

Optimality Theory and African Language Phonology

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1. Introduction

The inspiration for both the title and the theme of this paper is John Goldsmith's talk at the 20th ACAL, held at the University of Illinois in 1989. At that time, the dominant research paradigm was autosegmental phonology, a theory which is concerned with issues in the representation of distinctive features (Goldsmith 1976; Leben 2006). Work on African language phonology was so central to the development of autosegmental phonology, that Goldsmith (1990) in his presentation felt no need to defend or explain the mutual influence of theory and 'descriptive' work in African language phonology in the 13-14 years since his dissertation (Goldsmith 1976) had crystallized the basic autosegmental formalism and research program. Instead, it evaluated historical precedents to the autosegmental approach. I think no one listening to that talk would have guessed that some five years later, research on autosegmental formalism would have come virtually to a halt.

We know the reason for this. The rise of Optimality Theory (OT) shifted attention from theories of representations to a constraints-based theory of phonological processes and their interactions. It is now roughly 13-14 years since the influential founding work in Optimality Theory (Prince & Smolensky 1993, published 2004; McCarthy & Prince 1993a,b) made OT a leading paradigm for phonological research. This is a good moment to evaluate how this new theory has given us a new perspective on some classic problems in African language phonology: tone, vowel harmony, and reduplication.

In this paper, I first briefly introduce some central principles of OT that will be important to the analyses which follow. Then, for the sake of concreteness, I present one case study each in tone, vowel harmony and reduplication, to illustrate how work in OT has shifted our perspective on these topics. I conclude with some brief remarks on challenges that work on African language phonology poses for OT. *The paper comes with the following caveat:* it is not intended to be a survey of interesting work in OT on African languages. My apologies to authors of all the good work I do not have space to refer to here. And naturally, the choice of languages for the case studies is limited by my expertise.

2. Some tenets of Optimality Theory (OT)

I am assuming familiarity with the basic tenets of Optimality Theory (OT), either from reading the primary works cited just above or from good introductory textbooks like Kager (1999). As work like Kager (1999) and Leben (2006) points out, in contrast to autosegmental theory, OT is not primarily a theory of representations. Rather, it is a theory of how well-formedness conditions on representations interact to account for phonological processes. It is, in principle, independent of the representations chosen. This means that autosegmental theory and OT are not necessarily to be seen as incompatible or opposing theories. Indeed, they can both be seen as radically revising different aspects of *SPE* (Chomsky & Halle 1968) phonology.

The following principles of OT will be the focus of this paper. First, OT places severe limits on the abstractness of phonological analyses. In classic OT, there are only two levels of representation, the

* I would like to thank the organizers of ACAL 38 for inviting me to present my views on the role of theory in African linguistics at this conference. I would like to thank the audience members of ACAL 38, especially Akin Akinlabi, Mike Cahill, Rod Casali, Lee Bickmore and Michael Marlo, for thoughtful comments and discussion of the issues raised here.

input and the output. This contrasts with pre-OT derivational theories, which placed no limit on the number of intervening levels. A set of *Faithfulness* constraints evaluates the identity of inputs and outputs. Differences between input and output must be motivated by higher ranked *Markedness* constraints, discussed in more detail below. Predictable input features cannot be underspecified in OT; instead, all forms of output predictability must be expressed as Markedness constraints. Only unpredictable and/or invariant features of the input can be inflexibly specified. For these reasons, the relationship between inputs and outputs is necessarily more transparent in OT than was required in derivational theories.¹ OT also places severe limits on the arbitrariness of phonological processes. Processes are motivated by Markedness constraints: testable, cross-linguistically valid hypotheses about output well-formedness. Because Faithfulness constraints penalize changes between the input and the output, and Markedness constraints are the only motivation for changes, OT makes the strong claim that phonological processes should result in improvements in output well-formedness. The role of morphology in conditioning phonological processes has also become more prominent and explicit. For example, there are Faithfulness constraints referring specifically to morphological constituents, such as the Root - Affix distinction (Beckman 1997; Bakovic 2000). And prosody-morphology Alignment constraints play an important role in OT analyses of prosodic morphology processes like infixation and reduplication (McCarthy & Prince 1993b) and prosodic phonology processes like featural affixation (Akinlabi 1996, Zoll 1997).

