When cyclicity of operations unearths chains of tone

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Abstract

The dichotomy of researchers and thinkers presented by Isaiah Berlin (see also Aronoff 2016 for specific application to the field of linguistics) contrasts the 'fox' and the 'hedgehog' – whereby the latter is driven by a singular, focused goal around which all subsequent intellectual activity is channeled. I present this contribution to celebrate the achievements of the 'Igel of Igra', to specifically honor Gereon Müller for his singular and impactful "Leipzig School" contribution on formalizing and then gaining insights from being explicit about the order of operations, and the potential feeding and bleeding interactions that can be found in the syntax as a result. One of the central themes of IGRA research was the parallels between order of operations across various grammatical domains, and in this paper I specifically attempt to bring out parallels between tonal movement in phonology and A′-dependencies in syntax.

1. Overview

"The most striking property of African tone is its mobility" (Yip 2002: 133)

The dissertation of Georgi (2014) looks at reflexes of A′-movement across a range of languages and charts a four-way typology of patterns: these reflexes of A′-movement (usually on the verb or functional material through which the A′-moving element passes) may occur in *all* or *none* of the clauses of the dependency, in the clause where the dependency terminates, or solely in clauses where it does not terminate (the latter being Pattern III in the typology).. In charting these different means of chain-realization, Georgi discovered a virtually theretofore undocumented morphosyntactic pattern of *wh*-movement chains, the Pattern III (PIII): in which the reflex of movement is spelled-out on intermediate, but not the final landing position of a wh-phrase (see Georgi 2017 for a distillation of these patterns into an article-length presentation). An instantiation of Pattern III is one in which the reflex is exactly the same in all

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of the places where it surfaces other than the final position, and an example from Kiitharaka (Georgi 2017: 590) is one in which a prefixal focus marker on verbs surfaces along all verbs through which a moved wh-phrase passes, but not on the highest verb:

(1) n-uu$_k$ u-ku-thugania [ati John n-a-ug-ir-e [Lucy
foc-who 2sg-pres-think [that John **FOC**-SM-say-PERF-FV [Lucy
n-a-ring-ir-e t$_k$]]
FOC-SM-beat-PERF-FV]]
'Who do you think that John said that Lucy beat?'

Adopting the Crossmodular Structural Parallelism hypothesis in Nevins (2010) – that the most fundamental differences between the syntactic computation and phonological computation is not in the inventory of operations that the two contain, but mostly limited to the alphabet of primitives on which they operate – and thus that locality principles such as relativized minimality, boundedness, and defective intervention will apply in vowel harmony to features like [± high] in the same manner they do in syntax to features like [+wh], one can immediately ask the question of whether anything like Georgi's Pattern III is instantiated in phonological dependencies. Given that defective intervention, relativized minimality, and so forth are at work in long-distance dependencies between vowels in different syllables in the word domain, one can ask whether within vowel harmony there are cases of intermediate realizations of a moved element that are in turn not found on the final landing site – but the answer seems to be negative. However, vowel harmony itself, in light of Crossmodular Structural Parallelism, is more akin to phi-agreement phenomena (e.g. valuation on various positions that are 'missing' features needed for surface realization), and not really akin at all to an A′-movement phenomenon (without the notion of true 'displacement' to an ultimate landing site).

Let's consider a well-known example from vowel harmony, from the domain of metaphony (in which the stressed vowel constitutes a kind of 'landing site' for features from the final syllable). Final high vowels can cause mid-vowels to raise in processes such as Veneto metaphony (Walker 2010), even affecting intervening vowels on the way. For example, when the stressed vowel is penultimate, a final high vowel causes raising of the stressed penultimate vowel: *tenpo/t**i**npi* 'time sg/pl'. This also happens to intermediate mid-vowels along

the way, if stress happens to be on the antepenultimate vowel: *enʃene/inʃini* 'shin sg/pl'). However, low vowels do not undergo this raising (e.g. *gato/gati* 'cat sg/pl'), and interestingly, neither do mid-vowels that would be 'along the way' when stress is antepenultimate, e.g. *ázeno/ázeni* 'donkey sg/pl'. In other words, if a [+high] feature is destined to move two syllables to its left, it will affect the intervening syllable, but if the stressed target two syllables away is ineligible, it seems that the [+high] feature doesn't try to move there in the first place. Indeed, Walker characterizes such patterns as 'non-myopic', in the sense that when attraction is specifically to the stressed syllable, intermediate facilitators do not undergo the metaphony, despite being 'along the path'. Again, however, this failure to find a Pattern III here in terms of Crossmodular Structural Parallelism is perhaps unsurprising, as phi-agreement phenomena in syntax also do not seem to instantiate Georgi's Pattern III, and indeed, agreement does not contain the facilitatory 'intermediate' steps found with true movement, given the notion of an ultimate landing site.

