Ordering[*]

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1. Background

One of the most obvious differences between standard derivational phonology and Optimality Theory is that, at least based on an initial impression, OT should not be able to capture certain relations between inputs and outputs which could be captured in derivational phonology, because OT is not assumed in standard conceptions of the theory to have "intermediate stages" or derivations. This paper explores some of the machinery available to OT to account for data which is explained by rule ordering and similar derivational devices. In the OT literature, this issue has been addressed under the rubric "opacity". Devices which have been used within OT to replace serial derivations include the Parse/Fill approach, two-level constraints, output-output constraints, and sympathy theory, not to mention limited derivationality in the form of level ordering. The paper focuses particularly on two-level constraints, sympathy theory, constraint conjunction, and the use of abstract domains.

To put into perspective the question of how OT should handle facts classically handled by serial derivation, McCarthy 1997 shows that the earlier parse/fill approach and output-output constraints do not give a general account of rule ordering in OT, and says with respect to sympathy theory (p. 18) 'Arguably, this is *all* that is required to analyse observed opaque interactions'. Kiparsky 1998 appears to make a similar appeal to the desire for a unified account of opacity when he notes that Base-Output constraints cannot explain the opacity of interaction between stress and epenthesis in Bedouin Arabic, where a final syllable underlyingly superclosed by a cluster of consonants receives stress, even though the syllable is opened on the surface by vowel epenthesis.

(1) /al-walad/ → [ál-walad] 'the boy'
/al-himl/ → al-híml → [al-hímil] 'the load'

As Kiparsky points out, this variety of opacity cannot be handled by Base-Output constraints, since there is no surface form lacking the epenthetic vowel to serve as the foundation for anomalous stress in [alhímil] (although it happens that Sympathy constraints can be called on in this case).

I will show here that, well-intentioned desires to limit the number of ways of handling rule ordering notwithstanding, quite a number of devices actually play a crucial role in handling serial phenomena. No unified treatment of rule ordering is possible in OT, and instead one must use a range of devices to accomodate "opacity". This is unsurprising: were there to be a unified account of rule ordering in OT, one might suspect that the device being used is notational trickery allowing one to translate one concept into another, as one can translate uppercase letters into lower-case letters or vice versa. The question I address is whether it is possible to account for all derivational phenomena, once we have martialled the relevant descriptive

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machinery, or will it turn out that there are cases which completely resist a nonderivational analysis. There does turn out to be a way in OT to handle virtually all of the cases that I discuss here, though there is a theoretical price to be paid in many of these cases, since a relaxing of theoretical strictures is required. Whether or not this amounts to an unconscionable opening of the theoretical floodgates, or is simply a minor but necessary adjustment within the theory, can only be decided conclusively after a prolonged investigation of a range of derivational phenomena, which is beyond the scope of this paper. For instance, in order to account for the pattern of H deletion in Kerewe, a two-level account, with two cycles through Gen and Eval, is necessary. Positing a limited derivational aspect to OT does increase the power of OT, but it is unclear whether it amounts to surrendering any fundamental principles of the theory (since it is unclear what principles in OT are truly fundamental versus convenient assumptions). My primary aim is to point out some of the relevant cases, and consider what it takes to handle them.

2. Disjoint Predictions

A rather basic question about rule ordering which has received little attention in discussions of OT is, simply, just what is the benefit of eliminating derivational steps? One might imagine that some kind of simplification of grammars could result, by eliminating the possibility of extrinsic rule ordering. Allowing rules to be explicitly ordered, under the standard theory of linear rule ordering, allows a given set of *n* rules to be mapped onto *n*! grammars (thus 5 rules maps onto 120 grammars and 8 rules maps onto 40,320 grammars).[1] The consideration of reducing the number of possible grammars is fully negated by the fact that there is an equivalent complication in grammars in the form of constraint ranking, and insofar as a dozen or so constraint may be required to express what a single rule expresses, an OT grammar may actually fare much worse in terms of the combinatorics of basic elements defining grammars, since it is certain that a complete OT grammar requires orders of magnitude more constraints than there are rules in a rule-based account.[2] Another possible motivation for getting rid of rule ordering and serial derivation would be based on the assumption that serial derivations might have a kind of expressive power which is not actually needed to describe natural languages. Creating a tighter fit between theoretical prediction and actual languages is an admirable goal, but it is far from clear that there is anything that couldn't be handled by OT, once all of the necessary machinery is identified.[3]

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[1] In OT, constraints are not strictly ranked and are only partially ordered. With partial ordering (ranking), 5 constraints can be ranked 4,231 ways and 8 constraint can be ranked 431,723,379 ways. The general function for computing the number of partial orderings is not known, and values are only known up to *n*=14 (98,484,324,257,128,207,032,183).

[2] In its own right, it is not particularly important whether an OT grammar requires an order of magnitude more constraints than rules, since there is no theory-indepent way of judging the absolute complexity of an analysis. There is at present no reasonable basis for estimating the approximate ratio of rules to constraints, since complete OT-based analyses of languages are rare, and even in extended descriptions of languages in OT, many crucial constraints are implicit in the analysis (e.g. metathesis is a very efficient way to eliminate phonotactically bad sequences, but is rarely used, and yet very few analyses explicitly rule out metathetic candidates). A rule-based account, if technically correct, is necessarily complete up to the limits of the descriptive domain circumscribed by the account. Neither OT nor derivational theory posit intrinsic limits on the number of rules or constraints that may define a grammar, short of the obvious facts that the set of rules/constraints must be finite, and that constraints/rules are not posited without reason. However, a consequence of having more constraints is that there are more ways to order them and thus more possible grammars.

[3] For instance, McCarthy 1997, 1999 argues that OT is incapable of expressing 'Duke-of-York' derivations, but it is shown in section 4 that (nontrivial) DY derivations are well within the reach of OT.

Another question to be considered is whether there are things that could be accounted for in OT which could not be accounted for in standard derivational phonology, and which do not exist in languages — the implicit assumption has been that, lacking rule ordering, OT is somehow less powerful than a derivational account. I consider two such cases here, one involving Sympathy Theory and the other involving standard devices of OT. In the first example, involving Sympathy Theory, there are rule interactions (transitivity violations) that are impossible under standard derivational phonology; however these data can easily be accounted for under Sympathy theory.

Under standard linear ordering, if rule A precedes B and B precedes C, then A precedes C (and therefore C does not precede A). Common-sensical as this may be, this is an empirically testable hypothesis, and it is possible to construct hypothetical languages which require such a prohibited interaction. The imaginary language Kalaba cannot be modeled in derivational theory, since it involves exactly this contradiction. First, the language has a rule (2), deleting glottal stop before another consonant, which we see applying before the plural suffix *pa*.

(2) *Kalaba Glottal Deletion* $\text{ʔ} \rightarrow \varnothing \; / \_\_\_ \; \text{C}$

lim	'tongue'	lim-pa	'tongues'
to	'child'	to-pa	'children'
laʔ	'fish'	la-pa	'fishes'

Second, there is a syncope rule shown in (3) deleting high vowels in a doubly open syllable.

(3) *Syncope* $\underset{[+\text{hi}]}{\text{V}} \rightarrow \varnothing \; / \; \text{VC} \_\_\_ \text{CV}$

wali	'rice'	wal-pa	'rices'
kapu	'basket'	kap-pa	'baskets'
ugli	'porridge'	ugli-pa	'porridges'
tungu	'onion'	tungu-pa	'baskets'
neno	'word'	neno-pa	'words'

Finally, in (4) there is regressive voicing assimilation that affects obstruents.

(4) *Voicing assimilation* $\overset{\text{C}}{[\text{-son}]} \rightarrow [\alpha\text{voice}] \; / \_\_\_ \; \overset{\text{C}}{[\alpha\text{voice}]}$

nam	'meat'	nam-gu	'my meat'
nam	'meat'	nam-pa	'meats'
naz	'coconut'	nas-pa	'coconuts'
zig	'load'	zik-pa	'loads'
tot	'infant'	tod-gu	'my infant'

The pairwise ordering of these rules is shown in (5). First, Glottal Deletion must precede Syncope. Glottal Deletion in the second form on the right makes the first syllable open, which then allows Syncope to apply to the vowel *i* in 'fishes'. Second, Syncope must feed into Voicing Assimilation, as shown by the second set of data, where deletion of the high vowel allows *p* to assimilate to *g* in the first example, and allows *z* to assimilate to *p* in the second example. Thus we deduce the orderings ‘A precedes B’ and ‘B precedes C’, which in standard derivational theory entails that A precedes C.

(5)	Glottal Deletion Before Syncope				(A > B)		
	to	‘child’	to-pi	‘little child’	to-p-pa	‘little children’	← /topipa/
	laʔ	‘fish’	la-pi	‘little fish’	la-p-pa	‘little fishes’	← /laʔpipa/
	Syncope Before Voicing Assimilation				(B > C)		
	kapu	‘basket’	kab-gu	‘my basket’			← /kapugu/
	dizi	‘banana’	dis-pa	‘bananas’			← /dizipa/

The third set of examples in (6) show that, nevertheless, Voicing Assimilation precedes and is counterfed by Glottal Deletion, that is, C must precede A. These examples show that Voicing Assimilation does not take place between obstruents if they were underlyingly separated by a glottal stop, meaning that glottal deletion has not taken place at the stage where Voicing Assimilation applies.

(6)	Voicing Assimilation Before Glottal Deletion					(C > A)	
	to	‘child’	to-ʔ	‘old child’	to-gu	‘my old child’	← /to-ʔ-gu/
	tot	‘infant’	tot-ʔ	‘old infant’	tot-gu	‘my old infant’	← /tot-ʔ-gu/
	naz	‘coconut’	naz-ʔ	‘old coconut’	naz-pa	‘old coconuts’	← /naz-ʔ-pa/

Thus, the non-language Kalaba is predicted to be impossible in standard derivational theory. The data in (7) shows that Syncope could not be cyclic, which is the one circumstance that might allow for such a rule interaction.

(7)	dizi	‘banana’	nu-dzi	‘the banana’
	mu-n-dizi	‘in the banana’	ni-m-nu-dzi	‘it is in the banana’

Following standard assumptions about the relation between morphological structure and cyclicity, the following would be the cyclic bracketings and outputs.

(8)	[dizi]	[nu [dizi]]	[mu [nu [dizi]]]	[ni [mu [nu [dizi]]]]
	↓	↓	↓	↓
	dizi	nudzi	*munudzi	nimnudzi

To derive the correct pattern, Syncope must apply at the word level, iterating from left to right.

While Kalaba is an impossible language in derivational theory, Sympathy theory allows this language to be described rather easily. The core constraints driving deletion and assimilation are *HeteroVoice, Syncope, and *ʔC (it does not matter whether these are single constraints or sets of constraints which achieve a particular result). The tableaus in (9) show how the nonproblematic interactions can be handled trivially, since ordering Glottal Deletion before Syncope, and Syncope before Voicing Assimilation corresponds to transparent satisfaction of all constraints.

(9) *HeteroVoice: *[αvoice] [-αvoice]
Syncope: *VCVCV
*ʔC

	laʔpipa	*HetVoi	Sync	*ʔC
	lapipa		*!	
	laʔpipa			*!
☞	lappa			

	kapugu	*HetVoi	Sync	*ʔC
	kapugu		*!	
	kapgu	*!		
☞	kabgu			

The Sympathy account in (10) provides us with an easy way to describe the opacity of the interaction between Glottal Deletion and Voicing Assimilation, which is simply that voicing has to be faithful to the flower-candidate which loses no consonants. Since the candidate preserving all underlying consonants also has a voiceless consonant, the winning candidate must respect the voicing value of that candidate.

(10)

	tot-ʔ-gu	Ident-voi$_{\text{Max-C}}$	*HeteroVoi	*ʔC	Max-C
❀$_{\text{Max-C}}$	totʔgu		*	*!	
☞	totgu		*		*
	todgu	*!			*

Thus Sympathy Theory allows for interactions which cannot be modelled under standard derivational theory. Taking into consideration the further conditions on Sympathy Theory proposed in McCarthy 1999, note that the flower candidate is identical to the input, and thus it has a null set of unfaithfulness mappings in the sense defined in that paper. The tableau in (11) shows that the new interpretation of the assessment of violation of sympathy constraints changes nothing, and the form that is impossible for derivational theory to get is still possible under Sympathy.

(11)

	tot-ʔ-gu	❀Sym	*HeteroVoi	*ʔC	❋Max-C
❀$_{\text{Max-C}}$	totʔgu		*	*!	
☞	totgu	Max$_{ʔ}$	*		*
	todgu	Max$_{ʔ}$! Ident$_{d}$			*

Robust examples of such ordering relations have not emerged from 40 years of derivational phonological research,[4] a lacuna which is an under-appreciated problem in Sympathy Theory,

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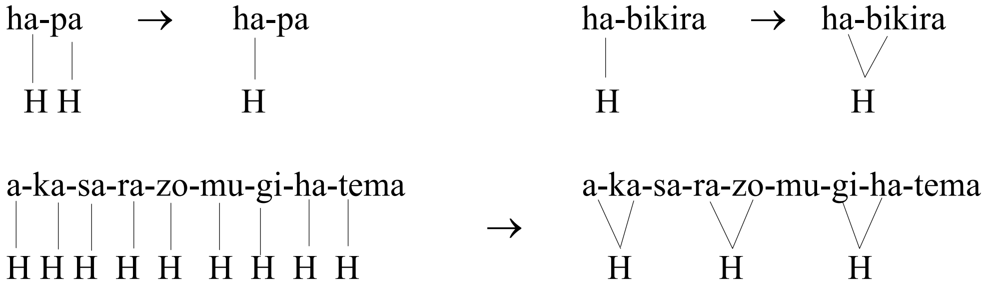
[4] Anderson 1969 inter alia proposes an alternative theory rule ordering, local ordering, which allows violations of the transitivity assumption, based on data from Old Icelandic, Faroese, Kasem, Sundanese, and Sanskrit. Most of these cases have been addressed and shown not to argue for ‘local ordering’, cf. Vroman 1972 for Old Icelandic, Phelps 1974 for Kasem and Sundanese, Phelps & Brame 1974 for Sanskrit. I am not aware of an explicit account of Faroese, and will not essay a full reanalysis of the data provided by Anderson; I will outline the bare essentials of the claim, and my objection to that analysis. The argument for nontransitive ordering in Faroese is based on the claim that a rule hardening geminate glides applies to the output of a rule inserting a glide after a prevocalic high glide or vowel, but only if the triggering vowel is not made to be prevocalic due a rule of intervocalic spirant deletion: hence, /bú-a/ → *bíwwa* → [bıgva] ‘to dwell’, but /týða/ →[tujja] ‘translate’. The proposed analysis depends on abstract underlying representations with abstract segments /ð/ and /γ/, and a rather specific acount of the glide / obstruent alternation exemplified by *bıgva* ‘to dwell’ ~ *bujr* ‘he dwells’. A crucial assumption of the argument is that this alternation involves hardening of a geminate glide, but no evidence is

and more generally with discussions of how OT can get various rule ordering cases. That is, certain aspects of the OT account of derivationalism result in unjustified generative power, reducing attractiveness that there might have been in a strictly parallel model.