A principle of OT which makes the theory of particular interest to comparative linguists is the proposal that OT analyses yield testable factorial typologies. What is meant by this is that a language-particular grammar consists of a ranked set of universal constraints. Re-ranking the constraints developed to account for any specific language yields a set of alternative grammars which should, in fact, define a typology of existing grammars for other languages. Alternative cross-linguistic or cross-dialectal outputs for identical inputs should also be analyzable by re-ranking a shared set of constraints. Factorial typologies derived by constraint re-ranking are, then, intended to be not only a way of testing particular OT analyses, but also provide a way of formalizing the range of possible cross-linguistic variation for a particular process.

Finally, even though OT is not a theory of representations, we do find innovations in the representation of tone which are most sensibly implemented in OT, as Leben (2006) points out. It has also led to innovations in the representation of vowel harmony and reduplicative morphemes. These points will be taken up in the case studies found in the next sections.

3. Tone: case study from Zulu (Nguni Bantu)

In this section, I show how a new theory of representations, Optimal Domains Theory (ODT), developed within OT, gives us a new perspective on tone in Bantu languages. For the sake of concreteness, this section will develop an analysis of verb tone in Nguni languages to illustrate ODT.

3.1. *The basic Nguni tone patterns*

It is a well-known property of basic verb tone in the Nguni languages (Zulu, Xhosa, Ndebele, Phuthi, Swati) that the rightmost High tone generally surfaces on the antepenultimate syllable (see, e.g., Cassimjee 1998, Cassimjee & Kisseberth 2001, Downing 2001, 2003, Khumalo 1987). This is illustrated in the Zululand Zulu and Xhosa data below, where we can see that the High tone underlyingly associated with the underlined vowel surfaces on the antepenult:

¹ Accounting for opaque phonological systems was recognized as a serious potential problem for OT very early on. It is beyond the scope of this paper to discuss this issue. See McCarthy (2002) for a fairly recent brief overview of the problem and the literature on it.

- (1) Zululand Zulu (Khumalo 1987, Downing 2001)
- | | | | |
|---|--------------------------|---|---------------|
| (a) <i>Stem high tones >3 syllable-stems</i> | | (b) <i>Pre-stem high tones (low-toned verb)</i> | |
| si-ya-phakámisa | 'we lift up' | <u>u</u> -yá-bala | 's/he counts' |
| si-ya-khulúmísana | 'we speak to each other' | <u>u</u> -yá-hleka | 's/he laughs' |
| | | <u>u</u> -ya-hlékisa | 's/he amuses' |
- (2) Xhosa (Cassimjee 1998; Cassimjee & Kisseberth 1998)
- | | | | |
|---|---------------------------|--|--------------------|
| (a) <i>Stem high tones >3 syllable-stems</i> | | (b) <i>Pre-stem high tones (low-toned verbs)</i> | |
| si-ya-sebénzisa | 'we are working' | bā-yá-fika | 'they arrive' |
| si-ya-shumayézana | 'we preach to each other' | bā-yá-bala | 'they count' |
| | | bā-ya-mónela | 'they are jealous' |

However, High tones which are underlyingly contributed by the penult or antepenult surface on the penultimate syllable. This is shown by the data below, where the vowels underlyingly associated with the High tone are again underlined:

- (3) Zululand Zulu (Khumalo 1987, Downing 2001)
- | | | | |
|----------------|--------------------|---------------|-----------|
| si-ya-létha | 'we bring' | si-ya-sebénza | 'we work' |
| si-ya-yi-líma | 'we plow it' | si-ya-bónísa | 'we show' |
| si-ya-bā-hléka | 'we laugh at them' | | |
- (4) Xhosa (Cassimjee & Kisseberth 1998)
- | | | | |
|----------------|----------------|---------------|--------------|
| si-ya-bóna | 'we see' | si-ya-fumána | 'we get' |
| si-ya-bā-khába | 'we kick them' | si-ya-finyéza | 'we shorten' |
| si-ya-zi-bíla | 'we boil them' | | |

This is the central problem, then, in analyzing Nguni tone. One finds two complementary targets of tone spread or shift: the antepenult *or* the penult. As we shall see, derivational autosegmental theory and ODT provide quite different accounts for the choice of targets.

