of fact, Sande concedes that both analyses are descriptively adequate, but diagnoses a tradeoff of theoretical complexity: The featural affixation analysis necessitates the adoption for a subtonal feature geometry with an independent root node, while the CbP account requires the option of construction-specific phonology. On this backdrop, Sande's choice seems to be a leap of faith in favor of the latter.

While I agree with Sande that global theoretical choices like the adoption of tonal feature systems and Cophonologies cannot be based on specific data from a single language, I believe that even the Guébie data actually provide two pieces of support for the feature-geometric account: *First*, adopting register features, the alternation between a lowering and a raising chain shift in the language falls out from simple and local standard OT-constraints already independently motivated for full tones (and other phonological features) transposed to the subtonal domain. On the other hand, the constraint in (106) is unprecedented in substance and format, introducing a complex arithmetic component in contrast to the widespread assumption that phonology doesn't require any kind of complex counting (see e.g., Goldsmith 1976; Myers 1987; McCarthy & Prince 1996; Prince & Smolensky 1993). There are no attested languages where the same kind of differential pitch raising/drop would happen across the board, and the constraint requires a complex arithmetic evaluation of scale values usually thought beyond the power of single rules or constraints (McCarthy 2003).[16] I take it as direct evidence for the Register Tier-approach that it allows to put the explanatory burden for the complex Guébie alternation on a mechanism independently motivated by the need to capture tonal register effects (downstep and upstep), whereas the Cophonology account has to resort to a

[16]Also recent claims advocating phonological "counting" (see, e.g., Paster 2019) do not use arithmetic operations of this type, but simply shifting and spreading rules specifying more than two phonological elements on a single tier (e.g., a rule spreading a H to two following moras like μ́μμ → μ́μ́μ́). Whereas this type of rule violates standard restrictions on phonological locality (Myers 1987; Hewitt & Prince 1989; McCarthy 2003), its application does not require explicit computation or comparison of numerical values as the PitchDrop constraint.

complex ad-hoc-constraint. *Second,* whereas the concatenative Register-Tier account directly accounts for the fact that the phonological effects of the Imperfective are restricted to subject and verb by phonological locality, in a Cophonology approach there is no principled way to correctly restrict the application of the PitchDrop constraint. Sande makes this point herself for the original version of Cophonology Theory where the domain of Cophonologies are word-internal constructions in a lexicalist architecture. The Guébie data are incompatible with this approach since the alternation applies across the word boundary between subject and verb. Thus the morphosyntactic domain for PitchDrop is too small. Strikingly the alternative Sande proposes, Cophonologies by Phase, implies that the evaluation domain of the constraint is the entire clause (CP Phase). But under this assumption, the unqualified version of PitchDrop first discussed by Sande (2018) (i.e., (106)) incorrectly predicts that all boundaries between words in an Imperfective clause should undergo the same change. Thus the application domain of PitchDrop is now potentially too big. Sande (2018, 2019) discusses different possibilities to restrict the constraint definition which solve the empirical problem, but they all amount to add further stipulative details to an already stipulative constraint, in contrast to the feature-geometric analysis where the locality restrictions fall out from general conditions on autosegmental locality.

For Gaahmg, applying a Cophonology account along the lines of Sande (2018) would similarly necessitate arbitrary ad-hoc constraints, requiring that every word form has two tones where the second one is lower than the first—again a constraint performing arithmetic computation. While this can be done technically, it leads again to a wrong crosslinguistic typology predicting languages where all word forms (or all clauses) have a falling tone independently of actual tone values. This arbitrariness is also evident from the fact that other constructions in Gaahmg, especially Double Plural Possessives deliberately create *rising* contours.

On the other hand, there are important generalizations on Gaahmg tone which cannot be captured without an autosegmental feature geometry involving tonal root nodes and subtonal features.

First, note that polarity in the Antipassive and the Genitive work fully in parallel, even though on the surface it is syntagmatic in the Antipassive, and paradigmatic in the Genitive. This can be captured in the feature geometry account since the underspecified affix root node in the Genitive (which phonetically replaces the initial base tone) is subject to the same OCP constraints as the epenthetic tonal root node in the Antipassive. In a Cophonology account, only the Antipassive could be derived by an OCP constraint. The Genitive would have to be captured by an unrelated antifaithfulness constraint requiring that the first tone of the base is replaced in a complex manner by a different tone on the surface.