To find a truly structural parallel of Pattern III, then, one needs to find a structural parallel of movement, and I contend that the process of tone shift in the Mijikenda and Nguni languages, extensively documented by Charles Kisseberth (and related work), instantiates this. In such languages, an underlying high tone on a prefix (e.g. 3rd person) shows up not in its 'deep structure' position, but rather is attracted towards the metrically strong penultimate (or ultimate, depending on the language) syllable; let us call this position the final landing site of the tone. As for Georgi's Pattern I – reflexes of movement both on the intermediate site and on the final landing site – it is clearly instantiated in cases where intermediate facilitatory syllables also arise with high tone. The elusive Pattern III, however, can be found, specifically when arising from the interaction of high tone attraction with so-called depressor consonants – voiced obstruent onsets, which prevent high tone in their syllable.[1]

This paper is largely an exposition of the intriguing patterns of tone shift in these languages in a manner that makes their relevance clear for potential explorations of Crossmodular Parallelism. (In fact, it raises the question of whether Georgi's Pattern III in syntax itself may be modeled as a kind of

[1] Note that prenasalized stops, such as /ⁿd/, do not pattern as depressor consonants in Mijikenda – perhaps because they are not contrastively voiced; see Hyman (2013) for discussion. See also Zheng (2023) for a fine-grained classification of three distinct types of depressor consonant effects on tone in Zulu.

realization plus later suppression on the final landing site, as is the case for depressor consonants with high tone shift). In addition, this paper aims to open questions related to cyclicity (again a topic fundamental to the research program of the Igel of Igra!), once verbs are combined with objects, as in these configurations, the high tone shift process cyclically moves further to the (pen)ultimate syllable(s) of the embedded object as well. While the investigation herein is largely preliminary – developed during the heady experience of being a Brugmann Scholar in Leipzig in 2014 during the World Cup – and its conclusions speculative, it is an attempt to foment interest in this topic through a new lens of its potential broader grammatical relevance.

2. Background on Crossmodular Structural Parallelism

As mentioned above, Crossmodular Structural Parallelism (see also Nevins 2008, Arregi & Nevins 2012, Murphy 2019) is a hypothesis about the nature of human language that seeks to minimize differences between levels that do not follow from a difference in alphabet. Thus, the core locality computation driving Agree and vowel harmony differs only in the alphabet of data structures to which it applies. This is an unorthodox hypothesis, driven by the goal of a higher-order synthesis between linguistic phenomena; it enables one to frame existing phenomena in new terms, such as *defective intervention*, and pursue the extent to which these follow the same logic. To see this, consider the various forms of the prefix /gɪ-/ in Nawuri, which vary in terms of rounding harmony, acquired from a [+round] vowel in the stem:

(2) Nawuri /gI-/ valuation (Casali 1995: 651):
  a. gɪ-baː ‘hand’
  b. gɪ-sɪbɪta ‘sandal’
  c. gʊ-aʊ ‘ear’
  d. gʊ-lɔ ‘illness’
  e. gi-ɲi ‘tooth’
  f. gi-keːliː ‘kapok tree’
  g. gu-jo ‘yam’
  h. gu-kuː ‘digging’

As straightforward as it may seem, not every segment that is [+round] is able to furnish a [+round] value for this prefix. In particular, *consonants* that

are [+round] will neither furnish this value for harmony, nor will they allow downstream values of [+round] on licit vowel providers to be furnished in harmony:

(3) Nawuri /gI-/ valuation blocked by a round consonant (Casali 1995: 652):
   a. gɪ-muː 'heat'
   b. gɪ-fufuli 'white'
   c. gɪ-pula 'burial'
   d. gi-boːtoː 'leprosy'

What's happening in (2) and (3) is that a [+round] element along the path of vowel harmony not only causes harmony to be blocked within that consonant's syllable, but in all syllables to its left that would otherwise potentially undergo it. This is defective intervention: an element along the path that is 'defective' for the requirement R (in this case, it's not [−consonantal])) causes the search to halt, and no further eligible targets to be reached.

(4) Nawuri /gV-/ noun class prefix must:
   ATR-Harmonize and Round-Harmonize:
   δ = right, F = [±ATR; ± round] & R = −consonantal]

This is fully parallel to defective intervention in syntactic agreement, in which an intervening element with case or person features that are not what the probe has been relativized for will cause the search to crash, even if a better target is available downstream, as in cases of dative intervention that block agreement between a probe and a lower nominative-cased target in Icelandic (Holmberg & Hróarsdóttir 2004), and illustrate the parallelism between locality patterns in syntax and how they shed light on opaque interveners in phonology. Going the other way round in terms of research directions, after formalizing *contrastive* and *marked* feature-values as probe-relativized differences on "needy vowels" that would trigger different locality patterns in harmony systems, in subsequent work, I imported this kind of value-relativization from phonology to morphosyntax in the typology of PCC effects (Nevins 2007). Work such as Murphy (2019) also brings repair effects well-studied from phonology to shed light on morphosyntax. Thus, more broadly speaking, research on crossmodular structural parallelism can flow in a multitude of directions, and indeed, it should, as true parallelism means that the application of identical computational principles or operations across modules shouldn't

privilege their instantiation in syntax over say, in phonology – it is more of a historical matter of where these principles were articulated or discovered first scientifically, but their synchronic grammatical status is equal across modules.