3.2. *Optimal Domains Theory (ODT)*

Let us first consider how these Nguni tone patterns can be accounted for in ODT (Cassimjee 1998, Cassimjee & Kisseberth 1998), a new theory cast within OT which aims to replace autosegmental representations as a way of formalizing the realization of a feature on segments. The representations in (5) compare the autosegmental representation and ODT representation of a single High tone which is realized on two syllables/vowels. The representation in (5a) shows the autosegmental representation. The High tone is linked by association lines to the two vowels. Each vowel the High tone is associated with realizes the High tone. The string of vowels associated with a single High tone indirectly defines the domain of realization of the tone. In the ODT representation in (5b), the two vowels are parsed into a binary High tone domain. As a result, they can be realized as High-toned, but obviously not by direct association with the High tone. Rather, in the unmarked case each vowel within a High tone domain (potentially) realizes the High tone.

- (5)
- | | | | | | | | | | | |
|-----|---|---|---|---|---|-----|----|---|---|-----------------|
| (a) | C | V | C | V | | (b) | (C | V | C | V) _H |
| | | | | |  | | | | | |

Tonal domains, like other prosodic constituents can be either binary or unbounded in size. They are subject to minimality (that is, they must minimally contain two moras or syllables). And they are subject to nonfinality (that is, they can exclude the final syllable). As Cassimjee (1998) and Cassimjee & Kisseberth (1998) show, these properties are typical of Bantu tone systems. We shall see in the

analysis below that these are also the central properties defining the Nguni tone patterns presented in the preceding section.

3.3. Nguni tone shift analysis - ODT version

We can make the following generalizations about High tone shift in Nguni based on the data in section 3.1. The rightmost High tone shifts from its input position to a position close to the right edge of the word (6), generally the antepenult (8). High tones must shift at least one syllable to the right (9), but they never shift to the final syllable (7).² The following constraints, adopted from Cassimjee & Kisseberth (1998)'s analysis of Xhosa, formalize these generalizations:

- (6) ALIGN TONE DOMAIN (ALIGNTD): Align R (TD, Word)
That is, the right edge of the tone domain is aligned with the right edge of the word.
- (7) NONFINALITY: The word-final syllable is not parsed into a tone domain.
- (8) AVOID PROMINENCE: Do not parse the stressed (penult) syllable into a tone domain.
- (9) MINIMALITY: Prosodic constituents (like tone domains) must be minimally bisyllabic.

The analysis of antepenult high tone shift – illustrated by the data in (1) and (2) – is exemplified by the tableau in (10):

(10) Tone domain targeting antepenult (parentheses indicate tone domain; '!' indicates stress foot)

/bá-ya-namatsela/	NONFINALITY	AVOID PROM	ALIGN TD
☞ a. (ba-ya-namá)[tse:la]			**
b. (ba-ya-nama[tsé:]la)		*!	*
c. (ba-ya-nama[tse:lá])	*!	*	
d. (bá)-ya-nama[tse:la]			***!***

Crucial constraint rankings:

- NONFINALITY >> ALIGNTD Optimizes excluding final syllable from TD
AVOID PROM >> ALIGN TD Optimizes not including penult in TD

Candidate (10a), with the rightmost high tone on the antepenult, is optimal because the tone domain (TD) edge is as far to the right as possible without violating higher-ranked constraints. In candidate (10b) the TD edge is too far to the right: it violates AVOID PROMINENCE by including the stressed penult. In candidate (10c) it is also too far to the right: it violates NONFINALITY (and also AVOID PROMINENCE, since the stress foot is included in the TD). In candidate (10d), the TD edge is not far enough to the right, violating AlignTD more than the optimal candidate.

MINIMALITY (9) explains why the penult is sometimes included in the tone domain. The tone domain, like other prosodic constituents, must be minimally bisyllabic. Ranking MINIMALITY above AVOID PROMINENCE optimizes the penult as the target of tone shift when the tone domain would otherwise be subminimal. This is shown in the tableau in (11):

(11) Tone domain targeting penult: Input High on antepenult

si-ya-yí-lima	NONFINALITY	MINIMALITY	AVOID PROM	ALIGNTD
☞ a. si-ya-(yi-[lí:]ma)			*	*
b. si-ya-(yí)-[li:ma]		*!		**
c. si-ya-(yi-[li:má])	*!		*	

² In some Nguni languages the high tone extends its domain rightwards by spread, in others by tone shift. Only shift is discussed here for the sake of simplicity. Cassimjee & Kisseberth (1998, 2001) provide detailed discussion of this variation, and Cassimjee (1998) and Cassimjee & Kisseberth (1998) show how this kind of cross-Bantu tonal variation can be analyzed as a factorial typology within the ODT framework.