Second, the Mid component in underlying Mid-Low melodies behaves systematically differently from other Mid tones. Thus in contrast to the Mid in simple-Mid-tone verbs, it is not raised to High in the Causative Gestalt, fails to exhibit Genitive polarity, and doesn't undergo Mid raising in the Subjunctive. All three exceptions follow directly from the analysis developed here if the Mid of Mid-Low melodies is Mid_2 (i.e., [high + low]) whereas other Mid tones are Mid_1 (i.e., [Low + high]. This Mid tone is exceptional, but not in a way which could be captured by Cophonologies. since the exceptionality of these Mids is due to their presence in underlying ML-complexes not to arbitrary lexical specification.

Third, The opaque underapplication of Chain Lowering in Double Body Part Plurals follows naturally in the feature-geometric account from the intervention of underlying material blocking the spreading of the register tone which implements Chain Lowering under this analysis. In a Cophonology approach without subtonal register features, this process cannot be captured as spreading. Hence there is no reason why underlying material should be able to intervene.

Recall finally that the feature-geometric account of Gaahmg developed here not only captures Gestalt contours, but also apparent cases of construction-specific phonology providing further evidence that Cophonologies are ultimately unnecessary.

8 Summary

In this paper, I have demonstrated that subtonal feature-geometric representations capture a wide array of phenomena in Gaahmg: Gestalt contours, both of a monotonic and of a polar type, a chain-shifting sandhi process, and morphologically restricted phonological alternations. Thus the language not only provides substantially new types of evidence for tonal feature geometries, but also a case where the same representation accounts for multiple heterogeneous phenomena in the same language in a unified way. In the final discussion, I have shown that the representational approach effectively obviates arithmetic constraints and morpheme-specific phonology, not only for Gaahmg, but potentially also for a much broader set of crosslinguistic data.

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A Appendix: Constraint Rankings and Ranking Arguments

A.1 Overall Ranking

(107) is the full ranking of constraints assumed in the analysis in the form of a stratified domination hierarchy (Tesar & Smolensky 1998), where the highest set ('stratum') of constraints ($\{*_{\text{h}}\underline{\circ}_{\text{l}} \ldots *\cdots\tau_{\omega}\}$) contains all constraints which are never violated by any output in the overall analysis, and all other constraints are ranked as highly as possible. Thus, the constraints in the second constraint stratum ($\{(\underline{\textsc{Share}}\ \text{l})_{\sigma} \ldots \textsc{Max}\ \circ\}$) are crucially dominated by at least one constraint from the highest constraint stratum for at least one evaluation, but are not crucially dominated by any of the lower-ranked constraints. The ranking of constraints inside a specific stratum is irrelevant for the evaluations in the analysis.