3. Georgi's discovery of Pattern III

As reviewed above, Pattern III is one in which reflexes of movement are found on intermediate sites, but not the final landing site. Thus, in Wolof long wh-movement, the classifier *k-* shows up on complementizers, and agrees with the wh-phrase by showing the reflex *-u* in agreement with the phrase that moves through it, although the final complementizer does not, instead showing default *-an*:

(5) [$_{CP}$ K-an l-a-ñu wax [$_{CP}$ k-u jigéén j-i foog [$_{CP}$
CL-an EXPL-a-3PL say CL-u woman CL-DEF.PROX think
k-u ma dóór]]]
CL-u 1SG hit
'Who did they say that the woman thinks that I hit?'

Georgi (2014) includes a range of data from Dinka *ke*-stranding, Kitharaka focus-marking, and German extraposition to exemplify Pattern III. The crucial logic that is developed for this typology of movement reflexes is based on the highly articulated "Leipzig School" about the order of operations (see Heck & Müller 2007 for an early development, among many subsequent fruitful applications). In particular, Georgi proposes that the operation of Wh-Agreement is ordered in between the two operations of Intermediate and Final Movement:

(6) Ordering for Pattern III in Wolof:
Intermediate Wh- Movement > Wh-Agreement > Final Wh- Movement

As a result, final wh-movement counterfeeds agreement, and it is for this reason that it underapplies at the highest C position, which has a different kind of movement feature (and is thus a different kind of operation) than intermediate movement; the ordering between these operations yields the variation in patterns such as PI vs PIII. (Note that Georgi 2017: §4.2ff also considers other approaches to deriving PIII, including deletion and realization rules that affect final vs non-final heads differently.)

4. Tonal Attraction in Digo

As mentioned above, vowel harmony does not seem to be a domain in which the notion of "intermediate" and "final" positions are necessarily applicable. On the other hand, within phonology, there is a phenomenon that clearly involves the notion of a final, destined, landing site, with intermediate positions: that of high tone shift as found throughout the Bantu languages (I thank John McCarthy for originally having suggested to me this as a domain to look into). For this particular study, we begin with the Digo language, which is part of the Mijikenda family spoken in coastal Kenya and Tanzania, and includes Chonyi, Digo, Duruma, Giryama, Jibana, Kambe, Kauma, Rabai, and Ribe. Digo tone was studied in Kisseberth (1984), from which the following data are drawn.

As Kisseberth says (p.106), "while a pitch contrast may be realized phonetically in one word, its point of origin may be in a preceding word." This is a highly dramatic example of what we might call 'chains' , in the syntactic sense, in the domain of phonological tones. A high tone with an origin leftwards within a phonological phrase is realized later on, sometimes even in a following word, as it seems to be attracted to a metrically prominent position. Sometimes, however, due to rule interaction, this high tone will be realized on an intermediate position along the way, and not in its target landing site.

Let's examine the pattern by first considering toneless prefixes (such as the infinitive) and toneless verbs (7a). These contrast with verbs that bear lexical H tone. The 'target' or landing site for High Tone in Digo is the final foot (the final two syllables), which usually involve a tonal realization with a High tone on the penultimate syllable that extends into a falling tone contour on the final syllable (7b), although when the final onset consonant is a voiced obstruent, a so-called 'depressor consonant' , then it blocks the high tone from surfacing on the following vowel (7c):

(7) Underlyingly toneless and H-toned verbs (Kisseberth 1984: 106–107, ex 1–3)

a. ku-ambir-a 'to tell'
b. ku-arŭk-â 'to begin'
c. ku-fukíz-a 'to apply heat'

Even when the H tone is lexically associated with the verb stem, the addition of

a reciprocal or applicative suffix (making this suffix the penultimate syllable) will thus attract the verb's H tone to be realized on this prominent position:

(8) When a verb bears lexical H tone, it is attracted to the final (two) syllables (Kisseberth 1984: 109, ex 6–8)
   a. ku-vugur-a, ku-vugurir-a 'to untie (for)'
   b. ku-bundúg-a, ku-bundugĭr-â 'to pound (for)'
   c. ku-chekecherăn-â 'to sift-appl-recip'

Now we turn to the phenomenon of high tone shift. Certain prefixes, such as *u* below (1pl.obj) in (9b), or *a* (3sg subj) in (10b), have an underlying H tone, but it doesn't surface on them, but is rather attracted to the (pen)ultimate:

(9) H-toned object prefixes (Kisseberth 1984: 110, ex 9)
   a. ku-ni-vugurir-a 'to untie for me'
   b. ku-u-vugurĭrâ 'to untie for us'

(10) H-toned subject prefixes (Kisseberth 1984: 111, ex 11)
   a. u-na-togor-a 'you are praising'
   b. a-na-togŏr-â 'he is praising'

So far, all we need to say is that there is movement/attraction to a 'criterial' position: the final two syllables. (Let us assume that the 'Fall' character on the final syllable is due to a very late phrasal L tone added to the very end.) This would simply be parallel to any straightforward case of A′-movement: there is an underlying position, and a criterial or landing position in which it is instead realized. (In this case, let us say it is because of the greater metrical prominence of the final foot as the potential metrical 'head' of the entire word).

Of course, one might already look at what happens when there is a depressor consonant as the onset to the final syllable. Consider, for example, a pattern like *ku-fukíz-a* 'to apply heat', in which the voiced obstruent onset [z] suppresses the final high tone. This would instantiate Pattern III, if we considered that in some sense, the criterial position is the final syllable. But let's instead assume it really is the final foot, and that both syllables are targeted in High Tone Shift.

The tonal attraction patterns can be schematized in the following diagrams, where boldface indicates the surface realization of H, parentheses around the final foot represent the target/criterial position, and DX represents a blocking depressor consonant. Low tones that are phrasal are represented by L_{φ}, and

Low tones that are morphological (and block further high tone movement) are represented by $L_{\mu}X$.

(11)	ku	a	(ru	ka)	>	kuarŭkâ
	H →	H	**H**	**H**		
				L_{φ}		
(12)	ku	fu	(ki	za)	>	kufukíza
	H →	H	**H**	DX		
				L_{φ}		

Now let us consider imperatives which have a different final vowel, one which never attracts a H. Instead, it seems that this mood involves an inherent morphological L on the penultimate syllable, to which the H is attracted, creating a fall:

(13) Imperatives have an L on the penult; attraction creates a fall (Kisseberth 1984: 153, ex 47):

a. ni-tsukur-a 'carry me'
b. a-tsukûr-e 'carry them!"

These data (showing what Kisseberth calls "Low Attraction", e.g. attraction to a morphologically Low-Toned penultimate vowel), allow us to conclude that the last foot is really the target of high tone shift in Digo. In declaratives, a phrasal L tone on the final syllable will cause a falling tone on it, and in imperatives, a morphosyntactic L tone on the penultimate syllable causes a fall on it, as shown in (14). We may thus assume that the target of H tone shift is both syllables. If depressor consonants are found on the onset of either the last syllable, or in fact, the penultimate syllable, then high tone will be inhibited.

(14)	a	tsu	(ku	re)	>	a-tsukûr-e
	H →	H	**H**			
			$L_{\mu}X$	L_{φ}		

With this in mind, we can now turn to a case of Pattern III (abbreviated PIII). What happens with a depressor consonant in the onset of the penultimate syllable of the imperative? It will prevent the falling tone found in (14b). However, interestingly enough, in this case we suddenly observe an intermediate High Tone realized along the way, in the anteantepenultimate syllable (as the

antepenultimate *also* has a depressor consonant in this case; <j> represents [ʤ]):

(15) Depressor Consonants and H prefixes in the Imperative (Kisseberth 1984: 157, ex 50)
   a. ni-rejezer-a ‘soak for me!’
   b. a-réjezer-e ‘soak for them!’

The example in (15b) instantiates the first case of a facilitatory, intermediate syllable – the only place that an H shows up along its path of attraction. As Kisseberth says (p.157), “The high tone associated with the object prefix has moved away from that prefix as far towards the neutralized vowel as possible”. This instantiates Georgi’s Pattern III, specifically under the conditions of depressor consonant(s) inhibiting the realization of the ‘movement reflex’ on its criterial position. In addition, it provides evidence against what Kisseberth & Cassimjee characterize as a “shifting” analysis, with one fell swoop movement to the target position. In other words, what we observe here is that in Tonal Attraction, there really is the usual case of movement towards the Metrical target (Georgi’s Pattern I), but when the high tone is “stuck” in an intermediate position and can’t move onwards, that’s where it will stay.

(16)

a	re	je	(ze	re)	>	aréjezere
H →	**H**	DX				
			$L_{\mu}X$	L_{φ}		

What these data show is that metrical attraction to the final foot proceeds rightwards, migrating syllable by syllable. Should it, however, be not possible to move all the way rightwards, due to depressor consonants in the way, the high tone will stop in its tracks in an intermediate position.