Candidate (11a), in which the tone domain extends through the penult, is optimal because it satisfies MINIMALITY. Not extending the tone domain to the penult, as in (11b) leaves it subminimal. Extending it beyond the penult, as in (11c), violates NONFINALITY.

In fact, the final syllable is never included in the tone domain, showing that NONFINALITY (7) outranks MINIMALITY. Notice that the optimal candidate in tableau (12) has a subminimal tone domain:

(12) Tone domain targeting penult: (parentheses indicate tone domain; '[' indicates stress foot)

si-ya-létha	NONFINALITY	MINIMALITY	AVOID PROM	ALIGNTD
☞ a. si-ya-[(lé:)tha]		*	*	*
b. si-ya-[(le:thá)]	*!		*	

Candidate (12a), in which the tone domain only includes the penult, is optimal even though it violates MINIMALITY. Candidate (12b) realizes the only other option by fatally violating NONFINALITY.

3.4. Comparison with a derivational analysis

Let us compare the ODT analysis just developed with previous derivational analyses of the Nguni tone patterns (e.g., Downing 1990, 1996, Khumalo 1987, Goldsmith et al. 1986, Peterson 1989). The following ordered rules would be necessary in a derivational account.³

(13) Derivational rules, applying in order given

(a) Final syllable extratonicity

< σ >] *accounts for why final syllable is outside the domain of tone spread*

(b) Non-iterative High tone spread

H
| \
σ σ *accounts for why all Hs (except those on penult in input) spread once*

(c) Final (toneless) foot extratonicity

(σ σ)] *accounts for why stressed penult is outside the domain of High spread*

(d) Iterative High spread

H
| \
σ σ *accounts for why all Hs spread as far right as possible*

The derivations in (14) illustrate the how penult High tone spread and antepenult High tone spread are derived by applying the ordered rule system in (13):

(14) Derivations

(a) Penult tone spread

(b) Antepenult tone spread

(13a,b) H
| \
-bo ni: <sa>

(13a,b) H
| \
-khu lu mi sa <na> →

(13c,d) H
| \
-khu lu mi (sa: <na>)

³ The derivational analysis in this section is based mainly on Downing (1990, 1996); the foot extratonicity rule (13c) is from Hyman (1989).

In the first step of the analysis, the final syllable is made extratonal; then the local High tone spread rule applies. These are all the rules which apply in (14a), as the final foot cannot be made extratonal by (13c) if it is associated with a High tone. In (14b), the final foot is toneless after Local High tone spread, and is made extratonal. Iterative High tone spread applies next, and targets the antepenult because it is the rightmost syllable visible to the phonology. The incorrect derivations in (15) motivate the crucial rule orderings:

(15)

(a) (13b) must precede (13c)

H
 (13c->b) |
 bo (ni sa)
 Other rules not applicable → *-bóni:sa

(b) (13b, c) must precede (13d)

H
 (13d-> b,c) | \ /
 -khu lu mi sa <na>
 → *-khúlúmísá:na

As we can see, the derivational analysis derives the correct results with the same number of rules as there are constraints in the ODT analysis. In terms of descriptive adequacy and simplicity, then, the two approaches can be considered equivalent. Where they differ is in terms of explanatory adequacy. What the derivational analysis fails to explain is what motivates the non-iterative tone spread rule (13b) that accounts for High spread from the antepenult to the penult. If the rightmost High tone in general surfaces on the antepenult, why do tones underlyingly on the antepenult spread away from that syllable, to the penult? There is no general autosegmental principle favoring binary linking, so the local spread rule is entirely stipulative. However, in ODT, we do have an explanation for why a High tone underlyingly on the antepenult must shift to the penult. Tone domains are prosodic constituents, subject to a Minimality condition. The requirement that tones spread at least once forces a High tone underlyingly on the syllable (the antepenult) that ordinarily attracts High tones to shift away from that position if that would satisfy Minimality. The rightmost High tone surfaces on the antepenult *except when* the antepenult has a High tone in the input. This is accounted for by ranking MINIMALITY (the requirement that all High tones must spread once) over AVOID PROMINENCE.