Even without the power of Sympathy theory, it is easy to show that OT predicts hypothetical process interactions which could not arise under standard derivational theory, and, importantly, which do not arise in natural languages. A number of Bantu languages have a dissimilative tone deletion called Meeussen's Rule which deletes a H after a H, and this process will be discussed for Kikerewe in the next section. Deletion of H after H is a consequence of the OCP, where deletion is an active repair for OCP violations. Another common tonal process in Bantu is rightward Tone Doubling, where H spreads once to the right, eliminating singly linked H tones. In a number of languages with tone Doubling, a following H tone blocks the rule which is an effect of the OCP as well. (12) illustrates an interaction between these processes with hypothetical data from the imaginary language Kintupú. We will further assume that tone Doubling does not spread H to a pre-pausal syllable, a very common restriction on this process; this restriction allows us to determine that the second of two H's does indeed delete, as in the first example. The second example illustrates spread of H rightward by one syllable. The third example illustrates the interaction between these processes.

(12)



What should be noticed in the mapping from input to output is that in the third example, a sequence of H's, two out of every three H tones ends up being deleted. This pattern can be described easily in OT. The crucial constraints are the constraint against HH, and a constraint against monosyllabic H domains. In the imaginary language Kintupú, these two constraints are undominated, and the tableau in (13) shows how the correct form is selected, by satisfying both of these constraints at the expense of Max-H. To guarantee that tones delete rather than fusing, Uniformity must also dominate Max-H.

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given for a geminate glide, and indeed Anderson does not consider an alternative analysis where the underlying form contains /gv/ which undergoes preconsonantal vocalization.

(13)

	a-ka-sa-ra-zo-mu-gi-ha-tema H_1H_2 H_3H_4 H_5 H_6H_7 H_8 H_9	*HH	*Mono-H	Unif	Max-H
	a-ka-sa-ra-zo-mu-gi-ha-tema | | | | | | | | \ / $H_1H_2H_3$ H_4H_5 H_6 H_7H_8 H_9	*!*******	********		
	a-ka-sa-ra-zo-mu-gi-ha-tema \ / \ / \ / \ / \ / H_1 H_3 H_5 H_7 H_9	*!***			****
	a-ka-sa-ra-zo-mu-gi-ha-tema $H_{1,2,3,4,5,6,7,8,9}$			*!********	
	a-ka-sa-ra-zo-mu-gi-ha-tema \ / H_1				******!**
☞	a-ka-sa-ra-zo-mu-gi-ha-tema \ / \ / \ / H_1 H_4 H_7				******

A derivational analysis of such processes would be founded on two rules, Meeussen's Rule which deletes H after H, and a rightward Tone Doubling rule, which is blocked from spreading H to a syllable before a H.

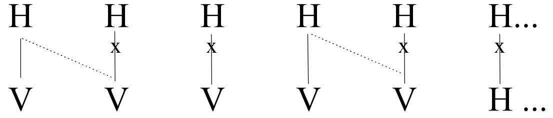
(14) *Meeussen's Rule*: $H \rightarrow \varnothing$ / H __
Tone Doubling:
H
| \ (blocked by H on following syllable; target nonfinal)
V V

The possible outputs from these rules are specified in (15), given either right-to-left or left-to-right iteration in each rule, and either of the possible rule orderings.

(15)	a.	MR (r-to-l)	ákasarazomugihatema	→	
		TD (r-to-l)	[ákásarazomugihatema]		
	b.	MR (r-to-l)	ákasarazomugihatema	→	
		TD (l-to-r)	[ákásárázómúgíhátémá]		
	c.	MR (l-to-r)	ákasárazómugíhatéma	→	
		TD (r-to-l,l-to-r)	[ákasárazómugíhatémá]		
	d.	TD (r-to-l,l-to-r)	ákásárázómúgíhátémá	→	
		MR (r-to-l)	[ákasarazomugihatema]		
	e.	TD (r-to-l,l-to-r)	ákásárázómúgíhátémá	→	
		MR (l-to-r)	[ákasárazómugíhatémá]		= c.

The pattern of retaining one tone and deleting two following tones, as was easily described under OT, ends up not being describable with ordered rules. Nor could one construct some new rule to perform this operation in one step, along the lines of (16).

(16)



This 'rule' has numerous properties which are prohibited by the general theory of rule-construction. First, the rules have to refer to structurally nonadjacent elements. Second, the rule must simultaneously affect multiple foci (in principle, an unbounded sequence). Third, this rule is not even a well-formed rule, insofar as the expression '...' has no formal status in the theory. The theory of rule ordering and rule formulation makes specific restrictive predictions about the interaction of processes, predictions not shared by OT. Lacking any indication that such processes are actually found in human language, this constitutes excessive power on the part of OT.

3. OT Machinery for Reconstructing Rule Ordering

I now turn to considering some of the formal machinery that will be needed to replace derivational concepts within OT.

3.1. Two-level constraints

One of the earlier devices proposed to replace derivations is two-level constraints. Two-level constraints were originally proposed by Koskeniemi 1983, and applied by Lakoff 1993 and Kartunen 1993. The essence of a two-level rule is that it refers simultaneously to the input and output stages, so that for example an input element X is mapped to an output element Y just in case it is preceded by Z in the input. Two-level constraints have been proposed in OT, for example in McCarthy 1996, Orgun 1996. While some cases of two-level constraints such as Bedouin Arabic have succumbed to reanalysis in terms of Sympathy Theory, there remain cases where Sympathy Theory just does not have the necessary power, and therefore Sympathy Theory cannot be the general theory which accounts for canonically derivational concepts. In the previous section, we have considered the tonal dissimilation known in the study of Bantu languages as Meeussen's Rule (MR), where a H tone is deleted after another H. In nearly all Bantu languages with this rule, such as Kikerewe (spoken in Tanzania), every H except the first in a sequence of underlying H tones gets deleted. Languages which exhibit this pattern of tone dissimilation include Kikerewe, Jita, Tonga, Rimi, Kihunde, Nilamba, Luganda and Haya. An example of this process from Kikerewe is seen in (17). Here, each of the prefixes /táá/, /tú/, /gí/, /kú/ and the first syllable of the stem /hééleezye/ are underlyingly H toned (see Odden 1999 for details of the Kikerewe tonal system). On the surface, each of those H tones except the leftmost is deleted, and the surviving H spreads once to a following non-final syllable by a general tone-doubling process.

(17) /abatáá-tú-gí-kú-hééleezye/ → abatáá-tu-gi-ku-heeleezye
'they who didn't give it to us for you (remote)'
(surface [abatáátúgikuheeleezye] because of low-level tone spreading)

In a derivational account in (18), this pattern is regulated by deleting tones from right to left, working through the string of H's.

(18) abatáá-tú-gí-kú-hééleezye → abatáá-tú-gí-kú-heeleezye →
abatáá-tú-gí-ku-heeleezye → abatáá-tú-gi-ku-heeleezye →
abatáá-tu-gi-ku-heeleezye ([abatáátúgikuheeleezye] by rightward spreading)

The problem in the OT account in (19) is that way more H's are deleted than are minimally required to avoid adjacent H's. The prediction of the OT approach is that only every *other* H tone should delete, since that is the least radical way to eliminate OCP violations. Minimal deletion of H would incorrectly result in the alternating pattern of H tones found in the second candidate.

(19)

	abatáátúgíkúhééleezye	*H H	Max-H
	abatáátúgíkúhééleezye	HHHH	
💣	abatáátugíkuhééleezye		HH
☜	abatáátugikuheeleezye		HH!HH

Nothing useful is added by an appeal to Sympathy theory, there being no obvious sympathy-inducing constraint. However, as seen in (20), a two-level approach to the constraint on H's proves to be quite useful. Rather than just prohibiting the appearance of a surface H after a surface H, we can instead prohibit a surface H which stands after an *underlying* H. By stating the constraint this way, deleting every other H is an ineffective strategy for avoiding violation of the constraint, since only the first surface tone in an underlying string of H's would not end up violating the constraint, given that the *surface* value of the first tone is not considered in computing whether the constraint is satisfied.

(20) */H/ H 'Surface H may not be preceded by an underlying H'

	abatáátúgíkúhééleezye	*/H/ H	Max-H
	abatáátúgíkúhééleezye	HH!HH	
	abatáátugíkuhééleezye	HH!	HH
☞	abatáátugikuheeleezye		HHHH

What this shows, then, is that both two-level constraints and sympathy theory are going to be needed in OT (on the presumption that sympathy theory is independently motivated).

This two-level version of MR actually helps OT to handle other rule-ordering effects in the language, since MR is not a surface-true principle of the language. In a derivational account, MR is ordered before processes which create HH sequences that do not undergo MR. For instance, an underlying toneless vowel may intervene between two H's, and by processes of syllable fusion or tone shift, the H's can become adjacent. In such a circumstance there is no deletion of the second H. As indicated in (21a), the persistive tense is formed with the toneless prefix -*a*- and the H toned prefix -*kí*-, which undergo syllabic fusion. Although fusion brings together two H tones on the surface, the second H is not deleted. With the right wording of the constraint, failure of the second H to delete can be accounted for in an OT account, on the basis of the two-level nature of the motivating constraint, since the surface HH sequence does not violate the two-level version of MR. The second H is underlyingly preceded by an underlyingly toneless TBU, /a/, and while that TBU has a surface H, it is only the underlying representation that is considered in determining constraint violation with respect to the first tone in the sequence. Similar non-deletion is illustrated in (21b), involving resyllabifications resulting from optional deletion of an intervocalic glide.[5]

(21) a. /a-ki-a-kalaanga/ → [acháákáláanga] ‘he is still frying’
H H → H H

b. tibákú'yásáma ~ tibákwáásáma ‘they aren’t opening the mouth’
/ti-ba-ku-yasama/ → ti-ba-ku-asama → [tibakwaasama]
H H → H H → H H

Finally, onsetless syllables cannot bear H tone in the language,[6] and underlyingly H toned syllables undergo rightward tone shift — see Odden 1995. The initial subject prefix of verbs in relative clause tenses is underlyingly H toned (e.g. /bá/), but if the prefix is onsetless (e.g. /á/), then the H shifts to the following syllable (and spreads to the right).

(22) /bá-ku-baziila/ → [bá-kú-baziila] ‘they who are sewing’
/á-ku-baziila/ → [akúbáziila] ‘he who is sewing’

Note in (23) that a H tone which is thus shifted to stand before another H does not trigger MR.

(23) /á-ku-chúmita/ → [a-kú-chúmíta] ‘he who is stabbing’
/á-ka-kálaanga/ → [a-kú-káláanga] ‘he who is frying’
a-ku-chumita → akuchumita
H H → H H

In all of these cases, there is no deletion of H after H since the two H’s are not underlyingly adjacent, and thus the surface HH sequence does not violate MR. Thus the mechanism that was required to handle the non-minimal pattern of H deletion also accounts for this set of what in a derivational theory would be counterfeeding interactions.

Derived HH sequences are not uniformly exempt from MR. One source of derived HH sequences that are subject to MR involves the interaction between MR and a phrasal tone insertion process, Lapse Avoidance, which inserts H at the end of a noun which stands before a toneless modifier within the phrase, illustrated in (24). This inserted H then spreads rightward because of Tone Doubling.

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[5] The location of association within the syllable between tone and moras of a long vowel (written as double vowels) is noncontrastive, and the simplest account of this is that the syllable is the structural bearer of tone in the language, hence if any mora in the syllable has H tone, the entire syllable has H, and vice versa. Underlyingly, adjacent vowels in different morphemes which are later syllabified together can individually bear H, as is the case of (21). Utterance-penult long vowels can have a falling pitch which is notated here as *v́v*, but this is due to principles of phonetic implementation which will be investigated in a separate paper.

[6] Leftward Spreading creates the only surface counterexamples to this generalization, wherein /i-tí/ → [ítí] “tree”.

(24)	oluguhyo	‘broken pot’
	luukizaano	‘green (Cl. 11)’
	oluguhyó lúúkizaano	‘green broken pot’
	ekikáláángilo	‘frying pan’
	kizito	‘heavy’
	ekikáláángiló kízito	‘heavy frying pan’

As (25) shows, no H is inserted if the following modifier has a H tone.

(25)	oluguhyo lúno	‘this pot’	oluguhyo luzímá	‘good pot’

The interaction between Lapse Avoidance and MR is seen in (26), where the noun has an underlying penult H. Under a derivational account, these data show either that Lapse Avoidance must be prevented from applying when the target vowel is preceded by a H (i.e. is subject to OCP blockage), or that the H inserted by Lapse Avoidance is subsequently deleted by MR.

(26)	ihéénze	‘cockroach	ihéénzé lyaangu	‘quick cockroach’
	ebhalúúwa	‘letter’	ebhalúúwáá ndeehi	‘long letter’

If H were inserted on the final vowel, it would spread rightward giving incorrect **ihéénzé lyáangu*.

In the OT account, these data are explicable given a specific interpretation of the two-level condition on adjacent H’s. Underlyingly adjacent H tone sequences are banned, and HH sequences which are not underlyingly adjacent are tolerated. These data show that the two-level condition against HH does not care about the underlying status of the second H. The constraint */H/H is thus not a constraint against underlyingly adjacent H’s, which would be too broad a statement, but is, specifically, a constraint against surface H immediately preceded by an underlyingly H toned TBU. MR is sensitive to the underlying status of only the first TBU in a HH sequence, and the constraint considers only the surface status of the second TBU. If the TBU’s are underlyingly adjacent (as they are in (26)), and if the first TBU has an underlying H (as it does in (26)), then the constraint prohibits surface HH, whether the second surface H also be an underlying H (as in the examples of (20), (22), (23)) or an inserted H (as in (26)).

So far, the two-level account of MR has fared well enough: problematic data will now be considered. In the data considered so far, a H on a TBU blocks a following H only if the leftmost TBU is underlyingly H. This is not always the case: some cases of rightward tone shift feed into MR. Like all object prefixes in the language, the 1sg object prefix has an underlying H tone: it is underlyingly a moraic nasal, which cannot bear tone on the surface. Consequently, the H from the nasal shifts to the following syllable.[7] The examples below illustrate this shift before underlyingly toneless stems. In the first example, the H shifts to the final syllable, and because that syllable is the utterance final syllable, the H spreads to the left. In the second example, the H shifts to the penult, but Tone Doubling is prevented from spreading that H to the final syllable. In the third example, H shifts from the nasal to the stem-initial syllable, and then undergoes Tone Doubling.

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[7] The nasal’s mora transfers to the preceding vowel, causing compensatory lengthening of the underlyingly short vowel.

(27)	'to V'	'to V us'	'to V me'	
	kusya	ku-tú-sya	kúú-n-syá	'grind'
	kubala	ku-tú-bála	kuu-m-bála	'count'
	kutwaangila	ku-tú-twáángila	kuu-n-twáángíla	'pound for'

As the data in (28) show, when the following stem begins with a H tone, the tone pattern is the same. This can be explained either by assuming that MR causes the root H to delete after the object prefix's H, and then H shifts from the prefix, or by assuming that the prefix H shifts to the H toned root initial syllable, thus merging with that H.

(28)	'to V'	'to V us'	'to V me'	
	kúlyá	ku-tú-lya	kúú-n-dyá	'eat'
	kubóna	ku-tú-bóna	kuu-m-bóna	'see'
	kutéékéla	ku-tú-téékela	kuu-n-téékéla	'cook for'

Examples such as *kuumbóna, kuuntéékéla* which derive from /ku-ḿ-bóna/, /ku-ń-téékela/ pose a problem for the two-level analysis of MR. The two-level account was crucial in forcing over-zealous deletion of H (whereby /abatáá-tú-gí-kálaangiizye/ becomes *abatáá-tú-gi-kalaangiizye* and not **abatáá-tú-gi-kálááangiizye* by a more conservative pattern of H deletion). The essential contribution of the two-level constraint is that the tone born by the first syllable in the sequence should be underlyingly H, both underlyingly present and underlyingly on the first TBU in the HH sequence, without reference to the surface tone. However, this statement of the constraint incorrectly predicts that no H tone at all should surface in /ku-ń-téékela/.