The patterns become even more interesting to observe once we consider verbs together with objects. In these cases, the rule of H-realization applies within the verb phrase. This confirms the earlier intuition that in fact this attraction is to the criterial/most prominent position, which in the case of transitive verb phrase, involves the final foot of the more deeply-embedded object (essentially in concord with Cinque’s (1993) Nuclear Stress Rule):

(17) Underlying H Verb plus Toneless Object Combinations (Kisseberth 1984: p.163, ex 61a)

a. nyama ‘meat’
b. ku-afŭn-â ‘to chew’
c. ku-afun-a nyămâ ‘to chew meat’

Comparing (17b) and (17c), we can clearly see that tone moves rightwards to the furthest right metrical peak possible. If this is the verb alone, it will be the verb’s last foot, but if there is an object, then it keeps marching onwards to the final metrical foot of the object, leaving no apparent evidence for its intermediate presence. This is illustrated below, where a double pair of parenthesis indicates the even more prominent deeply embedded final foot of the object:

(18)

ku	a	(fu	na)	((nya	ma))	>	kuafuna nyămâ
H →	H	H	H	**H**	**H**		
					L_{φ}		

A similar pattern can be found with a toneless object whose final syllable has a depressor, when paired with an H-toned verb. The high tone from the verb in this case will migrate all the way to the penultimate syllable of the object:

(19) Underlying H Verb plus Toneless Object with a Depressor (Kisseberth 1984: p.163, ex 61b)
a. chi-gwazo ‘a peg’
b. ni-na-rĕh-â ‘I’m bringing’
c. ni-na-reh-a chi-gwázo ‘I’m bringing a peg’

From this pattern alone, one cannot discern whether the H first moves to the metrical position of the verb, and then cyclically onwards to the metrical position of the ‘higher level’ (i.e. more stressed) item, namely the noun. As it turns out, there is evidence that it first moves to the metrical position of the verb. The evidence, again, comes from an interaction with depressor consonants, this time in the onset of the final syllable of the verb.

The data below present a surprise for the view that the verb is simply irrelevant in verb plus object phrases:

(20) Underlying H Verb with a Depressor, plus Toneless Object
a. mutu ‘someone’
b. ni-na-ádz-a ‘I’m mentioning’

Here we might expect wholesale shift to the object just as in (17), regardless of the fact that the verb has a depressor, but lo and behold, a high tone appears on the penultimate syllable of the verb in these cases, due to what is a "Throwback" rule when there is a final depressor consonant. Call this "Ultimate Depressor Doubling".

(21) Underlying H Verb with a Depressor, plus Toneless Object (Kisseberth 1984: p.163, ex 61b)
   a. mutu 'someone'
   b. ni-na-ádz-a 'I'm mentioning'
   c. ni-na-ádz-a mǔtû 'I'm mentioning someone'

Similar results, whereby differently from (17) and (19c), a high tone does stay around on the verb, in addition to the one migrating to the object, will also obtain if the H is from a prefix on the verb:

(22) Underlying H-Prefix Verb with a Depressor, plus Toneless Object (Kisseberth 1984: p.163, ex 61c)
   a. goma 'a drum'
   b. a-na-píg-a 'he's beating'
   c. a-na-píg-a gǒmâ

What's happening here? The crucial determining factor is the depressor consonant on the onset of the final syllable of the verb.[2]

Kisseberth proposes that Metrical Attraction and Ultimate Depressor Doubling (UDD) - a Right-to-Left Doubling Rule – are Cyclic. This means that procedures happen in steps. First UDD takes the high tone from the final syllable of the verb and doubles it leftward (representing the second H on another vertical level, to show its onward movement), and then the high tone can go on to migrate to the object within the verb phrase. This is shown below, where UDD copies the high tone onto the preceding penult, and then the second copy of tone itself moves onwards to the object. This is very different from (17) and (19c), where no high tone shows up on a verb when in tandem with an object. Clearly this is because the high tone has *doubled*, and one copy

[2]Similar throwback patterns can be found when there is a depressor onset in the Mijikenda languages Chikauama and Chirihe, with a downstepped high tone in the target syllable and a high tone in the preceding syllable.

stays on the verb, while the other continues to migrate. Finally, note that on the object, the rule of normal penult realization without depressors takes place. This is shown below in two cycles. Crucially, what cyclic means here (and yields a result with the intermediate tone retained) is 'not everything is done at once!'