3.5. Factorial typology

As Cassimjee & Kisseberth (1998), Cassimjee (1998) and Downing (2001) show, the ODT analysis of Nguni tone and the OT concept of factorial typology can also shed light on a long-standing problem in Bantu tone change, namely what relates the process of local (binary) High tone spread or shift – arguably, phonetically motivated (Myers 1999) – to the Nguni-like pattern of long distance High tone spread or shift. We can choose Jita to illustrate the more conservative Bantu local tone shift system. In Jita 2-3 syllable High stems, the stem high tone shifts to the penult from the antepenult; it does not shift from the penult, however, as the final syllable is extratonal. So far, this is just like Nguni, as we can see by comparing the data in (16a) with the data in (3) and (4). It is only longer stems that show tone shift is maximally binary as well as minimally binary in Jita. This can be seen by comparing the data in (16b) with the Nguni data in (1) and (2), above:

(16) Jita infinitives (Downing 1996)

(a) 2-3 syllable stems

oku-bóna	‘to get; see’
oku-bónéna	‘to get; see for (applicative)’
okw-í:ga	‘to find’
okw-i:gána	‘to find each other’
oku-kará:nga	‘to fry’
oku-bagára	‘to weed’

(b) Longer stems

oku-bónéna	‘to get/see for each other’
okw-i:gírana	‘to find for each other’
oku-surú:mbara	‘to be sad’
oku-saráruka	‘to split open’

As shown in (17b, c), in 2-3 syllable stems, the grammar determining the maximal size of the tone domain is potentially ambiguous. The same tone domain is selected as optimal whether MAXIMALITY

(17a) is ranked below ALIGNTD (6), as shown in (17b), or above ALIGNTD (6), as shown in (17c). In both grammars, the penult is the rightmost syllable in the tone domain for the shorter stems.

(17)

(a) MAXIMALITY: Prosodic constituents are maximally bisyllabic.

(b) Unbounded High domain (Nguni): ALIGNTD >> MAXIMALITY

	NONFINALITY	MINIMALITY	ALIGNTD	MAXIMALITY
☞ (CVCV)CV			*	
(CVCVCV)	*!			*
(CV)CVCV		*!	**	

(c) Binary High domain (Jita): MAXIMALITY >> ALIGNTD

	NONFINALITY	MINIMALITY	MAXIMALITY	ALIGNTD
☞ (CVCV)CV				*
(CVCVCV)	*!		*	
(CV)CVCV		*!		**

As Downing (2001) argues, this ranking ambiguity for the proper analysis of shorter stems could lead speakers to reanalyze the penult as the target of spread/shift in all forms. In OT terms, based on the more frequent 2-3 syllable stems, speaker-learners might settle on the relative ranking of MAXIMALITY and ALIGNTD in (17b) which optimizes unbounded tone spread (or shift), instead of the ranking that optimizes a binary system (17c). Extending this reanalysis to longer forms would lead to a change from a tone system with binary tone domains to one with long distance tone shift to the penult.

To sum up this section, the ODT analysis of Nguni verb tone patterns, crucially cast within OT, has several advantages. First, it limits abstractness, as the interaction of local and long-distance tonal processes can be formalized without resorting to abstract intermediate levels of representation. It also limits arbitrariness, as it provides an explanation for why so many Bantu languages require High tones to spread at least once even if this violates a general pattern of rightmost tone placement. Spreading at least once satisfies the prosodic principle of Minimality which constrains well-formed tone domains. As noted above, there is no autosegmental principle requiring tones to spread, and none is needed, since pre-OT phonology does not place a markedness requirement on phonological processes or output representations. Finally, the analysis defines a factorial typology which allows us to formalize the connection between Bantu tone systems with binary shift and those with unbounded shift through constraint re-ranking, plausibly motivated by the ranking ambiguity posed in analyzing the common shorter verb stems. In pre-OT autosegmental rules, bounded vs. unbounded application of tone spread/shift could not be explicitly formalized. This made it impossible to formalize how or why tone systems might change from one type of rule application to another.