(29)	ku-ń-téékela	(nasal tonotactics)	*/H/H	Max-IO(H)
Π a.	kuuntéékéla		*!	*
☟ b.	*kuunteekela			**
c.	kuńtéékela	*!		*

Compare the analogous choice involving the 1pl object prefix *tú*:

(30)	ku-tú-téékela	*/H/H	Max-IO(H)
☞	kutútéékela		*
	kututeekela		**!
	kututéékéla	*!	*

Deletion of all H's is blocked in (30) as being gratuitous: deletion of a single H suffices to avoid violation of MR, and the two-level condition on MR dictates which of the two H's (the leftmost) will survive. With /ku-ń-téékela/ in (29), H tone cannot be preserved on the leftmost underlying TBU because of inviolable surface tonotactics. Since the actual form (29a) violates MR (*ń* is underlyingly H toned), that form would be wrongly ruled out in favor of the toneless candidate which only violates the relatively low-ranked constraint Max-IO(H).[8] Thus the two-level account which was crucial to explaining the pattern of non-minimal H deletion and the

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[8] One might attempt to avoid this by ranking Max-IO(H) above MR, but such a move can be ruled out by the simple fact that such a ranking wrongly predicts that there is no OCP-driven H deletion at all.

counterfeeding pattern of certain cases of tonal movement is shown to be inconsistent with other facts of the language.

These data pose further problems for an OT analysis. Unlike the situation with H that shifts due to the general Onsetless Tone Shift rule, shift from the tone-bearing nasal of an object prefix feeds into MR. In the phrasal context where H is inserted before a toneless modifier, the H inserted by Lapse Avoidance *is* deleted if the preceding syllable has a H tone that shifts to that position from a H toned nasal.

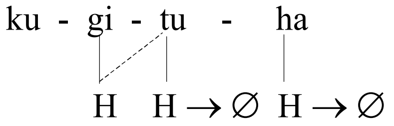
(31)	ku-bala	‘to count’
	kuu-m-bála	‘to count me; counting me’
	kuu-m-bálá kwaako	‘your (act of) counting me’

One would expect a H tone to be assigned to the final vowel by Lapse Avoidance — cf. /kubala kwaako/ → *kubalá kwáako* ‘your counting me’. The reason that no H surfaces on the final vowel is that the preceding vowel *á* has a H tone. However, that vowel does not have an underlying H, but rather has H as a result of rightward tone shift from a tone-bearing nasal. Therefore, it is wrong to say that a TBU must be underlyingly H toned to be visible to MR.

This problem can be resolved in OT if one adopts a partially derivational, multi-modular version of the theory (as has been suggested in various places such as McCarthy & Prince 1993; Kenstowicz 1994; Myers 1997; Kiparsky 1998; Ito & Mester 1999), where there are mutiple derivational levels, such as distinct word-level and phrase-level phonologies or even word-internal levels as there are in the theory of Lexical Phonology, and the output of the word-level phonology defines the input to the phrase level phonology. Under that assumption, the output of the word-level phonology, given underlying /ku-ḿ-bala/, would be *kuumbála*. When this form is resubmitted to the phrasal phonology in the phrase /kuumbála kwaako/, the fact that the H originated on the preceding TBU /ḿ/ in the word-level phonology is inaccessible information. Thus a candidate where H is inserted before the toneless modifier (which would surface as **kuumbálá kwáako* given the constraints that bring about tone doubling) would not be immune to the effects of MR.

There is another line of argument showing that MR is cyclic in the sense of applying distinctly at the word and phrasal levels, with rules interspersed between applications of MR, centering around the fact that MR deletes H on a vowel, and the vowel can then be reassigned H at the phrasal level. At the word level, MR is responsible for deletion of all but the first in a sequence of underlying H’s (and that leftmost H spreads by Tone Doubling).

(32) kú-há ← ku-há ‘to give’ (ku-há Búlemo ‘to give Bulemo’)



kugítúha ‘to give it to us’

Although /há/ is underlyingly H toned, the H of the preceding object prefix *tú* triggers deletion of the H of /há/. The H of *tú* is itself deleted because it is preceded by *gí* which has H.

Now consider what happens when this word is in a phrase, and Lapse Avoidance becomes relevant. As (33) shows, H tone is assigned to the final vowel.

(33) /ku-gí-tú-há kwaako/ → kugítúꜜhá kwáako 'your giving it to us'

If, in a derivational analysis, MR did not apply first at the word level, and only applied once in a derivation, after Lapse Avoidance at the phrase level, the wrong form would be derived. Lapse Avoidance would have no effect on underlying /ku-gí-tú-há kwaako/, since the final vowel of the stem already has H. MR would then apply (followed by Tone Doubling), deriving **ku-gí-tú-ha kwaako*. The correct result is derived if MR applies first at the word level, deriving *kugítuha*; at the phrasal level, Lapse Avoidance would give *kugítuhá kwaako* (surface *kugítúꜜhá kwáako* via Doubling).

There are also derived environment effects which in a derivational account argue for cyclicity. First, underived tautomorphemic H sequences are not subject to MR, as in *mu-nóóꜜló* 'small (cl. 1)', *omuuntu munóóló wáange* 'my small person', where both syllables of the stem *nóóló* have underlying H.[9] Second, MR only applies at the phrasal level to the output of Lapse Avoidance. The fact that MR does not apply to the output of word-internal syllable fusions (/ti-bá-ku-yásama/ → *tibákwáásáma* 'they aren't opening the mouth') or tone shifts (/ákuchúmita/ → *akúchúmita* 'he who is stabbing') is explained by ordering MR after these processes at the word level. Ordering cannot explain why these forms do not undergo MR at the phrasal level: the input to the phrasal phonology should be *tibákwáásama*, *akúchúmita*, which satisfies the structural description of MR. However, from the perspective of the phrasal phonology, these forms contain underived HH sequences — HH sequences which are present in the input — and therefore if MR is a cyclic rule and is only applicable to derived forms, phrasal application of MR is automatically blocked.[10]

At the phrasal level, MR only applies if the conditions for the rule derive by application of a rule, and therefore MR only applies in some substring if two conditions are met: the requisite structure (HH) is present, and some rule creates that structure. Insofar as rule application results in increased unfaithfulness to the input, this is equivalent to the condition that the sequence HH is present and there is an IO faithfulness violation with respect to H tone. In OT — following Lubowicz 1998 — this translates into conjoining MR with the constraint Dep-H, giving the compound condition "do not both insert H and violate MR". The adjacent H's of *akúchúmita* at the phrasal level are tolerated, despite violation of MR, since simple violation of MR is of no consequence, just as the violation of Dep-H which results from the mapping from /oluguhyo luukizaano/ to *oluguhyo lúukizaano* is of no importance. What is important in the

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[9] The downstep in the citation form is due to a principle of phonetic interpretation lowering a prepausal H. Since the H's of the syllables *nóó* and *ló* are distinct H's, lowering only affects the final syllable. In contrast, in *kúlyá* "to eat" derived from underlying /ku-lyá/ by Leftward Spread, there is only a single H associated to the last two syllables, hence the two syllables have the same pitch level.

[10] Two empirical questions regarding process interaction cannot be resolved, due to accidental gaps created by the morphology in the language: can onsetless shift feed into MR at the phrasal level, and does shift of H from the object prefix /ń/ feed into MR at the word level? Phrasal H insertion only applies to nouns, but nouns cannot have the H toned subject prefixes which undergo Onsetless Tone Shift, so the conditions for these two processes never coincide. As for shift of H from /ń/ and word level MR, the crucial test case would be one where /ń/ immediately precedes a toneless syllable that is itself followed by a H, i.e. something of the form /...ńcvcv́.../. This can only arise in Kikerewe if the second H were the grammatical H tone assigned to the penult or final vowel in certain tenses (see Odden 1998b). However, a separate principle deletes all H's in a word which come before this grammatical H, even those not adjacent to the grammatical H. Accordingly, /ba-laa-ń-balíla/ surfaces as *balaambalíla* "they will count for me", just as /ba-laa-ń-hanaantukíla/ becomes *balaampanaantukíla* "then will descend for me": the potential HH sequence is thus avoided by a separate, even more general mechanism.

OT analysis is that these two constraints cannot both be violated in the same substring, as is potentially the case with /kuumbála kwaako/.

It is now time to take stock of the attempt to account for Kikerewe’s pattern of OCP-driven H deletion eschewing sequential derivations. A purely non-derivational account has failed on two accounts. First, it has proven impossible to come up with any coherent account of the patterns found at the word level, pertaining to non-minimal deletion of H and the interaction between MR and various tone movement processes, even with two-level constraints. Second, it has proven necessary to posit at least two derivational steps in the form of a word-level derivation followed by a phrase-level derivation.

3.2. Constraint Conjunction

The next bit of useful machinery for reconstructing derivations is constraint conjunction. Three such arguments will be given here, one showing how constraint conjunction handles the problematic interaction between two tone sandhi rules in Zinza (another Bantu language of Tanzania), a second showing how constraint conjunction is crucial in handling the morphophonemics of N+C in Kimatuumbi, a Bantu language of Tanzania, and a third involving the interaction between OCP deletion, tone docking and tone throwback in Taita, a Bantu language of Kenya.

3.2.1. ZINZA TONE

First we consider the problem of Zinza tone sandhi — the essence of the problem is that there are two rules which are in a mutually counterfeeding relation, and no matter how the rules are ordered, the output of the second rule could feed into the other rule, and an OT account is at pains to explain this surface opacity. By the first rule seen in (34), any H tone deletes in a verb if it is followed by an object within the phrase.

(34)	akalima	‘he cultivated’	akalima Géeta	‘he cultivated in G’
	akatéeka	‘he cooked’	akateeka Géeta	‘he cooked in G’
	akamúlimila	‘he cultivated for him’	akamulimila Géeta	‘he cultivated for him in G’

By a second rule, illustrated in (35), any otherwise toneless phrasal head is assigned a final H if it is followed by a toneless complement.

(35)	akalima	‘he cultivated’
	akalimá Seengelema	‘he cultivated in S’

$H \rightarrow \varnothing$ / $[_{X}\mathrm{max}[\ldots\underline{\quad}\ldots]\ \ Y]$ Insert H on toneless word before toneless word.

The interaction between these processes is seen in (36), where we can see that H-deletion deletes any H’s in the verb, which creates a toneless word as an intermediate stage, but because the following word is toneless, a H must then be added at the end of the verb.

(36)

akatéeka	‘he cooked’
akateeká Seengelema	‘he cooked in S’
akamúlimila	‘he cultivated for him’
akamulimilá Seengelema	‘he cultivated for him in S’

akamúlimila Seengelema	*underlying*
aka**mu**limila Seengelema	*H deletion*
akamulimi**lá** Seengelema	*H insertion*

Consider an account of this pattern in OT. We can assume a constraint against H in a word followed by another word in the phrase, ‘No H-plus’, which causes deletion of H in verbs before an object. This constraint dominates faithfulness constraints such as Ident-H which require that underlying tones not be changed. There is also a Lapse-Avoidance constraint against two consecutive toneless words in a phrase, which causes insertion of H. Moreover, the H that is inserted under the compulsion of Lapse-Avoidance must specifically be assigned to the last vowel of the word, as dictated by a rightward tone alignment constraint.

(37) ***H+:** H tone is disallowed in a phrasal head which is followed by another word.
***L#L:** A toneless word cannot be followed by a toneless word in a phrase.
Align(H,r,ѡ,r)

Since lexical tones are not shifted or spread to the right in citation forms or non-deleting phrasal contexts, IO faithfulness must dominate the alignment constraint, as seen in (38).

(38)

	akamúlimila	IO-Faith	AR(H)
	akamulimilá	*!*	
☞	akamúlimila		***

Now we come to the tableau in (39), which tries to account for a form that undergoes both deletion of a lexical H and insertion of H at the phrasal level, and the question is, how can we assure selection of the correct form with the lexical H deleted and a final H inserted. The first candidate can be ruled out since it violates the ban against sequences of toneless words. The problem is that the remaining candidates *both* violate the ban on phrase-medial H equally, and while the actually correct candidate better satisfies rightward alignment, we independently know from (38) that rightward alignment is subordinate to IO-faithfulness, and therefore it should be better to keep the underlying H tone in position than to delete one H and insert another, or to shift the H to the right, as we have in the actual output.

(39)

	akamúlimila Seengelema	*L#L	*H#+	IO Faith	AR(H)
	*akamulimila Seengelema	*		/ú/	
💣	*akamúlimila Seengelema		*		i i a
☜	akamulimilá Seengelema		*	/ú/ /a/	

(Classical) sympathy theory provides no help here. The obvious sympathy candidate would be the intermediate form that you get after H deletion and before phrasal H insertion in a derivational account, with no H tone on the first word. We might identify that sympathy candidate as the best form satisfying No-H-plus, as in (40), although this involves suspending McCarthy's proposal that only faithfulness constraints can be sympathy selectors — see Ito & Mester 1998, DeLacy 1999, for arguments against limiting the class of selector constraints to faithfulness.

(40)	akamúlimila Seengelema	*L#L	*H#+	IO Faith	AR(H)
❀*H+	*akamulimila Seengelema	*		/ú/	
	*akamúlimila Seengelema		*		i i a
	akamulimilá Seengelema		*	/ú/ /a/	

But even with this candidate identified, we still have no basis for prefering final H over keeping H in its underlying position. In terms of similarity to the sympathy candidate, the incorrect second candidate and the correct third candidate are *equally* bad, differing only in the *location* of the badness. Given that, it should be left to IO faithfulness to prefer a form with H in the same location as in the input, which leaves us where we started from. This is a kind of 'A to B to A' Duke of York derivation which McCarthy points out would pose a problem for Sympathy theory.[11]

Constraint conjunction (Crowhurst & Hewitt 1998 inter alii) can be called on to handle the problem that, of the two candidates which violate the constraint against medial H, we have been unable to discard the more lexically faithful candidate which also violates rightward alignment. But this is just what constraint conjunction is designed to handle, that is, it allows one to pick out from the set of candidates that violate a constraint A, all of those candidates which also violate another constraint B.

(41)	akamúlimila Seengelema	*L#L	*H#+ ∨ AR(H)	*H#+	IO Faith	AR(H)
	akamulimila Seengelema	*!			/ú/	
	akamúlimila Seengelema		(*) *! (***)	*		i i a
☞	akamulimilá Seengelema		(*)	*	/ú/ /a/	

As the tableau in (41) indicates, ordering the conjunction of No-H-plus and rightward alignment above IO-faithfulness allows us to rule out the candidate which keeps the lexical H in place, but avoids the incorrect implication that there is any *general* inclination for rightward shifting or spreading of tones in the language, and in fact the only directional preference for tone shift, spread, or preservation, happens to be to the left in this language.