(23)

a	na	(pi	ga)	((go	ma))	>	a-na-píg-á goma
H →	H	**H**	DX				(End of First Cycle)
			H →				

(24)

a	na	(pi	ga)	((go	ma))	>	a-na-píg-a gŏmâ
		H					
			H →	H	H		
					L_{φ}		

Derivationally, the high tone moves to the final syllable of the verb, but given the depressor consonant in the onset, is doubled and one copy is thrown back to the penultimate syllable of the verb. Then, the final high tone on the verb migrates to the object. Naturally, if the migration to the object took place before the rule of throwback could apply, then UDD would be bled. On the surface, the throwback to the penultimate looks like opaque overapplication, as there is no high tone following it. Crucially therefore, the second-cycle application of Metrical Attraction to its eventual position on the Object counterbleeds UDD, yielding the overapplication of the high tone in the verb, an intermediate stopping point. Unlike in (17), when there is a depressor consonant on the verb, we can detect intermediate movement in the verb on its way to the object.

This is a surface PIII pattern (as the tone does not appear on its final landing site within the verb), whereby the early cycle feeds UDD. Subsequently, the later cycle of metrical attraction counterbleeds it. Naturally, the specific ordering here that yields a PIII effect is somewhat different from the specifics of Georgi's PIII rule interaction, but the surface effect is one in which cyclicity of operations yields realization on an intermediate, but not final position, and crucially lends evidence that such effects cannot be treated as 'one fell swoop'.

4.1. More than one H in the Input

What if there are more than one H in the input? In fact, this provides an opportunity to look at rule interaction of two different types, potentially involving movement of the same kind of element but within different domains.

(25) More than one H in input: one from prefix and one underlying on verb (Kisseberth 1984: p.122 ex 25 and p. 125 ex 27)

a. ku-pupŭt-â ‘to beat’
b. a-na-púpút-â ‘he is beating’
c. ni-na-furukŭt-â ‘I am moving about restlessly’
d. a-na-fúrúkút-â ‘He is moving about restlessly’

Here it appears that the one H is attracted to the metrically prominent foot, but that the other H is attracted to the first syllable of the stem, and is realized high all the way across the stem (realized on each syllable as far right as it can go within the phrase); call this Stem-Raising, and assume it is ordered later, in a Post-Cyclic Stage. There are thus demonstrably two separate processes at work: one of metrical tone attraction, and one of H realization on the stem. These are, in syntactic parlance, two separate ‘chains’, and the second, more local one is formed later:[3]

(26)	a	na	fu	ru	(ku	ta)	>	a-na-furukút-â	
	H →	H	H	H	**H**	**H**		(End of First Cycle)	
			H			L_{φ}			
(27)	a	na	fu	ru	(ku	ta)	>	a-na-fúrúkút-â	
	H →	H	H	H	**H**	**H**		(Post-Cyclic Stem-Raising)	
			H →	**H**					
						L_{φ}			

Having observed stem-raising as a consequence of a second H tone in the

[3]Note in fact, that these all-H stem forms are even found without the ‘rise’ on the penult we have seen all along, as this rise actually seems to be an implementation of an H on the penult in the configuration L_H. Thus when no H follows due to a depressor in the ultimate, it is only a level H, or when an L precedes due to a depressor in the antepenult, it is a level H.

input, let's go back to phrasal cases with an object. Suppose the Verb and Noun each have a High Tone.

(28) a. chi-karǎngô 'frying pan'
b. ni-na-azǐmâ 'I'm borrowing'
c. ni-na-azim-a chi-kárángô 'I'm borrowing a frying pan'
(Kisseberth 1984: p. 171, ex 64c)

What's happening here is the following: Metrical Attraction feeds Stem-Raising, which creates a local 'plateau' on the object at a Post-Cyclic Stage.

(29) Cyclic Application of Metrical Attraction
a. Earlier Cycle: Noun's H attracted all the way to object metrical peak, Verb's H attracted to verb metrical peak:
[ni-na-azim-á] [chi-karangó]
b. Later Cycle: Metrical Attraction of Verbal H cannot apply again to Noun's Final H [ni-na-azim-á chi-karangó]
c. Stem Raising moves then Verbal H onto the Noun Stem:
[ni-na-azim-a chi-kárángó] > ni-na-azim-a chi-kárángô

This again suggests that tonal movement, even onto objects from the verb, is always going stepwise, syllable by syllable, and will go as far rightwards as it can – usually all the way, unless something else blocks it. In this case the object already *has* an H tone on its metrical peak, and so the H tone from the verb still migrates rightward, but instead implements Stem-Raising in positions prior to the peak. I have used the term 'Stem-Raising' here also to make salient a potential parallel with A-movement, given that this is a 'lower' and 'more local' type of movement.[4] But interestingly it is fed by what we might call A′ movement in (28). The head of the chain created by Metrical Attraction at the end of the verb stem in turn becomes the foot of a chain of stem raising on the noun stem.

We've seen what happens when there is one H on the verb and one on the Noun: both of them end up on the noun, but in different places. Now there is

[4]Jardine (2016) characterizes the stem-raising process in Digo as an unbounded process, making it computationally more complex than many segmental phonological processes.

one more interesting case to consider: suppose the Verb has *two* High Tones, and it is combined with an object.