4. Vowel harmony in two dialects of Yoruba

Cole & Kisseberth (1994) argue that Optimal Domains Theory (ODT) is not only relevant for tone systems, but best formalizes other long distance assimilation process, like vowel harmony. The goal of this section is to sketch an ODT analysis of vowel harmony in two dialects of Yoruba – Standard Yoruba and Ife Yoruba, highlighting the advantages of an ODT analysis.⁴

⁴ The analysis presented in this section has been informed by other recent work in OT on Yoruba, like Akinlabi (1994), Bakovic (2000), Orié (1997, 2001), Pulleyblank (1996). However, space does not permit discussing these analyses or critiquing them. I have not marked tone on the Yoruba data, as it is not relevant to the vowel harmony analysis.

4.1. The data

Yoruba has seven vowels: i e o u – advanced (ATR); ε a ɔ – retracted (RTR). As we can see, only the mid vowels have advanced and retracted counterparts. Not surprisingly, only words containing mid vowels show ‘perfect’ harmony:

(18) Yoruba mid vowel retraction harmony (Pulleyblank 1996: 297; Orié 2001: 121)

<i>Advanced</i>		<i>Retracted</i>	
[ege]	‘dirge’	[εgε]	‘cassava’
[ese]	‘cat’	[εsε]	‘row’
[ogede]	‘incantations’	[ɔgεdε]	‘banana; plantain’

Disharmony is found in words with ‘a’ or ‘i’, which have no advanced or retracted counterparts, respectively. In both Standard Yoruba (SY) and Ife Yoruba (IY), all vowels preceding ‘a’ are retracted (19c); however ‘a’ can be followed by either advanced (19b) or retracted (19a) vowels. This is evidence that harmony is directional in Yoruba, namely, triggers are towards the right edge of a words, and affect vowels to their left.

(19) Disharmony with [low] vowels (Pulleyblank 1996: 306) – Standard Yoruba

a.	[abere]	‘needle’	b.	[awo]	‘plate’
	[afɔ]	‘cloth’		[adi]	‘palm-nut oil’
c.	[eba]	‘food made from gari’		[*eba]	
	[εgba]	‘whip’		[*εgba]	

Where the dialects differ is in the disharmony patterns found with [high] vowels. In Standard Yoruba (SY), word-final [high] vowels can be preceded by a retracted or advanced vowel (20a). Word-medial [high] vowels are opaque to harmony: they must be preceded by advanced vowels, even if the harmony trigger (i.e., the vowel following them) is retracted (20b):

(20) Disharmony with [high] vowels in SY (Pulleyblank 1996: 305, 311)

a.	[ebi]	‘guilt’	[ebi]	‘hunger’
	<i>Opacity of word-medial high vowels</i>			
b.	[elubɔ]	‘yam flour’	[erukpe]	‘earth’

As Orié (2001) shows, in Ife Yoruba (IY), we find a different disharmony pattern with [high] vowels. Word-final [high] vowels must be preceded by an advanced vowel (21a). Word-medial [high] vowels are transparent to harmony: they can be preceded and followed by retracted vowels (21b):

(21) Disharmony with [high] vowels in IY (Orié 2001: 129, 132, 133)

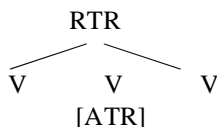
a.	[ebi]	‘guilt’	[*εbi]	[eru]	‘fear’	[*εru]
	<i>Transparency of word-medial high vowels</i>					
b.	[elubɔ]	‘yam flour’	[*elubɔ]	[ɔdide]	‘parrot’	[*odide]

The challenge for an OT analysis – any analysis – is to account for the following asymmetries. Why are different types of disharmony associated with [low] vs. [high] vowels? Why do we find different disharmony patterns, depending on whether the [high] vowel is word-final or word-medial? How can one account for the different disharmony patterns found in SY vs. IY? Why is a word-medial [high] vowel transparent to harmony in IY but opaque in SY?