It should not be surprising that constraint conjunction could handle some rule-ordering. Applying a rule typically results in a pattern of faithfulness violations, but also tends to improve performance with respect to phonotactic constraints. A derivational account involving application of one rule and no application of another rule is thus likely to result in a characteristic pattern of violations and satisfactions of constraints. To the extent that constraint conjunction provides a tool for regulating the acceptance of complex patterns of violations across con-

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[11] See section 4 for discussion of revised Sympathy Theory proposed in McCarthy 1999. Under that theory, and providing that a well-formedness constraint can be the sympathy selector, the Zinza facts succumb to analysis in terms of Sympathy; but then as also shown there, this version of ST does not aparently differ in any significant way from derivational theory in terms of its ability to handle Duke of York derivations.

straints, it is not hard to see that constraint conjunction is a useful bit of machinery for emulating rule ordering.

3.2.2. KIMATUUMBI NC CLUSTERS

A second case where constraint conjunction is crucial in handling ordering comes from Kimatuumbi (a Bantu language of Tanzania (see Odden 1996)) — here, neither Sympathy Theory nor two-level constraints will handle the facts. In this language, sequences of nasal plus consonant are subject to different sets of modifications, depending on the derivational source of the sequence. Ultimately, the contrasting effects result from derived differences in the moraicity of the nasal. These effects will be refered to as *mų*-effects and *n*-effects, since the underlying sequences causing these changes are /mų/ for one class of effects, and /nį/ or /ñ/ for the other. One morpheme triggering the *mų*-effect is the class 1 prefix /mų/, whose underlying high back vocoid is seen when attached to a vowel initial stem or in other contexts where its vowel is lengthened and thus not deletable, as in the first two examples of (42). Otherwise, the vowel /ų/ deletes after /m/. The crucial consonantal change triggered by /mų/ is the nasalization of a following voiced stop, seen in the first example of (b). /mų/ has no effect on a voiceless consonant, and it forms a geminate with a following nasal.

(42)	a.	mw-aákį́	/mų-ákį́/	‘hunter’	áka	‘to hunt’
		mųų́-ndų	/mų-n̩dų/	‘person’	kaá-ndų	‘little person’
	b.	m-málaángį	/mų-bálaángį/	‘counter’	a-bálaángį	pl.
		m-páandį́	/mų-páandį́/	‘planter’	a-páandį́	pl.
		m-mátį́	/mų-mátį́/	‘plasterer’	a-mátį́	pl.

Another context where the mų-effect can be seen is with the prefix /mų/ marking second plural subjects, whose vowel is optionally deleted, as in (43). Here too we can see nasalization of a voiced stop, in the first example of (b), and no effect on the other consonants.

(43)	a.	mw-aaké			‘you should hunt’
	b.	m-málaangįte	~	mų-bálaangįte	‘you counted’
		m-paánde	~	mų-paánde	‘you should plant’
		n-nóolįte	~	mų-nóolįte	‘you (pl.) sharpened’

One morpheme triggering n-effects is the class 9 noun prefix in (44), underlyingly a palatal nasal /ñ/, as seen when the prefix comes before a vowel. When coming before an underlyingly voiceless consonant, this nasal causes voicing, and before another nasal, there is degemination of the nasal. This nasal has no nasalizing effect on a following voiced consonant.

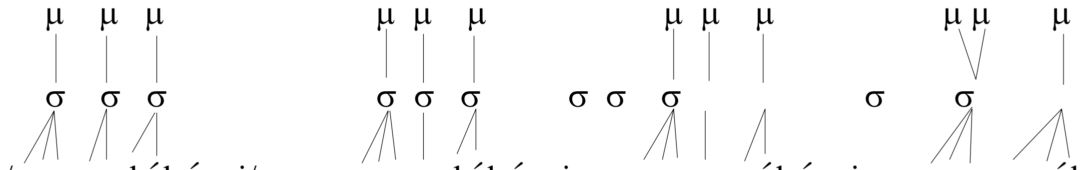
(44)	ñ-epeésį		‘light (cl. 9)’
	n-deléká	/ñ-teléká/	‘cooked (cl. 9)’
	namátá	/ñ-namátá/	‘sticky (cl. 9)’
	m-balaángá	/ñ-balaángá/	‘counted (cl. 9)’

A second context illustrating the n-effect involves the 1sg prefix /nį/, where underlying /į/ undergoes optional deletion after /n/; (45) shows that this nasal also triggers voicing and degemination, but causes no nasalization.

(45)	n-déḷịịke	~	nị-téḷịịke	'I cooked (recent)'
	nóolịte	~	nị-nóolịte	'I sharpened'
	m-bálaangịte	~	nị-bálaangịte	'I counted'

An important question is what distinguishes the prefixes with respect to changes on a consonant. As argued in Odden 1996, *mụ*-prefixes have an intermediate stage where the nasal is moraic, when the nasal effects take place. The mora can be seen in (46) when a vowel precedes the nasal, since the nasal desyllabifies, compensatorily lengthening the preceding vowel.

(46)



/nga-mụ-bálaángị/ → nga-m-bálaángị → nga-m-málaángị → ngaa-m-málaángị

'it's a counter'	
(cf. nga-Lịbụlụ́le	'it's Libulule')
kịgómaa m-paánde ← /kịgóma mụ-paánde	'you should plant kigoma'
(cf. kịgóma mụ-paánde	'you should plant kigoma')

Unlike the *mụ*-prefixes, the *n*-prefixes are not moraic at the relevant stage, so the noun prefix /ñ/ is simply underlyingly nonmoraic. When the class 9 prefix comes before a vowel in (47), there is no lengthening, as there is with other vowel-final prefixes.

(47)	ñ-epeésị	'light (cl. 9)'
	(cf. mw-eepeésị	'light (cl. 3)'
	nga-ndeléká	'it is cooked (cl. 9)'
	(cf. ngaa-nteléká	'it is cooked (cl. 3)'

/nga-ñ-teléká/ → nga-ñ-teléká → nga-n-deléká

The prefix /nị/ has a vowel, but undergoes vocalic deletion before a consonant without moraic preservation.

(48)

kịgóma nịtéḷịịke → kịgóma ndéḷịịke 'I cooked cassava'

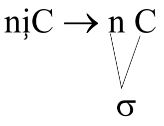
The consequence of mora deletion in the prefix *nị* is that the prefix induces different segmental effects on a following consonant.

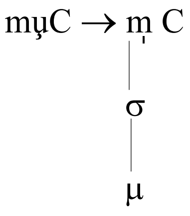
The two classes of nasal plus consonant effects are summarized in (49).

(49)	mųp	→	m̩.p	→	μ + mp	n(į)p → mb
	mųb	→	m̩.m	→	μ + mm	n(į)b → mb
	mųm	→	m̩.m	→	μ + mm	n(į)m → m

The derivational rules are given in (50).

(50) Vowel deletions:



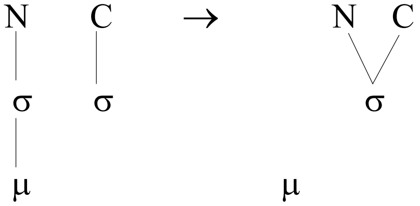


Postnasal voicing: C → [+voice] / [$_\sigma$ [+nas] ___

Degemination: $C_i \rightarrow \varnothing$ / [$_\sigma$ C_i ___

Nasalization: $\begin{matrix}\text{C}\\ \text{[+voice]}\end{matrix} \rightarrow$ [+nasal] / [+nasal] [$_\sigma$ ___

Nasal readjustment:



The process of vowel deletion affecting /nį/ does not result in a moraic nasal, whereas the deletion affecting /mų/ renders the nasal moraic. Subsequently, various rules are sensitive to these differences in moraicity. Degemination in (51) affects onset geminate nasals, and thus degemination does not affect a moraic nasal plus nasal, since that is not a tautosyllabic cluster.

(51)	*underlying ñ*	*NC derived by deletion of both V and μ*	*NC derived by V deletion with μ preservation*	
	/ñ-nV/	/nį-nV/	/mų-nV /	
	.nnV.	.nį-nV.	.mų.nV.	*Syllabification*
			.m̩.nV.	*V-deletion*
	.nV.	.nV.		*Degemination*
			μ .nnV.	*Nasal resyllabification etc.*

Postnasal onset voicing in (52) only affects onset clusters of nasal plus consonant, and thus does not affect a moraic nasal plus a consonant in a following syllable for the same reason.

(52)	*underlying ñ*	*NC derived by deletion of V and µ*	*NC derived by V deletion with µ preservation*	
	/ñ-tV/	/nį-tV/	/mų-tV/	
	.ntV.	.nį.tV.	.mų.tV.	*Syllabification*
		.ntV.	.m̩.tV.	*V-deletion*
	.ndV.	.ndV.	NA	*Postnasal voicing*
			µ .ntV.	*Nasal resyllabification etc.*

The nasalization process in (53), which affects voiced consonants, affects only a consonant preceded by a moraic nasal, and not an onset nasal plus consonant.

(53)	*underlying ñ*	*NC derived by deletion of V and µ*	*NC derived by V deletion with µ preservation*	
	/ñ-bV/	/nį-bV/	/mų-bV/	
	.mbV.	.nį.bV.	.mų.bV.	*Syllabification*
		.mbV.	.m̩.bV	*V-deletion*
	NA	NA	.m̩.mV.	*Nasalization*
			µ .mmV.	*Nasal resyllabification etc.*

The opacity of all of these processes is due to the fact that moraic nasals are surface desyllabified, with the mora being transfered to any preceding vowel.

The quandry to be resolved in an OT account is how to distinguish various kinds of nasal plus consonant sequences, depending on their derivational source. We can quickly rule out a two-level account. The basic idea of a two level account of postnasal voicing would be to penalize sequences of nasal plus consonant, but only if the consonants were underlyingly adjacent. This would correctly allow voicing to be triggered by the noun prefix /ñ/, since it is not followed by a vowel, and would block voicing in the case of underlying /mų/ plus consonant. The problem is that this does not distinguish /mų/, which does not trigger voicing, from /nį/ which does, even though in both cases the consonants are underlyingly nonadjacent.

(54) *N [-voice] (if underlyingly adjacent)

	ñt	*NT	Ident(voi)
	nt	*	
☞	nd		*

	mųt	*NT	Ident(voi)
☞	nt		
	nd		*

	nįt	*NT	Ident(voi)
💣	nt		
	nd		*

The beginnings of a sympathy-based account are given in (55). In accounting for the opacity of postnasal voicing with respect to deletion of /ų/, the goal would be to identify the intermediate stage, /mųt/, via some failed candidate and require identity to that candidate with respect to voicing. To derive opacity specifically in the case of reduction of /mų/ but not /nį/, we will identify the sympathy-inducing constraint more precisely as Max-round which penalizes deletion of round vowels. Thus deletion of *u̧* induces no voicing, despite the phonotactic constraint, because the output is required to look like the intermediate form where no round vowel is deleted.

(55)	mu̧t	*mu̧C	$\text{ID-Voi}_{\text{Max(rd)}}$	*NT	Max(rd)
❀$_{\text{Max(rd)}}$	mu̧t	*!			
☞	nt			*	*
	nd		*!		*

In the case of underlying /nt/ where no vowel is deleted in (56), the best candidate satisfying Max-round is simply the phonotactically best candidate, which avoids voiceless consonants after nasals.

(56)	ñt	*ni̧C	$\text{ID-Voi}_{\text{Max(rd)}}$	*NT	Max(rd)
	nt			*!	
☞❀$_{\text{Max(rd)}}$	nd				

And when the deleted vowel is /i/ in (57), the flower candidate is also the phonotactically best form, since although a vowel is deleted in that form, it is not a round vowel.

(57)	ni̧t	*ni̧C	$\text{ID-Voi}_{\text{Max(rd)}}$	*NT	Max(rd)	ID(voi)
	ni̧t	*!				
	nt		*!	*		
☞❀$_{\text{Max(rd)}}$	nd					*

As indicated in the tableaus of (58), the same kind of analysis will account for the preservation of geminate nasals arising from deletion of /u̧/, in contrast to degemination as found with underlying nasal plus nasal sequences, or ni̧-plus-nasal sequences.

(58)	mu̧n	*mu̧C	$\text{Max-C}_{\text{Max(rd)}}$	*NN	Max(rd)
❀$_{\text{Max(rd)}}$	mu̧n	*!			
☞	nn			*	*
	n		*!		*

	nn	*ni̧C	$\text{Max-C}_{\text{Max(rd)}}$	*NN	Max(rd)	Max(C)
	nn			*!		
☞❀$_{\text{Max(rd)}}$	n					*

	ni̧n	*ni̧C	$\text{Max-C}_{\text{Max(rd)}}$	*NN	Max(rd)	Max(C)
	ni̧n	*!				
	nn			*!		
☞❀ $_{\text{Max(rd)}}$	n					*

We cannot handle the interaction between *u̧*-deletion and nasalization of voiced consonants with Sympathy Theory, in particular, we cannot explain why nasalization affects only the output of *ų*-deletion. In the derivational account, what explains this pattern is the fact that the trigger is derivedly moraic. Under a Sympathy approach, the sympathy candidate would be one where the onset nasal is moraic, thus triggers nasalization of the following voiced stop. The question is how to identify such a form. We could focus on moraic preservation, and make the sympathy constraint be Max-mora, as in (59), which attempts to derive [aammwéenį] from /a-mų-bwéenį/. But this won't work, since the actually best candidate satisfying Max-mora is the third one in (59) where the nasal itself is *not* moraic, but the mora is nevertheless preserved in the output by being transfered to the previous vowel, so the required sympathy candidate can't be identified: if the sympathetic candidate cannot be identified, there is no basis for allowing nasalization in this case.[12]

(59)

	a-mų-bweenį	Max(μ)	*mųC	*N̩
	amųbweenį μ μ		*!	
(❀)	am̩bweenį μμ			*!
✿Max(μ)	aambweenį μμ			
	ambweenį μ	*!		

For Sympathy to work, we have to presume that syllable structure is present underlyingly, and there is a syllable node that underlyingly dominates *mų*. To identify a form with a moraic nasal as the sympathy candidate, the sympathetic constraint will be Max-IO-syllable. The tableau in (60) shows how the flower candidate can be identified. The crucial difference between this approach and the Max-mora approach is that while transfer of the mora to the preceding vowel preserves the mora, it does not preserve the syllable, whereas the candidate where the nasal becomes syllabic also preserves the syllable.

(60)

	mų.b σ σ	Max-σ	*mųC	*N̩	*N̩D	Max-V
	m̩.b σ σ			*	*!	*
❀Max-σ	m̩.m σ σ			*		*
	μ mb σ	*!				*
	mų.b σ σ		*!			

Given the right flower candidate so identified, the actual form can be selected because of its similarity to the flower candidate with respect to consonant nasality, as in (61).

---

[12] Note incidentally that the candidate also cannot be identified by requiring that the mora be preserved in an IO-faithful manner, since the mora is actually underlyingly on the deleted vowel *ų*.

(61)

	mų.b σ σ	*mųC	Ident-Nas$_{\text{Max-}\sigma}$	*N̩	*N̩D	Max-V	Ident-Nas
☞	mm σ					*	*
	mb σ		*!		*	*	
❀$_{\text{Max-}\sigma}$	m̩.m σ σ			*!		*	*
	mų.b σ σ	*!	*				

A theoretical problem with this approach is that it works only if one assumes that inputs in Kimatuumbi are syllabified, at least in any string that can lead to a nasal plus consonant sequence, which contradicts the premise of richness of the base. Moreover, this analysis requires that there actually *be* IO faithfulness constraints for the syllable, which McCarthy 1999 claims is simply not the case. A fatal empirical problem with the sympathy analysis is that it also incorrectly predicts that there should be nasalization when the vowel /į/ deletes, but we know there is no nasalization resulting from reduction of *nį*. Since we are looking for the best form that preserves the underlying syllable of /nį/, we cannot help but find the second candidate in (62a), and prefer it over the first candidate, which then leads us to incorrectly require identity with respect to nasality in deriving the actual form in (62b).