(30) a. chi-ronda 'wound'
b. a-ka-tsútsúkâ 'he is cleaning'

As we have seen above, in isolation, the verb's rightmost H will undergo Metrical Attraction, and the one to the left will undergo Stem-Raising.

(31) a. chi-ronda 'wound'
b. a-ka-tsútsúkâ 'he is cleaning' (Kisseberth 1984: p.172, ex 65b)

What happens when we put the verb and noun together? If there is no Cyclic Application, we would expect the same pattern as in (28), namely Metrical Attraction to the rightmost word (the Noun), and then one-fell-swoop Stem-Raising in the rightmost word (the Noun). But this isn't what happens. Instead, the H tone on the prefix seems to 'wait' until the verb's H tone cycles from the verb's metrical peak onto the object's metrical peak, and then afterwards applies post-cyclic stem raising to everything from the verb stem onward, within the phrase and even across word boundaries:

(32) Cyclic Application of Metrical Attraction
a. Earlier Cycle of H-movement: [á-ka-tsutsuká] [chi-ronda]
b. Later Cycle of H-movement: [á-ka-tsutsuka chi-rondá]
c. Postcyclic Stem-Raising moves Verbal H to the *Verb* Stem and raises all subsequent syllables: [a-ka-tsútsúka chí-róndá] > a-ka-tsútsúka chí-róndâ

These examples. taken together, exemplify cyclicity – namely, not doing everything at once, but proceeding according to domains – in the formation and interaction of tonal chains, namely (a) if there is only one H tone in a verb-object combination, it will migrate all the way to the object's metrical peak; (b) but if the final syllable of the verb has a depressor consonant, in addition there will be a high tone on the penult of the verb; (c) if there is a high tone on the object as well, the verb's high tone will be realized as stem raising on the object, and (d) if there are two high tones on the verb, one high tone will be realized as stem raising from the verb all the way to before the object's peak. These complex set of interactions can be straightforwardly

understood if these moving tones form chains, link by link, where sometimes these chains will end at intermediate positions before their landing site, and if stem-raising is a late, postcyclic rule applying to an entire stretch after all the cyclic behavior has happened.

I have treated Stem-Raising as postcyclic, thereby breaking the parallel with A-movement in syntax (indeed, we might ask what Post-Cyclic syntax-internal rules (as opposed to PF operations) exist in today's local derivational landscape – although Late Merger of Adjuncts seems to be one very good candidate, and perhaps Stylistic Fronting in Scandinavian as well Bošković 2004); I thank Kenyon Branan for our discussion of these points. As such there may be no 'Improper Movement' problem to speak of in the case of tonal movement in phonology. In fact this raises the general question of whether, given two separate tonal-chain creating processes, if one is cyclic and A′-movement-like, and one is simply postcyclic and A-movement-like and follows the first one – does the notion of improper movement apply? To make this question sharper within the domain of phonology, let us however to a case which does exemplify this parallel, this time going back to vowel harmony.

5. An Aside: Williams-Cycle Effects in Vowel Harmony

The discussion of improper movement (in other words, the ban against A′ movement in syntax occurring before A-movement) is part of a more general set of concerns about ordering relations between different types of operations in syntax, known as Williams cycle effects. In the most general sense, since A′ movement involves larger syntactic chunks of the tree than A movement does, this relative difference in domain size, whereby 'larger domains are necessarily later domains' can be architecturally implemented to guarantee that A′ movement cannot feed A movement (see Williams (2003) for this proposal, and Hornstein & Nevins (2005) for discussion). Are there Williams-cycle type effects in phonology – in other words, cases in which we can clearly show that two processes P and P′ , where P′ involves a larger domain than P, cannot involve a feeding relation from P′ to P? It turns out we can, with vowel harmony.

Vata (Kimper 2011) has both word-internal and cross-word [ATR] harmony. Call these W and W′ harmony for convenience. The ATR vowels are /i, e, o, u ʌ/, whereas the −ATR vowels are /ɪ, ɛ, ʊ, ɔ, a/.

(33) Root-controlled W-harmony in Vata:

a. kla-lɛ ‘seize-with’
b. ŋɔnʊ-lɛ ‘sleep in’
c. pi-le ‘prepare with’
d. su-le ‘crush with’

(34) W′ harmony spreads [+ATR] regressively – among monosyllables:

a. n la yo ‘I called child’ > n lʌ yo
b. o ka za pi ‘He will food cook’ > ɔ kʌ zʌ pi

(35) However, W′ harmony cannot feed W harmony in polysyllabic words: ɔ nɪ saka pi ‘he not rice cook’ > ɔ nɪ sakʌ pi, *ɔ nɪ sʌkʌ pi

This would suggest that all W harmony precedes all W′ and that there is no cycle back to W (hence the mention of Williams (2003)). If we consider improper movement to really be about processes applying in larger domains not feeding back into processes applying within smaller domains, then Digo tone would seem to be exempt anyway, as both tonal migration and stem-raising apply in phrasal domains of the same size. Of course, within phonology, the notion of domains has been classically implemented in terms of what are called strata, whereby all processes within the lexical, or word-level stratum must occur before all processes within the postlexical, or across-word stratum. Notably, however, most discussions of A and A′ movement within syntax do not adopt a notion of ‘strata’ of syntactic operations, despite some of the apparent parallels that Williams-cycle effects bring out.