As Pulleyblank (1996) makes clear, accounting for why we find transparency vs. opacity with the same set of vowels is a particularly important challenge, as there is no pre-OT analysis which makes these two types of disharmony follow from switching a single parameter setting. What transparency and opacity have in common is that they are both commonly associated with vowels which are incompatible with the harmonizing feature. As work like Archangeli & Pulleyblank (1994) argues, Hi/RTR and

Lo/ATR are antagonistic feature combinations. Opacity then easily follows from a grounding constraint penalizing antagonistic feature combinations, blocking further propagation of [RTR], for example, once a [high] vowel is reached. Transparency should also easily follow from the same sort of grounding constraint preventing the transparent vowel from realizing the antagonistic combination. However, transparency raises a representational problem, namely, how to allow harmony on both sides of the transparent vowel without creating the ill-formed gapped configuration in (22):

(22) Mind the gap!



These representational problems for autosegmental theory lead us to be open to an alternative theory of representations for vowel harmony.

4.2. ODT analysis of transparency and opacity in Yoruba vowel harmony

As Cole & Kisseberth (1994) show, transparency and opacity in vowel harmony systems can be accounted for in ODT from a simple constraint re-ranking, defining these two options as outputs of a factorial typology resolving the conflict between perfect harmony and grounding constraints. The analysis developed in this section applies their general approach to Standard Yoruba and Ife Yoruba.

Recall from the preceding section that our analysis must account for the following generalizations. Perfect harmony takes the word as its domain: that is, harmony is a long-distance prosody. Words containing only mid vowels, like those in (18), illustrate perfect harmony throughout the word in both dialects. The constraint in (23) formalizes this generalization by defining the word as the domain for the harmonizing feature:

(23) WIDE SCOPE ALIGNMENT (WSA): A featural domain should extend to the next word edge.

Following Pulleyblank (1996), I assume that harmony is contrastive for morphemes, not underlyingly associated with a particular vowel.⁵ The alignment constraint in (24) captures this property, and also formalizes that the trigger for harmony occurs towards the right edge of the word (and propagates towards the left edge of the word to satisfy WSA (23)):

(24) ALIGNR(ROOT-TR, WORD) (Pulleyblank 1996: 304):

Align the right edge of the lexical TR harmony feature's domain with the right edge of the word.

The grounding constraints in (25), adapted from Archangeli & Pulleyblank (1994), formalize the generalization that [high] and [low] vowels do not fully participate in vowel harmony because they are incompatible with the harmonizing feature. [High] vowels are optimally advanced, to satisfy (25a), while [low] vowels are retracted to satisfy (25b). Formalizing the grounding constraint for [low] vowels as an alignment constraint accounts for the fact that they always trigger harmony on a preceding vowel, as shown in (19). The constraint in (25b) optimizes this by requiring [low] vowels to initiate a [RTR] harmony domain. These two constraints are high ranked in both dialects, as they are never violated.

⁵ I am assuming that [RTR] vs [ATR] values must be lexically specified for words containing mid vowels, where the value is contrastive. Thanks to Akin Akinlabi for discussion of this point.

(25)

(a) *Hi/RTR: A [high] vowel feature is antagonistic to [RTR].

(b) ALIGNR(LO, RTR):

Every [low] vowel must have the right edge of a [RTR] domain at its right edge.

As Cole & Kisseberth (1994) argue, the difference between opacity and transparency falls out from the relative ranking of WSA (23) with the EXPRESS constraint in (26). This constraint is satisfied if all the vowels in the harmony domain realize the harmonizing feature in the output:

(26) Express: All the vowels in the featural domain must realize the feature.

Transparency violates EXPRESS (26) while satisfying WSA (23). The transparent vowel is included in a wider, antagonistic feature domain, but does not express the harmonizing feature. Opacity violates WSA (23) while satisfying EXPRESS (26). The opaque vowel begins a new feature domain; all vowels within each domain express the feature defined by that domain.

The tableaux in (27) through (29) exemplify the analysis of disharmony in Standard Yoruba (SY) where high vowels are opaque to harmony. In all of these tableaux, I have chosen words where the lexically-specified ATR/RTR value is the opposite of the one optimized by the grounding constraints in (25) in order to show how the analysis optimizes the disharmony patterns in (19) and (20).