(62) a.

	nįb	Max-σ	*nįC	*N̩	*N̩D	Max-V
	m̩b			*	*!	*
❀$_{\text{Max-}\sigma}$	m̩m			*		*
	μ mb	*!				*
	nįb		*!			

b.

	nįb	*nįC	Ident-Nas$_{\text{Max-}\sigma}$	*N̩	*N̩D	Max-V	Ident-Nas
💣	*mm					*	*
☜	mb		*!		*	*	
❀$_{\text{Max-}\sigma}$	m̩m			*!		*	*
	nįb	*!					

There is no way to identify the correct sympathy candidate in this case: somehow, in the case of į-deletion, we have to exclude a sympathy candidate which is, in character, the same as the one that we relied on to derive the correct form in the case of ų-deletion.

There is a way in OT to solve this problem, by appealing to constraint conjunction. The basic idea of the constraint conjunction approach is to say that it is acceptable to delete a round vowel and thus violate Max-rd, or to violate the ban on nasal+voiced sequences, as seen in numerous cases of [nd]. What is not acceptable is to violate both constraints at the same time. By conjoining Max-round with a ban on nasal plus voiced stop, and ordering that conjunction above the relevant faithfulness constraints, we get the desired effect.

(63) (*ND ∨ Max(rd))

The tableaus in (64) show how this works. It is in the case of underlying *mų* in the first tableau that the conjunction is relevant. The serious competition is between the last two candidates, one with nasalization and one without. The candidate without nasalization is out because it has violated both halves of the conjunct. In the second and third tableaus, the conjunction is irrelevant, since no round vowel is being deleted, and thus the conjunction cannot be violated.

(64)

	mųb	(*ND ∨ Max(rd))	*mųC, *nįC	Max(rd)	ID-Nas	*ND
	mųb		*!			
☞	mm	(*)		*	*	
	mb	(*) *! (*)		*		*

	nįb	(*ND ∨ Max(rd))	*mųC, *nįC	Max(rd)	ID-Nas	*ND
	nįb		*!			
	mm				*!	
☞	mb	(*)				*

	nb	(*ND ∨ Max(rd))	*mųC, *nįC	Max(rd)	ID-Nas	*ND
☞	mb					*
	mm				*!	

Thus constraint conjunction is one way in OT to handle data that would otherwise be intractable and would therefore refute OT.

3.2.3. TACHONI TONE

The third case involving crucial use of constraint conjunction in disposing of rule ordering comes from the analysis of tone mapping principles in Tachoni, a Bantu language spoken in Kenya. The data in (65) illustrate the tone pattern of verbs which are not inflected with the melodic H, a tense-aspect marker of the language. Underlying H toned vowels are underlined.

(65) *Toneless verbs*

oxu-sy-a	'to grind'	oxu-bal-a	'to count'
oxu-chiing-a	'to carry'	oxu-kaban-a	'to divide'
oxu-karuxasy-a	'to invert'	oxu-chiichakan-a	'to continue'
oxu-yoombool-a	'to spill tr.'	oxu-beechakal-a	'to belch'

H verbs

oxu-bék-a	'to shave'	oxu-téex-a	'to cook'
oxu-búkul-a	'to take'	oxu-fúúndix-a	'to knot'
oxu-bótooxan-a	'to go around'	oxu-ng'ínaang'iny-a	'to shine'

oxu-xámulul-a	‘to strain’	oxu-syáánixil-a	‘to dry at fire’
oxu-fúkirisany-a	‘to agree’	oxu-táángaasy-a	‘to announce’

Verbs in this language come in two varieties: H toned and toneless. If the root is H toned, the H is realized on the first root syllable, as a level H on a long vowel except in penult position, where it is realized as a falling tone. Somewhat exceptional are monosyllabic H verbs, where the lexical H is realized on the pre-stem syllable.

(66)	oxú-fwa	‘to die’	oxú-ha	‘to give’
	oxú-lya	‘to eat’	oxú-nywa	‘to drink’
	oxú-rya	‘to fear’	oxú-ya	‘to be ripe’

This leftward shifting of H is due to a principle shifting H off of the final syllable — the number of contexts where H can appear on a final syllable is very small, and can be explicitly enumerated.

Contrasting with this simple pattern is the pattern exhibited when a melodic H tone is added to the verb, as happens in the near future tense. Examples are given in (67). Boxed data indicate surface forms involving complex interaction between phonological principles.

(67) *Toneless verbs*

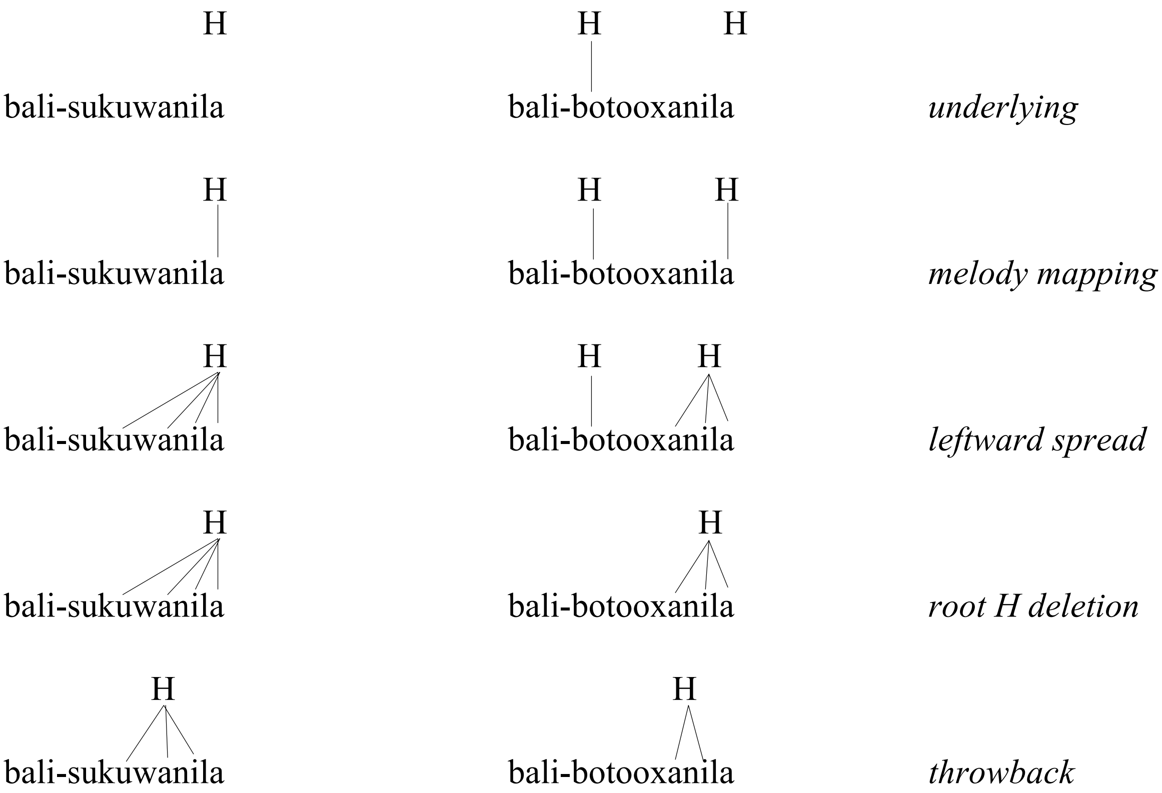
ba-li-sya	‘they will grind’	ba-li-bála	‘they will count’
ba-li-chíínga	‘they will carry’	ba-li-kabána	‘they will divide’
ba-li-chiingána	‘they will carry e.o.’	ba-li-karúxásya	‘they will invert’
ba-li-laambáála	‘they will lie down’	ba-li-chiichákána	‘they will continue’
ba-li-sukúwáníla	‘they will scrape for each other’		

H verbs

ba-li-lya	‘they will eat’	ba-li-beka	‘they will shave’
ba-li-teexa	‘they will cook’	ba-li-bukúla	‘they will take’
ba-li-karáánga	‘they will fry’	ba-li-fuundíxa	‘they will knot’
ba-li-botooxána	‘they will go around’	ba-li-ng’inaang’ínya	‘they will shine’
ba-li-xamulúla	‘they will strain’	ba-li-syaanixíla	‘they will dry at fire’
ba-li-taangáásya	‘they will announce’	ba-li-fukirísánya	‘they will agree’
ba-li-botooxáníla	‘they will go around for’	ba-li-botooxánáníla	‘they will ...for e.o.’

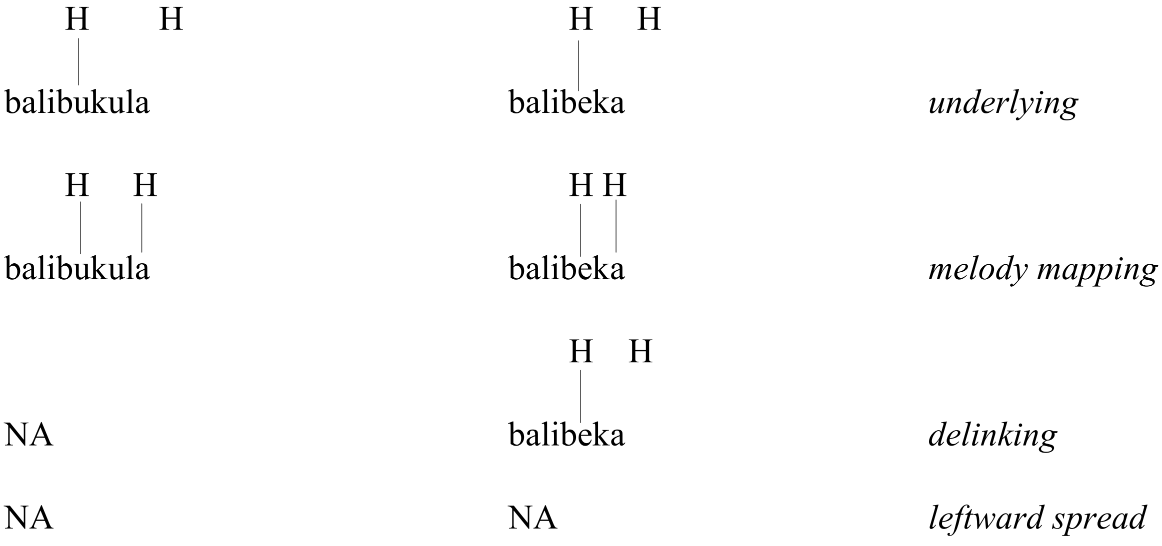
The analysis of this pattern in a derivational account is straightforward. A H tone is assigned to the final vowel as long as that vowel is not also stem-initial, and is later delinked if the preceding syllable has a H tone. Subsequently, the H spreads leftward, stopping at the stem-penitial syllable, or when the preceding syllable has a H tone. Any underlying H in the stem to the left of the melodic H is deleted; finally, H shifts off of the final syllable. The derivation in (68a) illustrates the analysis with a relatively long toneless verb stem, and (68b) does the same for a H stem.

(68) a. ba-li-sukúwáníla 'they will scrape for e.o.' b. ba-li-botooxáníla 'they will go around for e.o'



The difference between trisyllabic and disyllabic H roots is made clear in (69), where we can see that while the melodic H is realized on a trisyllabic stem because at the stage in the derivation where the melodic H is first docked to the final vowel, the two H's in the stem are not on adjacent syllables, whereas in the case of a disyllabic stem, the melodic H is adjacent to the root H and is thus set adrift (or, is prevented from docking in the first place, the choice being empirically insignificant).

(69) a. ba-li-bu̲kúla 'they will take' b. ba-li-be̲ka 'they will shave'



H H
|
balibukula balibeka *root H deletion*

H
|
balibukula NA *throwback*

The analysis of these patterns in OT is challenging, and it must answer one question pertaining to the non-suface nature of these generalizations: how does a deleted H block the basic assignment of melodic H, and why doesn't the deleted H also block leftward shifting of final H? The basic analysis of Tachoni, without concern for rule ordering (opacity), can be expressed via five constraints. The melodic H must be mapped to the stem, due to high ranking of Max-H. Insofar as the H is realized on a sequence of vowels, both right and left alignment are active, but since the melodic H is not actually realized on the initial or final syllables themselves, noninitiality and nonfinality are also active. Nonfinality is only rarely violated, and surface final H's can be disregarded (they can be required by specific constraints when they appear). Stem initial H, on the other hand, is not rare — on the contrary, in lieu of a melodic H, the root H of a verb will appear on the first syllable — and in fact it is only the melodic H which is blocked from initial position in the stem. Therefore, Noninitiality will be restricted to affecting only the melodic H. The tableau in (70) shows how one representative form can be derived.

(70)	balisukuwanila H	Nonfin	Noninit$_{\text{Melodic}}$	MaxH	AL	AR	IdentH
a.	balisukuwanila			*!			
b.	balisukuwanilá	*!			uuai		a
c.	balisukuwaníla				uu!a	a	i
d.	balisúkúwáníla		*!			a	uuai
☞ e.	balisukúwáníla				u	a	uai

Turning to a H toned stem, we also require a constraint prohibiting multiple H tones within the stem, *H...H, in order to motivate deletion of the root H.[13] A strictly surface-oriented approach cannot explain why underlyingly H toned stems block spreading of the melodic H to the second stem syllable in *balibo̱tooxáníla*, not **balibo̱tóóxáníla*; intuitively, this is because there would be an OCP violation, except that the initial syllable is not actually H toned. As with Kikerewe, we can account for this pattern by positing a two-level version of the OCP, one which prohibits a surface H on a syllable that is after a syllable which is underlyingly H toned. Armed with such a constraint, the correct form can be derived.

---

[13] The choice of which tone to delete can be handled by a high ranking stipulation that melodic tones must be parsed.

(71)	balibótooxanila H	*/H/H	*H...H	MaxH	AL
a.	balibótooxaníla		*!		oooa
b.	balibotooxaníla			*	ooo!a
☞ c.	balibotooxáníla			*	ooo
d.	balibotóóxáníla	*!		*	o

An alternative is to employ a sympathy constraint, one which preserves the tones of the best candidate not deleting any H's. Thus the flower candidate *balibótooxáníla*, which is essentially the intermediate form in (68b), has no H on *too*, and therefore the best candidate is one that also has no H on *too*.

(72)	balibótooxanila H	*H...H	Ident(H)$_{\text{Max(H)}}$	*HH	MaxH	AL
a.	balibótooxaníla	*!				oooa
b.	balibótóóxáníla	*!		*		o
❀ c.	balibótooxáníla	*!				ooo
d.	balibotooxaníla		oa!		*	oooa
☞ e.	balibotooxáníla		o		*	ooo
f.	balibotóóxáníla		o oo!	*	*	o

Preservation of the melodic H is, apparently, fairly important in the language, and the relevant constraint must outrank the constraint */H/[H], under the two-level account of the blocking effect of the root initial H. Notice in (73) that the appearance of H on the penultimate syllable results in violation of */H/[H]; the alternative is to block throwback, or to delete the melodic H. Since the melodic H is retained but thrown back to a position right after the underlying root initial H, Max-H for the melodic H must be rather highly ranked.