6. A Preliminary Excursion into Giryama and Ribe

Giryama and other Mijikenda languages, within the same family as Digo, have a more consistent pattern of targeting the penult. These examples, as studied by Volk (2011), show even longer distance movement of the H tone, *past an intervening infinitival verb* and onto the object (Volk 2011):

(36) ni- na- mala ku- gula n-guuwo
1SG- PRES- want to- buy clothes
‘I want to buy clothes’ (Volk 2011: 58, ex 45)

(37) a- na- mala ku- gula n-guúwo
3SG- PRES- want to- buy clothes
'She wants to buy clothes' (Volk 2011: 58, ex 45)

The Pattern III cases are sometimes called 'Fission' in the tonology literature, especially because the Mijikenda languages have a more dramatic process than Digo's Ultimate Depressor Doubling, in which a depressor consonant *anywhere* along the chain will cause H tone doubling to the syllable before it. Let us call this "Anywhere Depressor Doubling" (ADD). Kisseberth & Cassimjee (1992) explicitly say that data such as these provide "the basis for choosing between a two-step operation of spreading and subsequent delinking, and a one-step operation of shifting the H tone". Parallel to the case in (22) above, consider what happens in Ribe when both the verb and the noun contain depressor consonants (recall that prenasalized stops are not depressors):

(38) ni- na- piga ma-bu.mbu.mbu
1SG- PRES- beat CL-drums
'I am beating drums' (Volk 2011: 58, ex 45)

(39) a- na- píga má-bu.mbuú.mbu
3SG- PRES- beat CL-drums
'She is beating drums' (Volk 2011: 58, ex 45)

A single underlying high tone, intending to move only to the highest metrical peak (always a penultimate syllable in these languages), will be copied due to Ultimate Depressor Doubling and be retained on the verb stem, and then also be doubled on the noun stem, due to ADD by the depressor consonant in *bu* – and then finally realized in the target position as well. These two intermediate realizations, due to depressor consonants anywhere along the path, in addition to the final landing site, in patterns such as (39) can be seen as a mix of Pattern II (realization on the highest position) and a variable/recursive Pattern III (non-realization on intermediate depressed syllables), as shown in Ribe. Microvariation in Georgi-patterns within the same language family of this sort is extremely interesting to pursue further, and the above examples, illustrating more cases of intermediate realization due to Anywhere Depressor Doubling (ADD) are really only the tip of a potentially very cyclic iceberg.

7. Conclusion

Georgi's documentation and formalization of PIII has forced us to look further at nonlocal phenomena in phonology through a different lens. It is not clear that for these phenomena at hand, the specific implementation in terms of final steps that counterfeed (or counterbleed) the reflex-realizing process is always the right one for tonal chains – and in fact, perhaps the effect of depressors raise the question of an implementation of PIII in terms of independently-motivated removal (or repair) of the realization in final position. Thus, there are in principle two different ways to derive these PIII effects: in Georgi's analysis, the intermediate movement steps and the final movement step are structurally different kinds of feature-based movement, and rule ordering among these different kinds can potentially determine counterfeeding effects. Another approach to deriving PIII patterns, which is what is developed here for the tonal chains, is that all of the movement steps are of the same type, but that the presence of depressor consonants along the path can cause non-realization in certain positions (and instead, yield their pronunciation on an intermediate, earlier position).

Note that while in the tonal cases examined here, the terminal landing site goes unrealized because of the presence of depressor consonants, we do not necessarily see an independently observable property of the terminal landing site in PIII languages with wh-agreement phenomena that might cause this non-realization. An alternative set of models to explore — for both sets of PIII phenomena — would be a calculus of preferential positions of chain realization, e.g. the entire tonal chain is first formed through every position, and subsequent conditions determine which links are overtly realized; cf. Cassimjee & Kisseberth's (1998) Optimal Domains Theory for a parallel/violable version of this. In both phonology and syntax, we find that these patterns are relatively rare, perhaps because they require a specific interaction of rule ordering – the implementation adopted here for both sets of cases. Perhaps, indeed, PIII in syntax could be 'rare' precisely because such removal operations specifically on the landing position (for grammaticalized reasons relating to being in absolute-initial position) require the right combination of circumstances. In any case, we have come full circle, as the phonology patterns have now invited us to go back to the syntactic cases and re-examine them through this lens.

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