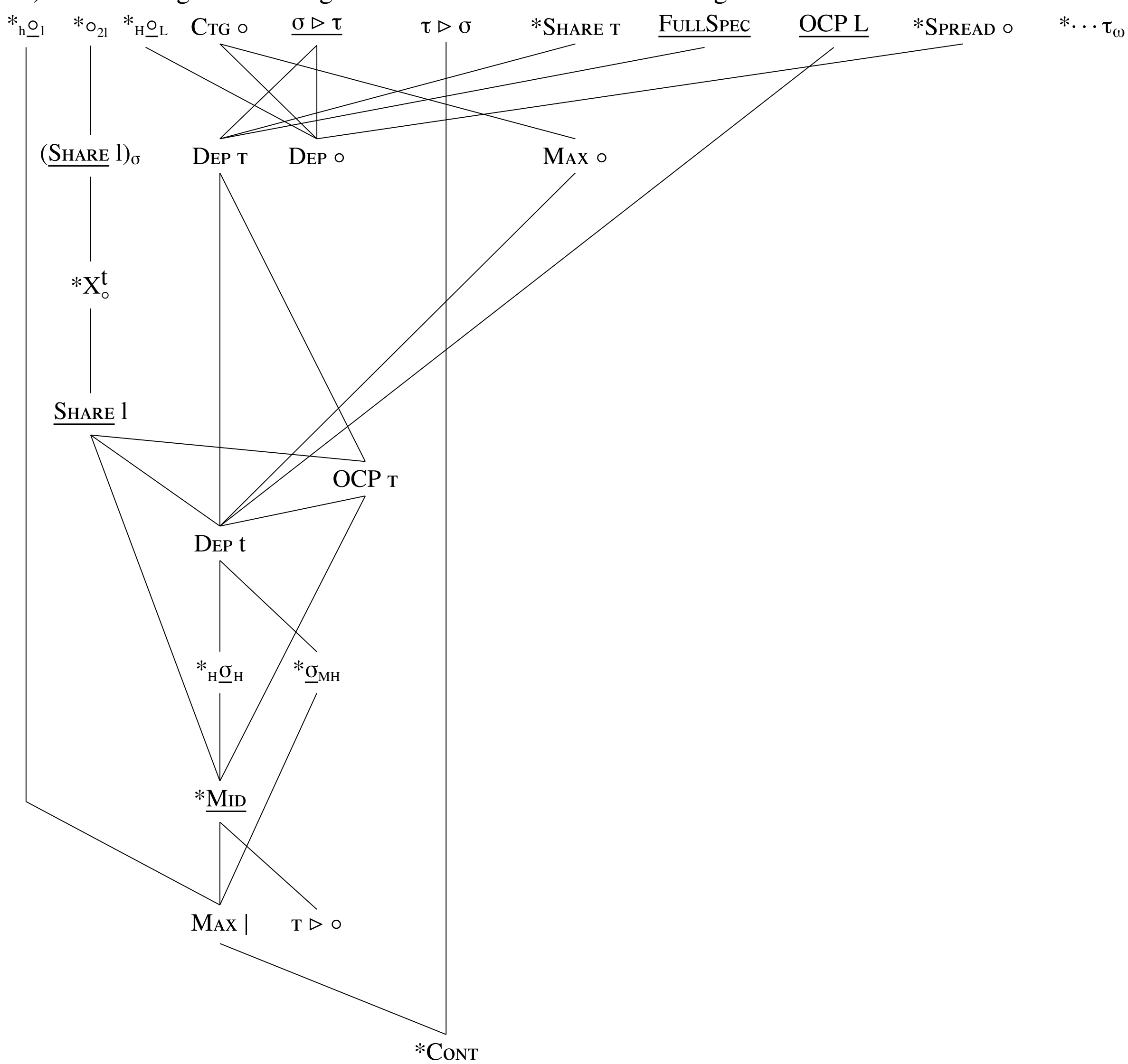
(107) Full ranking assumed in the analysis

$$\left\{\begin{array}{c} *_{\text{h}}\underline{\circ}_{\text{l}} \\ *\circ_{\text{2l}} \\ *_{\text{H}}\underline{\circ}_{\text{L}} \\ \textsc{Ctg}\ \circ \\ \underline{\sigma \rhd \tau} \\ \tau \rhd \sigma \\ *\textsc{Share}\ \textsc{t} \\ \underline{\textsc{FullSpec}} \\ \underline{\text{OCP L}} \\ *\textsc{Spread}\ \circ \\ *\cdots\tau_{\omega} \end{array}\right\} \gg \left\{\begin{array}{c} (\underline{\textsc{Share}}\ \text{l})_{\sigma} \\ \textsc{Dep}\ \textsc{t} \\ \textsc{Dep}\ \circ \\ \textsc{Max}\ \circ \end{array}\right\} \gg *\text{X}^{\text{t}}_{\circ} \gg \underline{\textsc{Share}}\ \text{l} \gg \text{OCP}\ \textsc{t} \gg \textsc{Dep}\ \text{t} \gg \left\{\begin{array}{c} *_{\text{H}}\underline{\sigma}_{\text{H}} \\ *\underline{\sigma}_{\text{MH}} \end{array}\right\} \gg *\underline{\textsc{Mid}}$$

$$\gg \left\{\begin{array}{c} \textsc{Max}\ | \\ \textsc{t} \rhd \circ \end{array}\right\} \gg *\underline{\textsc{Cont}}$$

The Hasse diagram in (108) depicts the crucial dominance relations among constraints motivating the ranking in (107) (omitting some of the redundant relations). Note that every constraint stratum in (107) corresponds to a row of constraints with the same vertical alignment here. The specific arguments for single dominance relations in the Gaahmg analysis are listed in appendix A.2.