(73)	balibúkula H	Nonfin	MaxH	*/H/[H]	AR	AL
a.	balibukulá	*!	*			aaa
☞ b.	balibukúla		*	*	a	a
c.	balibukula		**!			

Under the sympathy account, it is crucial that the sympathy candidate allow violation of *HH in order to not violate Nonfinality.

(74)	balibúkula H	*H...H	Nonfin	symp	*HH	MaxH	AL
	balibúkulá	*!	*				**
❀	balibúkúla	*!			*		*
	balibukula			úú!		**	
☞	balibukúla			ú		*	*

The problem which OT faces in accounting for the facts of Tachoni is that preservation of the melodic H is not completely inviolable: in particular, melodic H is simply deleted in disyllabic H roots (*balibeka* "they will shave"). Under the two-level account of the opaque effect of the root initial H, the wrong candidate is chosen — one with a penult H tone.

(75)		balibéka H	Nonfin	MaxH	Noninit$_{\text{Melodic}}$	*/H/[H]	AR	AL
☜	a.	balibeka		*!*				
	b.	balibeká	*!	*		*		e
💣	c.	balibéka		*	*		a	
	d.	balibéká	*!		*	*		

One might attempt to solve the problem by absolutely preventing the melodic H from ever appearing root initially, but this will not work, since in fact from a toneless root CVC root, root initial H is actually possible, viz. *balibála* “they will count”. Thus noninitially is a violable constraint.

The problem can be easily identified, and the bad candidate can be ruled out, once one notices that the incorrectly derived form **balibéka* both violates noninitiality and deletes a H tone (the root H), whereas *balibála* only violates noninitiality — that is, one cannot both violate noninitiality and Max-H, a concept expressed in (76) by constraint conjunction.

(76)		balibéka H	MaxH ∨ Noninit$_{\text{Melodic}}$	Nonfin	MaxH	Noninit$_{\text{Melodic}}$	*/H/[H]
☞	a.	balibeka			**		
	b.	balibeká		*!	*		*
	c.	balibéka	*!		*	*	
	d.	balibéká		*!		*	*

Thus, the ability to capture the logical notion “not (A and B)” proves crucial in stating rule ordering generalizations within OT.

3.3. Abstract operational domains

Another device to be called on to dispose of derivational concepts is the reified domain, relevant for data from Makonde (a Bantu language of Tanzania and Mozambique). The concept “domain” is a general one applicable to mathematical functions and linguistic operations alike, meaning roughly “the set of things that a rule can apply to”. Applied to phonology, “domains” have been construed as abstract constituent structures that are posited to account for restrictions on substrings which do or do not undergo a phonological process. Certain domains have achieved favor (though not universal acceptance), e.g. the syllable or the foot, and are presumably part of a restricted set of universal domains. Here we analyse vowel reduction in Makonde (a Bantu language spoken in Tanzania and Mozambique, discussed in Liphola 1999), where the notion ‘domain’ can resolve problems of rule application in an OT account — in this case the notion of ‘domain’ does not correspond to any motivated phonological constituent, and its sole function is to serve as an instruction to reduce a sequence of mid vowels.

In Makonde, unstressed mid vowels optionally reduce to [a] — stress is regularly on the penultimate syllable. Thus when the vowels of the roots *tot* and *tep* are in the penultimate syllable and are therefore stressed, they cannot be reduced, but when some affix follows the root, the root vowel is unstressed, and reduction of the mid vowel is possible.

(77)	kú-tóót-a		(*kú-táát-a)	‘to sew’
	kú-tót-áán-a	~	kú-tát-áán-a	‘to sew each other’
	kú-tót-ááng-a	~	kú-tát-ááng-a	‘to sew repeatedly’
	kú-téép-a		(*kú-táàp-a)	‘to bend’
	kú-tép-áán-a	~	kú-táp-áán-a	‘to bend from e.o.’
	kú-tép-ááng-a	~	kú-táp-ááng-a	‘to bend repeatedly’

The data in (78) further show that the high vowels do not reduce.

(78)	kú-píít-a	‘to pass’	kú-púút-a	‘to wash’
	kú-pít-áán-a	‘to pass each other’	kú-pút-áán-a	‘to wash each other’
	kú-pít-ááng-a	‘to pass repeatedly’	kú-pút-ááng-a	‘to wash repeatedly’

The motivating force behind this vowel reduction is presumably the markedness constraint against mid vowels. One way to eliminate mid vowels is to raise them to high vowels; this repair strategy can be ruled out by positing that preservation of the specification [-hi] is high-ranked, and therefore the remaining strategy of deleting the vowel’s place specification is forced. The fact that only unstressed vowels may reduce is the result of a high-ranking of the constraint requiring faithfulness of stressed syllables to underlying place specifications, and this constraint will not be considered further.

(79) *Mid Max(place) Max(-hi)(mid vowels cannot raise)

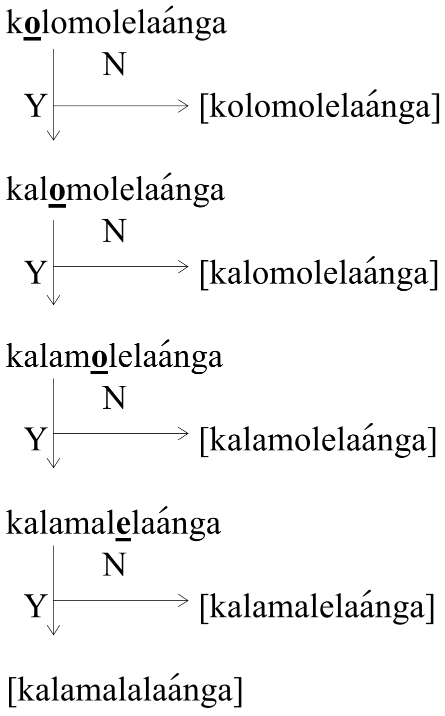
	kútépáána	*Mid	Max(-hi)	Max(place)
	kútépáána	*!		
	kútípáána		*!	
☞	kútápáána			*

While vowel reduction is optional, there is a strict pattern to exercising the option. Reduction begins at the left edge of the stem, and affects any number of vowels, but once reduction has stopped, it is impossible to restart the process. None of the patterns in (b) are possible, since they involve reducing a vowel after reduction has stopped its left-to-right scan.

(80)	a.	kolomolelaánga	‘cough for (repeated)’
		kalomolelaánga	kalamolelaánga
		kalamalelaánga	kalamalalaánga
	b.	*kolomolalaánga	*kolomalalaánga
		*kolamalalaánga	*kalomalalaánga
		*kalomolalaánga	*kalamolalaánga

This has a simple explanation in derivational theory. Beginning at the leftmost point, one has the option of either applying the rule, or stopping. If at a given stage, the choice is made to stop, this generates a phonetic form where all preceding mid vowels are reduced. The choice to stop can be made at a number of points in the string, thus there are a number of outputs.

(81)



How can this pattern be derived under the assumptions of OT? The first thing to deal with is the fact that for a single input there are many outputs. As (82) makes clear, there is a trading relation between satisfying the ban on mid vowels and satisfying the faithfulness condition on preservation of vowel place. Since any improvement in a form in terms of decreasing the number of mid vowels is paired with loss of place, there is a perfect stalement between these two constraints, as long as they are unranked.

(82)	kolomolelaánga	*Mid	Max-place
☞	kolomolelaánga	****	
☞	kalomolelaánga	***	*
☞	kalamolelaánga	**	**
☞	kalamalelaánga	*	***
☞	kalamalalaánga		****

However, as (83) also makes clear, there are many other patterns of vowel reduction which result in exactly four stars across the two columns, and not all of these forms are good.

(83)	kolomolelaánga	*Mid	Max-place
👎	*kolomolalaánga	***	*
👎	*kolomalalaánga	**	**
👎	*kolamalalaánga	*	***
👎	*kalomolalaánga	**	**
👎	*kalomalalaánga	*	***

To resolve this, we can attack the problem structurally by constructing a kind of abstract ‘domain’, especially if we assume a model like Optimal Domains Theory (however, this use of ‘domain’ departs from observed usage in that theory, and should not be taken to imply that this *is* an analysis within ODT). Here, the function of the domain is simply to be a diacritic structure wherein mid vowels are required to reduce, via the constraint $*\text{Mid}_{\text{r-d}}$ which prohibits mid vowels within the R-D constituent. By tying the occurrence of reduction to the structure of this domain, and by judiciously constraining the edges of the domain, we can derive the observed pattern of vowel reduction. As spelled out in (84), the domain is absolutely aligned to the left edge of the stem, and the right end of the domain can be any position after that. The pattern of optionality in reduction then reduces to different sizes of reduction domain, each of which is equally good.

(84)	kolomolelaánga	A(r-d,l,stem,l)	$*\text{Mid}_{\text{r-d}}$	A(r-d,r,stem,l)	A(r-d,r,stem,r)
☞ a.	()kolomolelaánga				kolomolelaanga
☞	(ka)lomolelaánga			ka	lomolelaanga
☞	(kala)molelaánga			kala	molelaanga
☞	(kalama)lelaánga			kalama	lelaanga
☞	(kalamala)laánga			kalamala	laanga
b.	kolomo(la)laánga	ko!lomo			
	kolo(mala)laánga	ko!lo			
	ko(lamala)laánga	ko!			
	(ka)lomo(la)laánga	ka!lomo			
	(ka)lo(mala)laánga	ka!lo			
c.	*(kalomola)laánga		*!*		
	*(kolomola)laánga		*!**		
	*(kolomala)laánga		*!*		
	*(kolamala)laánga		*!		

The candidates in (84a) are all acceptable, since the left edge of the structure is absolutely at the left edge of the stem, and there are no mid vowels within the structure. In the group of bad candidates in (b), reduction follows nonreduction, and these forms can be ruled out because a domain structure is not left-aligned with the left edge of the stem. In the final group of bad candidates, in (c), the reduction structure is perfectly aligned to the left edge of the stem, but not all mid vowels within the domain are reduced. By judicious use of such a structure, one can handle the problem posed by the pattern of iteration found in Makonde vowel reduction. The question to be asked is whether it is a good thing to adding such devices as process-triggering domains to the arsenal, when they have no independent justification or function in the language and do not correspond to phonological entities justified in other languages.

4. Sympathy and Duke of York Derivations

McCarthy 1997 claims that Sympathy Theory is more restrictive in precluding Duke-of-York derivations of the form A→B→A, where a form is first changed, and later the changed property is restored. In a modification of Classical Sympathy intended to address a counterexample to this claim, McCarthy 1999 sets forth Extended Sympathy Theory, introducing the concept of ‘Cumulativity’, which is the requirement that the sympathetically successful output must accumulate all of the IO faithfulness violations of the sympathy candidate. This section revisits the data from Zinza discussed in section 3.2.1 and explores the issue of inheritance of faithfulness violations, with respect to the derivation of the form /akanywá Seengelema/ → *akanywa Seengelema* → [akanywá Seengelema]. We will see that EST is identical to derivational theory in important ways in its ability to reconstruct such derivations.

McCarthy 1997, 1999 emphasizes the supposed impossibility of so-called Duke of York derivations in OT. Suppose that we have a derivation such as (85).

(85)	/ABC/	
	ADC	(B → D / __ C: Underlying /B/ can condition the next rule)
	EDC	(A → E / __ D: The rule applies)
	EBC	(D → B / E__: Then the segment is turned back into a B)

The problem is explaining why /A/ changes to [E] when the motivating segment, [D], is not actually found on the surface. With sympathy theory, a solution might be essayed by making reference to a sympathetic candidate *EDC*, where the trigger segment [D] is actually found. But to be identified as the sympathy candidate, *EDC* must be the best candidate satisfying the selector constraint, which McCarthy stipulates must be an IO Faithfulness constraint; therefore this supposed sympathy candidate *EDC* must be more like *ABC* than another imaginable sympathy candidate *EBC*. But obviously *E**B**C* would be more faithful to the input than *E**D**C*, and therefore *E**D**C* could *not* be identified as the sympathy candidate. To the extent that the sympathy candidate is a reconstruction of an intermediate derivational stage, the sympathy candidate and therefore the intermediate form *EDC* cannot exist, and DY derivations are impossible in OT.

Kiparsky 1998 shows that some DY derivations *are* theoretically possible in Sympathy Theory, and reconstructs a hypothetical Duke of York derivation in OT, using Sympathy Theory. The derivation is given in (86). The crux of this example is that the winning candidate is fairly similar to the sympathy candidate, and is actually closer to the input, in terms of IO faithfulness, than the sympathy candidate is.

(86)	/maat/	
	maati	Epenthesis (repair trimoraic syllable)
	maači	Palatalization
	maač	Final apocope
	mač	Shortening (another trimoraic syllable repair)

As seen in (87), from a sympathy candidate *maači*, the surface form [mač] can be selected over the competitor **mat* by requiring consonantal identity with the sympathy form. It is a simple matter to identify *maači*, since that is the best candidate which preserves all input moras.

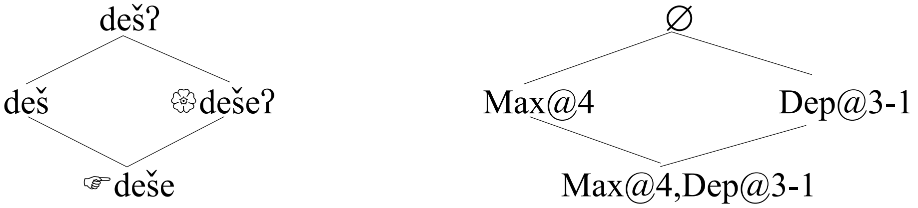
(87)

	maat	*μμμ]$_\sigma$	*ti	❀Ident(hi)	Ident(hi)	Dep-V	★Max-μ
	mat			*!			*
❀	maači				*	*!	✓
☞	mač				*		*
	maat	*!		*!			✓
	maati		*!	*!		*	✓
	maač	*!			*		✓

While no language is given with this property, this demonstrates that DY derivations are not entirely out of the reach of OT.

In response to this challenge to the claim of restrictiveness, McCarthy 1999 modifies ST based on the concept of 'cumulativity of unfaithfulness'. In this revision, a critical prerequisite for being judged successful in terms of similarity to a sympathy candidate is that every faithfulness violation of the sympathy candidate must also be found in the winning candidate. This requires not just keeping track of, for example, how many Ident-IO violations there are in a candidate, but also the exact location of the violations. The classical case of Tiberian Hebrew /dešʔ/ → [deše] is graphically represented as in (88).

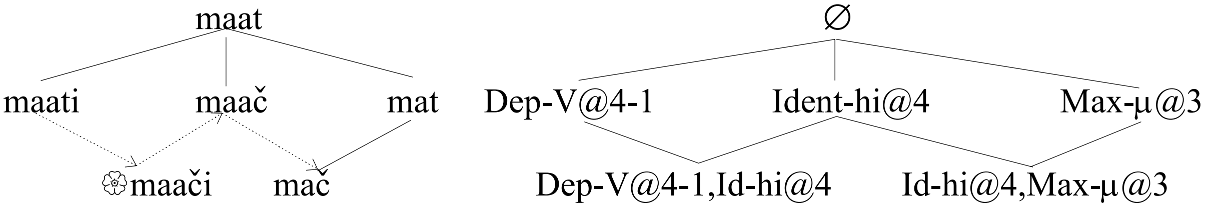
(88)



Here, *deš* has violated Max at input segment 4 (by deleting the glottal stop), and the flower candidate *dešeʔ* has violated Dep by inserting *e* to the right of segment number 3 (notated as Dep@3-1). The actual output form *deše* inherits the Dep@3-1 violation of *dešeʔ* plus adds the violation Max@4: in contrast, the candidate *deš* fails to inherit the violation Dep@3-1 from the sympathy candidate, and thus is excluded. That is, *deš* does not accumulate the unfaithfulness of the flower candidate *dešeʔ*, because it does not have the unfaithful epenthetic vowel.

Turning to the attempted DY derivation of *mač* from /maat/, (89) shows that the desired output candidate *mač* has the faithfulness violation Ident-hi@4 in common with the sympathetic candidate, plus the violation Max-μ@3. However, neither the desired output nor the near competitor *mat* inherit from *maači* the violation Dep-V@4-1, that is, it does not retain the epenthetic vowel, and thus in McCarthy's terms these candidates are *non-comparable* to the flower candidate.

(89)



Since neither *mač* nor *mat* have inherited all of the faithfulness violations of *maači* (lacking the epenthetic vowel), *mač* and *mat* cannot be distinguished in terms of faithfulness to the sympathy candidate, and indeed all candidates other than the flower candidate itself fails sympathy. Thus sympathy cannot be called upon to emulate this DY derivation, it is claimed.

4.1. The DY derivation of Zinza

We now return to Zinza tone sandhi, which involves the interaction of a rule deleting phrase-medial H in (90a), and a rule adding H to the end of a toneless word before a toneless word in (90b), with the interaction of these processes seen in (90c).

(90) a. akatéeka Géeta → akateeka Géeta ‘he cooked in G’
b. akalima Seengelema → akalimá Seengelema ‘he cultivated in S’
c. akatéeka Seengelema → akateeká Seengelema ‘he cooked in S’
akamúlimila Seengelema → akamulimilá Seengelema
‘he cooked for him in Sengerema’

We have seen in 3.2.1 that these data cannot be accounted for with Classical Sympathy Theory. Extended Sympathy Theory, on the other hand, can capture the relevant distinction, since the actual output has a property in common with the flower candidate, namely the specific loss of input H on the prefix *mu*.

(91) /$a_1k_2a_3m_4\acute{u}_5l_6i_7m_8i_9l_{10}a_{11}$ Seengelema/

	akamúlimila Seengelema	*L#L	❈*H#+	❀Sym	IO Faith	AR(H)
❀$_{*H+}$	*akamulimila Seengelema	*!			/ú/	
	*akamúlimila Seengelema		*	*$\aleph_0$![14]		i i a
☞	akamulimilá Seengelema		*	{Dep$_{11}$}	/ú/ /a/	

IO-faithful **akamúlimila Seengelema* is rejected by the sympathy constraint, precisely because it *is* IO-faithful, in not sharing the loss of the lexical H tone. Note, incidentally, that the sympathy candidate is the best (only) candidate satisfying the constraint against phrase medial H tone, which indicates, following Ito & Mester 1999, De Lacy 1999, that not all sympathy-selectors are faithfulness constraints.

Now consider the examples in (92), with underlying H’s on the last two syllables. This form would seem to be a problem for a sympathy account, since the surface H is realized on a syllable with an underlying H, so this would seem to be a retreat in unfaithfulness that is not supposed to be allowed.

(92) /aka-mú-pá/ → aka-mú-pa ‘he gave him’
aka-mú-pá bukoko → aka-mu-pá bukoko ‘he gave him grey spotted bananas’

The problem is clear in tableau (93).

(93)

	akamúpá bukoko	*L#L	❈*H#+	❀Sym	IO Faith	AR(H)
❀$_{*H+}$	akamupa bukoko	*!			/ú/ /á/	
💣	*akámupa bukoko		*	{Dep$_3$}	/ú/ /á/ /a/	u a
	akamúpa bukoko		*	*$\aleph_0$!	/á/	a
☜	akamupá bukoko		*	*$\aleph_0$!	/ú/	

The phonetically occurring form *akamupá bukoko* should be rejected by the sympathy constraint because it apparently does not share with the sympathy candidate the loss of input H on

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[14] The number of stars assigned to a candidate violating the sympathy constraint is, according to McCarthy, greater than the number assigned to the worst “conforming” candidate, i.e. candidate inheriting all of the faithlessness of the flower candidate. Intuitively, that means that an infinite number of stars is assigned, since there is no upper limit on the length of the worst conforming candidate (and each added segment increases the number of stars). It is generously assumed that the length of the worst candidate is countable, in the technical sense, and thus has size $\aleph_0$, but verification of this assumption requires mathematical proof.

the final vowel, and this would lead to incorrect selection of **akámupa bukoko* where the inserted H is only slightly misaligned by being inserted on the rightmost vowel which doesn't have an underlying H tone. A bit more analysis shows that *akamupá bukoko* need not be rejected as constituting a retreat in faithlessness.

Although there is a H on the last vowel of the verb in the output, just as there is in the input, that doesn't mean that the two H's are the same H's. If we analyse the final H as being not the retention of the underlying H, but rather the replacement of one underlying H with a different H, then we escape the disasterous sympathy-consequences noted in (93). The successful derivation of this form requires distinguishing two phonetically identical candidates, one where the underlying token of H is directly preserved, and another where the underlying H is missing and a different H is inserted.[15] The former candidate incurrs the full wrath of violating the sympathy constraint, whereas the latter candidate only suffers the rather mild consequence of adding a H not found in the sympathy candidate.

(94)	akamúpá bukoko	*L#L	✵*H#+	❀Sym	IO Faith	AR(H)
❀$_{*H+}$	akamupa bukoko	*!			/ú/ /á/	
	akámupa bukoko		*	{Dep$_3$}	/ú/ /á/ /a/!	u a
	akamupa bukoko H_{input}		*	*$\aleph_0$!	/á/	a
☞	akamupa bukoko $H_{inserted}$		*	{Dep$_7$}	/ú/ /á/	

The finger candidate wins in the competition against the one with an antepenultimate H because of differences in IO Faithfulness as well as rightward alignment. This provides a case where a DY derivation is not beyond the reach of OT, any more than it is in derivational theory, and, since such a relation actually exists in Zinza, this would be a desireable result for OT.

Zinza provides independent phonological evidence for distinguishing H tones which are present in underlying representations from H's which are inserted in response to some constraint, and those phonological tests show that the correct analysis must indeed be one where an underlying H is replaced with an epenthetic H. To see this evidence, we will look at some details of the tone system of Zinza. The essence of the argument is as follows. A H on either of the last two moras of the word spreads bidirectionally to the penult and final moras, as long as the final syllable is not prepausal. However, an inserted H does not spread: then, using the test of tone spreading, the surface H in *akamupá bukoko*, from /akamúpá bukoko/, must be an inserted H tone, not a preserved underlying H tone, since it does not spread to the penult.

4.2. Tone Doubling and Penult H Tones

As in many Bantu languages, verbs in Zinza may be inflected with a floating melodic tone in certain tenses — see Hewitt & Crowhurst 1998 for an OT analysis of the cognate process in Zezuru Shona, and Poletto 1998 for closely related Runyankore. In Zinza (as in Runyankore and Shona), the position where this H is realized depends on whether the verb stem has an underlying H tone, or is underlyingly toneless. If the verb is toneless, the melodic H is realized on the second mora of the stem (as long as that is not the word-final syllable, in which

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[15] Specifically, the inserted H has no input correspondent whereas the retained H corresponds to the input H.

case the H is realized on the initial mora). The underlying tone of the stem is revealed in the infinitive, and the habitual is one tense exhibiting this melodic H tone.

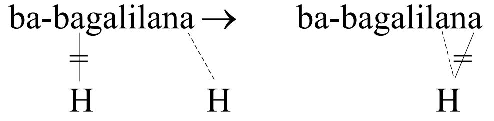
(95)	ku-lima	‘to cultivate’	ba-líma	‘they cultivate’
	ku-limila	‘they cultivate for’	ba-limíla	‘they cultivate for’
	ku-limiana	‘to cultivate for e.other’	ba-limílana	‘they cultivate for e.other’
	ku-libatilana	‘they tread for e.o.’	ba-libátilana	‘they tread for e.o.’

If the stem is underlyingly H toned, the melodic H appears on the surface penultimate syllable — the underlying H is deleted, since only a single H may appear within the stem.

(96)	ku-bóna	‘to see’	ba-bóna	‘they see’
	ku-bónana	‘to see each other’	ba-bonána	‘they see each other’
	ku-témelana	‘to chop for e.o’	ba-temelána	‘they see for e.o’
	ku-bágalila	‘to weed for’	ba-bagalíla	‘they weed for’
	ku-bágalilana	‘to weed for e.o’	ba-bagalilána	‘they weed for e.o.’

Despite the fact that the H surfaces on the penultimate syllable, it can be argued that the H is assigned to the final syllable and is shifted to the left, by a process shifting any word-final H to the left. Thus the derivation would be as in (97).

(97)



The evidence for assigning the melodic H to the final syllable and shifting it to the left, rather than directly assigning it to the penult, is the fact that H has a different phonetic realization when it is directly assigned to a long penult than it has when a long penult receives H by shifting. A H which is underlyingly on a long penult is realized as a fall. Thus consider the following lexically H toned roots, where the H is underlyingly on the first syllable of the stem.

(98)	ku-téeka	‘cook’
	ku-yéela	‘go strolling’
	ku-kwáata	‘touch’

Similarly, if a melodic H tone is assigned to a long syllable, it is realized as a falling tone, as in the following example of toneless CVCVVCV stems in the habitual.

(99)	*Infinitive*	*3pl. habitual*	
	ku-holoota	ba-holóota	‘snore’
	ku-baziila	ba-bazíila	‘sew’
	ku-fukaana	ba-fukáana	‘wrestle’

In a derivational account, one would assume a rule which shifts a H tone exclusively to the first mora of a long, H-toned penult.

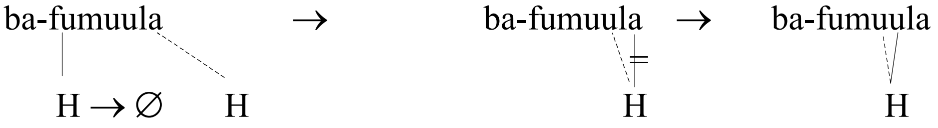
In contrast, a H assigned to the final syllable but retracted to the penult is realized as a level H.

(100)

Infinitive	*3pl. habitual*			
ku-téeka	ba-téékа	←	ba-teeká	'cook'
ku-yéela	ba-yééla	←	ba-yeelá	'go strolling'
ku-kwáata	ba-kwááta	←	ba-kwaatá	'touch'
ku-fúmuula	ba-fumúúla	←	ba-fumuulá	'argue'
ku-búúbuuta	ba-buubúúta	←	ba-buubuutá	'blow on a fire to ripen bananas'

The melodic H would be assigned to the final syllable, and causes deletion of the preceding lexical H. After application of the rule creating falling tones on H toned long penults, the final H is shifted to the penultimate syllable, where it is realized as a level H tone.

(101)



There is further evidence for a process that shifts final H to the penult. Noun class prefixes are underlyingly toneless, as can be seen in the examples on the left in (102). Just in case the following CV stem is lexically H toned, the H shifts from the final syllable to the penult: if that syllable is long, the H surfaces as level H.

(102)

Class 3	omu-lilo	'fire'	omú-bu	'mosquito'
Class 5	ii-po	'maize cob'	íí-hwa	'thorn'
Class 6	ama-po	'maize cobs'	amá-hwa	'thorns'
Class 9	een-te	'cow'	één-da	'louse'

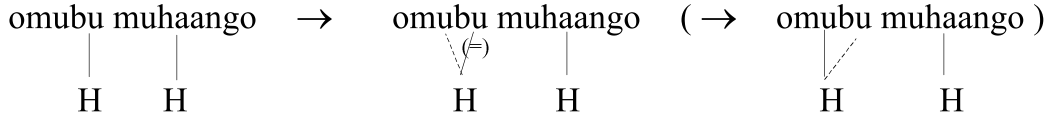
We now turn to the phrase-medial realization of an underlying H tone, either a H lexically linked to the final syllable or a melodic H assigned to the final syllable. The examples in (103) show that the underlyingly final H is realized on the penult and final syllables in utterance-medial position.

(103)

omuuntu	'person'	omúbu	'mosquito'
omuuntu muháango	'large person'	omúbú muháango	'large mosquito'
enyémela	'antelope'	éémbwa	'dog'
enyémelaa mpáango	'large antelope'	éémbwáá mpáango	'large dog'

The analysis of these data is somewhat ambiguous, but the central point is clear, namely that when a word with an underlyingly final H tone is utterance medial, the final H appears on both the final and penult syllables. As we have already seen, word final H tone shifts to the penult; these data indicate either that shifting should be decomposed into leftward spreading from word final syllables plus utterance final delinking, or shifting from word final syllables plus rightward spread from penult to final in utterance medial position.

(104)



A melodic H assigned to the final syllable in a H toned verb also undergoes this same process. It is necessary to either select a verb tense where the phrasal process of H deletion does not apply — the negative habitual is such a tense. The data in (105) are examples of the negative habitual of H toned verbs.

(105)	tibatééka	‘they don’t cook’
	tibatééká maláaya	‘they don’t cook malaaya’
	tibabóna	‘they don’t see’
	tibabóná Seengelema	‘they don’t see Sengerema’
	tibasigála	‘they don’t remain’
	tibasigálá Seengelema	‘they don’t remain in Sengerema’

The data in (106) are analogous in that for reasons of the syntactic context for deleting H in verbs, a verb followed by a postposed subject does not undergo H deletion. These examples that show that phrase final, utterance medial affirmative verbs which do not lose their H tone similarly spread the final H to the penult.

(106)	atééka	‘he cooks’
	atééká Bulemo	‘Bulemo cooks’
	asigála	‘he remains’
	asigálá Bulemo	‘Bulemo remains’

There is further evidence that if a H tone ends up on the penultimate mora, it will spread to the right in utterance medial context. The perstitive tense is one of those tenses which are not subject to deletion of H tone phrase-medially. As can be seen in the following data, if the verb stem is lexically H toned, that H appears exclusively on the stem-initial mora, except that if that mora is also the penultimate mora, the H spreads to the final syllable as well.

(107)	tucháá-kúlatila	tucháá-kúlatila chaasa	‘we are still following (a chaasa)’
	tucháá-fúlula	tucháá-fúlula maláaya	‘we are still transplanting (malaya)’
	tucháá-téeka	tucháá-téeka bukoko	‘we are still cooking (bukoko)’
	tucháá-kóma	tucháá-kómá bihógo	‘we are still tying (a red cow)’

This provides independent evidence for the process spreading H from penult to final, showing that such alternations are not found exclusively in the context where final H shifts to the penult.

To summarize the details of final and penult H tone in phrase medial position, we have seen that if a H tone is on an utterance-medial word-final vowel, either because the vowel has an underlying final H, or because the melodic H suffix is assigned to the final vowel, then that H will be realized on the surface on both the final and penultimate syllables. However, these processes do not affect the H tone which is assigned at the phrasal level before a toneless modifier, cf. *kulimá bukoko* ‘to cultivate bukoko’ (**kulímá bukoko*).