(108) Hasse diagram showing crucial dominance relations among constraints



A.2 Ranking Arguments

The following table provides ranking arguments for all dominance relations shown in (108) with links to the tableaux demonstrating them (explicitly or implicitly) or to the relevant data in the paper:

$_{h}\underline{\circ}_{l}$	≫ MAX |	(Association line to) Register-h is deleted to avoid subtonal register contour	(23)
$*\circ_{2l}$	≫ ($\underline{\text{SHARE}}$ l)$_\sigma$	l-spreading is blocked as an $\underline{\text{OCP L}}$ repair	(70)
$*_{H}\underline{\circ}_{L}$	≫ DEP ○	○-epenthesis to avoid subtonal melody contour	(46)
CTG ○	≫ DEP ○	Contiguity is satisfied at the cost of ○-epenthesis	(46)
CTG ○	≫ MAX ○	Contiguity is satisfied at the cost of ○-deletion	(74)
$\underline{\sigma \rhd \tau}$	≫ DEP T	Empty syllable is repaired by full-tone epenthesis (including a melody tone)	(63)
$\underline{\sigma \rhd \tau}$	≫ DEP ○	Empty syllable is repaired by full-tone epenthesis (including a ○-node)	(63)
$\tau \rhd \sigma$	≫ *$\underline{\text{CONT}}$	Association of affix tone creates contours	(17)
*SHARE T	≫ DEP T	Melody epenthesis instead of melody spreading/sharing	(74)/(75)
$\underline{\text{FULLSPEC}}$	≫ DEP T	H-insertion to achieve melody-association of ○	(74)/(75)
$\underline{\text{OCP L}}$	≫ DEP t	L-dissimilation happens at the cost of h-insertion	(70)
*SPREAD ○	≫ DEP ○	Melody insertion is prefered over full-tone spreading	(64)
($\underline{\text{SHARE}}$ l)$_\sigma$	≫ $*X^{t}_{\circ}$	Chain lowering applies across deleted tones in monosyllabic nouns	(30)
DEP T	≫ DEP t	L-dissimilation is achieved by register-h insertion on L_1 not by melody-H insertion on L_1	(70)
DEP T	≫ OCP T	L-dissimilation is achieved by register-h insertion on L_1 not by melody-H insertion on L_2	(70)
MAX ○	≫ DEP t	L-dissimilation is achieved by register-h insertion not by L-deletion	(70)
$*X^{t}_{\circ}$	≫ $\underline{\text{SHARE}}$ l	Chain lowering is blocked across deleted tones in polysyllabic nouns	(29)
$\underline{\text{SHARE}}$ l	≫ *$\underline{\text{MID}}$	Chain Lowering creates surface M-tones	(23)
$\underline{\text{SHARE}}$ l	≫ DEP t	Insertion of register-h happens to avoid creating a L not sharing l with another tone	(70)

(Continued)

<u>Share</u> l	≫ OCP t	Two adjacent melody-ls are tolerated to avoid a L not sharing l with another tone	(70)
OCP t	≫ Dep t	h is inserted to avoid two adjacent ls	(78)
OCP t	≫ *<u>Mid</u>	Creation of M in the Antipassive to avoid two adjacent melody-hs	(64)
Dep t	≫ $*_{H}\underline{\sigma}_{H}$	H-suffixation to Incompletive H-bases does not trigger dissimilation by l-insertion	(15)
Dep t	≫ $*\underline{\sigma}_{MH}$	Underlying MH-verbs do not trigger repairs by l-insertion	(15)
$*_{H}\underline{\sigma}_{H}$	≫ *<u>Mid</u>	Mid raising is blocked after tautosyllabic H	(85)
$*\underline{\sigma}_{MH}$	≫ Max |	High lowering after Mid applies at the expense of deleting association lines	(89)
*<u>Mid</u>	≫ Max |	Mid raising applies at the expense of deleting association lines	(83)
*<u>Mid</u>	≫ t ⊳ ○	Floating melody-h is not associated if this would create a Mid tone	(84)
Max |	≫ *<u>Cont</u>	Underlying contour tones surface as such, and tone affixation leads to new contour tones	(17)