The relevant distinction is not hard to make in OT. In the two cases where word final H spreads to the penult, the H tone is underlyingly present, either associated to the final vowel (in the case of /omu-bú/ → [omúbu] ~ [omúbú...]), or not associated and just present as a floating H tone suffix, to be mapped to a specfic vowel of the stem by appropriate constraints. In the one case where final H does not spread to the penult, that H tone is not underlyingly present, and is inserted only in response to constraints. In other words, singly linked input-present H tones are disallowed in both the final and penult moras.[16]

(108) Nonfinality $\begin{array}{cc} & *\mathrm{H}_{\mathrm{in}} \\ & | \\ \mathrm{V} & \mathrm{V}_{\omega}] \end{array}$ Nonpenultimacy $\begin{array}{cc} *\mathrm{H}_{\mathrm{in}} & \\ | & \\ \mathrm{V} & \mathrm{V}_{\omega}] \end{array}$

These data remind us that a distinction which can be made in OT is between properties found in the input versus ones not found in the input, as encoded in two-level constraints.

Since we now have a diagnostic for distinguishing H tones which are present in the input versus ones inserted in order to satisfy a constraint, we can return to the central question of the DY derivation /aka-lyá bukoko/ → *akalya bukoko* → [akalyá bukoko] 'he ate bukoko'. This derivation seemed to be problematic, given that there is a word-final H tone in the input, no final H in the intermediate stage (sympathetic candidate), but there is a final H on the final vowel in the output. With our diagnostic for distinguishing input H's from inserted H's (i.e. whether the final H spreads to the penult), we can now see that the surface H is not a 'restoring' of the input H, but, just like in the derivational account, is a totally separate H. As such, the output form shares with the sympathetic candidate the loss of the input H, and thus does not incur a fatal violation of the sympathy constraint due to non-cumulativity.

(109)	akalyá bukoko	*L#L	✵*H#+	❁Sym	IO Faith	AR(H)
	akálya bukoko		*	{Dep_3}	Max_6,Dep_3	a!
☞	akalyá bukoko		*	{Dep_6}	Max_6,Dep_6	
❁	akalya bukoko	*!			Max_6	

Thus at least this kind of DY derivation is not beyond the reach of OT, any more than it is in derivational theory.

4.3. A DY derivation in Kimatuumbi

Kimatuumbi provides another DY derivation, the crux of which centers around the interaction of three processes, one being a rule that shifts final H tone to a preceding long vowel, one shortening long vowels in a word which is followed by a modifier, and one being Glide Formation, which compensatorily lengthens the following vowel. The interaction between Glide Formation and phrasal shortening is surface opaque, since long vowels derived by applying GF do not undergo shortening. This might suggest that somehow vowel shortening is

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[16] It is immaterial whether these two constraints are collapsed into one, or whether abstract foot structure is invoked; it also does not matter whether there is a single phonological principle at work, or two accidentally similar ones.

blocked from applying just in case Glide Formation has applied.[17] However, tone retraction provides independent evidence that what really happens is that the long vowel is shortened, and is then re-lengthened as a side effect of glide formation. The evidence for this is the fact that tone retraction is sensitive to vowel length: final H is retracted only to a long vowel, and when an underlyingly long vowel is shortened, tone retraction no longer takes place. The crucial DY derivation is found in forms such as /mu̧-eembé waángu/ which surfaces as [mweembé waángu] “my mango”, in contast to the citation form [mweémbe] “mango” where shortening does not take place, and final H is retracted. Failure of retraction in [mweembé waángu] can only be explained via the intermediate form [mu̧-embé waángu], where there is no long vowel. Thus, /mu̧-eembé waángu/ → *mu̧-embé waángu* → [mw-eembé waángu].

The first process to be motivated is the phrasal Shortening process (Odden 1987, 1990, 1996) which shortens long vowels in words followed by modifiers illustrated with nouns (110a), verbs (110b), and adjectives (110c).

(110)	a.	ki̧kól[oo]mbe	‘cleaning shell’
		ki̧kól[o]mbe chaángu	‘my cleaning shell’
		mi̧k[aá]te	‘loaves’
		mi̧k[a]té mi̧kúlu mi̧kúlú	‘large loaves’
	b.	naan-kál[aa]ng[i̧i̧]le	‘I fried for him’
		naan-kál[a]ng[i̧]le Mambóondo	‘I fried for Mamboondo’
	c.	nn[aá]so	‘long (sg.)’
		mi̧l[a]só mi̧laáso	‘long (pl.)’

This alternation can be derived by a rule shortening vowels in the head of XP, or via a constraint prohibiting long vowels in the head of XP.

(111) **Shortening**

$$*\underset{\mu\;\;\mu}{\sigma}\quad]X\quad [...]\quad]X^{MAX}$$

The second process is Glide Formation, which desyllabifies a high vowel before a vowel. The data of (112) show this process applying to the combination of a noun class prefix plus a vowel-initial prefix, with the examples on the left showing the underlying vowel before a consonant-initial stem.

(112)	l[i̧]-ku̧n’u̧ú̧nda	‘filtered beer’	l[y-oo]wá	‘beehive’
	k[i̧]-kálaango	‘frying pan’	k[y-u̧ú̧]lá	‘frog’
	[i̧]-kálaango	‘frying pans’	[y-u̧ú̧]lá	‘frogs’
	l[u̧]-toóndwa	‘star’	l[w-aa]té	‘banana hand’

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[17] Thus constraint conjunction might be invoked, preventing simultaneous violation of those constraints which are characteristic of the application of GF and shortening.

Evidence for compensatory lengthening due to glide formation is seen in (113), where the form on the left shows the underlying short vowel either word initial or after the vowel *a*, and the forms on the right showing a long vowel just in case glide formation applies.

(113)	[a]té	‘banana hands’	lw-[aa]té	‘banana hand’
	ka-[ų́]lá	‘small frog’	ky-[ųų́]lá	‘frog’
	[į]pukú	‘rats’	tw-[įį́]pukú	‘little rats’

The data in (114) further show that stems may have underlying initial long vowels, and that the underlying long/short distinction is neutralized when Glide Formation applies.

(114)	[eé]mbe	‘mango fruit’	mw-[eé]mbe	‘mango tree’
	ma-[ée]ke	‘storage structures’	ly-[ée]ke	‘storage structure’
	[eé]la	‘money’	mw-[eé]la	‘in money’

Since Glide Formation creates long vowels, and Shortening shortens vowels, we want to know how these processes interact. (115) shows that Shortening does not apply to the output of Glide Formation.

(115)	ly-[oo]wá lįnaántopá	‘heavy beehive’	← /lį-owá lįnaántopá/
	ky-[ųų́]la chaángu	‘my frog’	← /kį-ų́la chaángu/

This is explained derivationally by ordering Shortening before Glide Formation. In OT, this can be handled by conjoining Max-μ and Ident-μ, the idea being that Glide Formation changes the moraic identity of the prevocalic high vowel (thus signals application of GF), and Shortening results in violation of Max-μ, so that the statement “do not apply GF and then Shortening” translates into the conjunction “do not violate Max-μ and Ident-μ”.[18]

The process of Heavy Retraction can be seen at work in the data of (116a-b). These examples are verbs in the subjunctive, where a H tone is assigned to the third stem mora, as seen in (a). The examples in (b) illustrate the case where the third mora is word final and is also preceded by a long vowel.

(116)	a.	ų-lyé	‘you should eat’	ba-temé	‘they should chop’
		n-teleké	‘you (pl.) should cook’	ų-lindiíle	‘you should guard’
		į-n’alan’áate	‘it should shine’	ų-bųųndáye	‘you should blunt’
	b.	ų-kaáte	‘you should cut’	ų-toóle	‘you should take’

The appearance of H on the second mora, rather than the expected third, can be explained by assigning the H to the third mora, as expected, resulting in a final H (viz. intermediate *ųkaaté*), and then retracting that H to the preceding long vowel, via a rule of Heavy Retraction. In addi-

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[18] This approach actually does not work so simply, since Shortening can apply to the output of Glide Formation, as in the case of /ák-į-an-a įtúumbili/ → *ák-y-aan-a įtúumbili* → *ák-y-an-a įtúumbili* “to net-hunt monkeys for each other”. The problem can be resolved by applying Glide Formation cyclically, in which case the derived vowel length in the case of *ákyaana* would already be in place when phrasal shortening is encountered. We will disregard this problem here.

tion to explaining alternations such as those in (116), Heavy Retraction explains why a final H tone cannot (generally) be preceded by a long vowel.

Further evidence for Heavy Retraction, and data demonstrating the interaction between Shortening and Heavy Retraction, can be found in (117). These nouns have a penultimate rising tone — a surface anomaly since generally long vowels with H tone in nouns have falling tone and not rising tone. We can see from the forms on the right that the H tone is underlyingly on the final syllable, and that it shifts to the left just in case it is preceded by a long vowel. If, however, the vowel is shortened because of phrasal Shortening, then the final H remains in its orginal position.

(117)	mboópo	“machete”	mbopó yaángu	“my machete”
	makoóndį	“fists”	makondį́ átatų	“three fists”
	eémbe	“mango fruit”	embé yaangu	“my mango fruit”

Thus, [mboópo] derives from /mboopó/ via Heavy Retraction; phrase-medially, /mboopó yaangu/ undergoes shortening, which bleeds Heavy Retraction.

A long vowel which is created by Glide Formation does not trigger application of Heavy Retraction. This is shown by the examples of (118), where the form on the left presents surface failure of Retraction, and the form on the right motivates the underlying short vowel.

(118)	ly-oowá ← /lį-owá/	‘beehive’	ma-owá	‘beehives’
	ky-iikí ← /kį-ikí/	‘stump’	ka-ikí	‘little stump’

Now we come to the three-way interaction between Heavy Retraction, Glide Formation, and Shortening. We know that Shortening precedes Glide Formation from the derivation /kį-ų́la chaángu/ → [kyųų́la chaángu], where the long vowel derived by GF does not get shortened. Shortening must precedes Heavy Retraction, because retraction does not take place in /eembé yaángu/ → [embé yaángu] “my mango fruit” where Shortening has applied. Heavy Retraction must precede Glide Formation because a long vowel created by the latter rule does not trigger retraction, as shown by /lįowá/ → [lyoowa] “beehive”. From this we derive the strict ordering Shortening >> Heavy Retraction >> Glide Formation. This ordering is directly justified by the derivation of the data in (119).

(119)	mweémbe ← /mų-eembé/	“mango tree”
	mw-eembé waángu	“my mango tree”
	kyaáme ← /kį-aamé/	“deserted place”
	kyaamé chaángu	“my deserted place”

Beginning with underlying /mų-eembé waángu/, the first rule to apply is Shortening which derives the intermediate form *mų-embé waángu*. At this point, Heavy Retraction cannot apply; then the last rule to apply is Glide Formation, which has the consequence of re-lengthening the vowel, giving the surface form *mweembé waángu*. These data show that a Duke of York derivation is crucial to explaining the interaction of processes in Kimatuumbi. It would be insufficient to simply block Shortening from applying in a context where Glide Formation would also apply (the tack taken by McCarthy handling the interaction between dorsal-rounding and final unrounding in Makah). The failure of Heavy Retraction to apply, despite the surface long vowel, justifies the intermediate step in the derivation. It is thus pointless to struggle to find ways to rule out DY derivations in OT, since such derivations actually do exist in human language.

4.4. DY Derivations in wider perspective

Presumably, the reason why it is seen as important to rule out DY derivations in OT is to establish a difference in predictions between derivational phonology and OT. Ironically, the concept of ‘cumulativity of unfaithfulness’, which was seen as an important step in ruling out DY derivations, actually increases the resemblance of OT to derivational theory, and thus strengthens the case that Sympathy Theory is a reconstruction of the intermediate step in derivational theory, not an independent concept. If a rule is applied to an underlying form as sketched in (120), this makes the form different from the underlying form, and results in IO faithfulness violations — thus a string is unfaithful to the input, that is, different from the input, only if a rule has applied.

(120)

$$/\text{ABC}/ \xrightarrow{\text{(via rules I,J,K)}} \underset{\text{[differs from /ABC/ by changes } \alpha\beta\gamma\text{]}}{\text{WXY}} \xrightarrow{\text{(via more rules)}} \underset{\text{[inherits changes } \alpha\beta\gamma\text{, adds changes LMN)}}{\text{[LMN]}}$$

A derivation from /ABC/ to intermediate *WXY* results from applying a set of rules {I,J,K}, which creates faithfulness violations {α,β,γ}. A derivation which goes further, necesarily first undergoes rules {I,J,K}, so the form must inherit the faithfulness violations of the intermediate form, and thus ‘cumulativity’ is common to Sympathy and to derivational theory.

McCarthy 1999 states that in DY derivations, “later steps do not accumulate the results of earlier steps, since some later step literally undoes the effect of an earlier step”. Given that understanding of DY derivations, though, DY derivations have *never* been proposed in derivational theory and would run counter to the standard assumptions of derivational theory. In derivational theory, once a rule is applied, it cannot be ‘unapplied’: time only flows forward. It is possible that some later rule can blindly assign a value which accidentally turns out to be the same as one found in an earlier stage. Even in derivational theory, a later rule never literally reaches back in time and undoes an earlier step — rules Markovianly apply only to what is locally available at the given moment.

(121)	/ba/	/bap/	/bat/	
	ba	ba	ba	deletion of final consonant
	[bat]	[bat]	[bat]	insertion of [t]: coincidentally the same *kind* of segment as was present underlyingly: *not* the same literal *token* of the consonant

The OT account of DY derivations also shares this essential property with derivational theory. A derivation of the form A → B → A is possible in OT, as long as ‘restored’ A is token-wise distinct from underlying A.

The example from Zinza provides a model for handling one class of DY derivations in OT, namely those cases where an underlying object is deleted, and then another token of similar phonetic character is subsequently inserted. Not only will this work for tones and entire segments, but insofar as any featural change can be modeled as the deletion of one specification followed by the insertion of another, then it is probable that any delete-insert DY derivation can be handled.

There is also reason to believe that a DY derivation of the form insert - delete as proposed by Kiparsky, where /maat/ → *mač* via sympathy with *maači*, is actually possible, even in EST. Although the candidate *mač*, with no final vowel, will not survive the sympathy constraint because it lacks the epenthetic vowel, as can be seen in (122), there is a phonetically identical candidate (d), [mač<i>] with an epenthetic vowel with is phonetically unparsed. This tableau differs minimally from the one given by Kiparsky, only adding an explicit constraint to drive apocopation of the final vowel, which prohibits the last syllable from ending in a vowel

(122)		maat	*V]$_{\sigma}$#	❀Symp	Ident(hi)	Dep-V	★Max-μ
	a.	mat		$*^{\aleph 0}$!			*
❀	b.	maači	*		*	*	✓
	c.	mač		$*^{\aleph 0}$!	*		*
☞	d.	mač<i>			*	*	*

This last candidate thus inherits the Dep violation found in the flower candidate, but is otherwise phonetically identical to the candidate *mač* which was ruled out by its excessive faithfulness to the input. This indicates that DY derivations of the type insert - delete are not beyond the reach of OT, either. Whether such derivations are actually found in languages remains a matter for research; whatever the outcome of that search, there is no evidence that the ability to handle DY derivations distinguishes derivational phonology from OT.

5. Summary

In the course of this discussion, I have considered certain cases of serial derivation found in the Bantu languages of Tanzania, and have argued that a considerable range of theoretical devices proves to be required to handle these phenomena. It then remains a topic for future research to determine whether the devices that turned out to be necessary to handle the languages discussed here are sufficient to handle derivational concepts in non-Bantu language, or in languages spoken outside of Tanzania, or whether further devices will need to be added to the theory.

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