The tableau in (27) shows why it is optimal in this analysis for a low vowel to trigger [RTR] harmony to its left, leading to disharmony in words where the morphological harmony value is [ATR]:

(27) SY [low] vowel disharmony – [ATR] (A) input harmonizing value

/ErakpO _A /	ALIGNR(LO, RTR)	EXPRESS	DEP-RTR	ALIGNRT (ROOT-TR)	WSA
☞ a. (era) _R (kpo) _A			*		*
b. (erakpo) _A	*!	**			
c. (erakpo) _A	*!	*			

Crucial constraint rankings:

EXPRESS >> WSA: [Low] and [high] vowels are opaque to harmony of antagonistic features

EXPRESS >> DEP-RTR: [RTR] feature not present in the input occurs in the output to satisfy EXPRESS

Candidate (27a) is optimal, as it satisfies the grounding constraint (25b) requiring low vowels to initiate a [RTR] domain as well as EXPRESS. Candidates (27b) and (27c) are not optimal, as they violate both EXPRESS and the grounding constraint (25b): the [low] vowel does not initiate a new featural domain.

The tableau in (28) shows why it is optimal in this analysis for word-final high vowels to co-occur with retracted vowels in the preceding syllables, leading to disharmony. As shown in (28), a disharmonic retracted vowel is optimal before a word-final high vowel, because this allows the input [RTR] feature to occur in the output:

(28) SY word-final [high] vowel disharmony – [RTR] (R) input harmonizing value

/Ebi _R /	*Hi/RTR	EXPRESS	DEP-ATR	ALIGNRT (ROOT-TR)	WSA
☞ a. (ɛ) _R (bi) _A			*	*	*
b. (ɛbi) _R	*!				
c. (ɛbi) _R		*!			

Crucial constraint rankings:

EXPRESS >> WSA: [Low] and [high] vowels are opaque to harmony of antagonistic features

EXPRESS >> DEP-ATR: [ATR] feature not present in the input occurs in the output to satisfy EXPRESS

Candidate (28a) is optimal as it satisfies the grounding constraint on high vowels (25a), as well as EXPRESS. Candidate (28b) is non-optimal, as it violates the grounding constraint, while (28c) is non-optimal as it violates EXPRESS.

The tableau in (29) shows why word-medial [high] vowels are opaque in Standard Yoruba. Unlike word-final [high] vowels, word-medial ones are never preceded by a retracted vowel. When the input harmonizing feature can be aligned at the right edge of the word, the optimal way to satisfy the two highest ranked constraints is for word-medial [high] vowels to be opaque and trigger [ATR] harmony on preceding vowels:

(29) SY word-medial *opaque* [high] vowel – [RTR] (R) input harmonizing value

/ElubO _R /	*Hi/RTR	EXPRESS	DEP-ATR	ALIGNRT (ROOT-TR)	WSA
☞ a. (elu) _A (bɔ) _R			*		*
b. (ɛlU _b ɔ) _R	*!				
c. (ɛl u bɔ) _R		*!			

Candidate (29a) is optimal, as it satisfies all the highest ranked constraints. Candidate (29b), while perfectly harmonic, violates the grounding constraint for [high] vowels. Candidate (29c), with a transparent [high] vowel, violates EXPRESS.

As shown by the tableaux in (30) and (31), simply reversing the ranking of WSA with EXPRESS accounts for why [high] vowels have a different disharmony pattern in Ife Yoruba (IY). As shown in (30), word-final high vowels must be preceded by [ATR] vowels in this dialect because this allows WSA and the grounding constraint to be satisfied:⁶

(30) IY word-final [high] vowel disharmony – [RTR] (R) input harmonizing value

/Ebi _R /	*Hi/RTR	WSA	EXPRESS	DEP-ATR	ALIGNRT (ROOT-TR)	MAX- RTR
a. (ɛ) _R (bi) _A		*!		*	*	
b. (ɛbɪ) _R	*!					
c. (ɛ b i) _R			*!			
☞ d. (ɛbɪ) _A				*	*	*

Crucial constraint rankings:

WSA >> EXPRESS: [high] vowels are transparent to harmony of antagonistic features

EXPRESS >> DEP-ATR: [ATR] feature not present in the input occurs in the output to satisfy EXPRESS

EXPRESS >> MAX-RTR: [RTR] present in the input does not occur in the output to satisfy EXPRESS

Candidate (30d) is optimal, even though it does not realize the input harmonizing feature. The other candidates show how the highest-ranked constraints make it optimal for the grounded [ATR] feature of the word-final high vowel to determine harmony for the word. Candidate (30a) violates high-ranked WSA; candidate (30b) violates the grounding constraint; candidate (30c) violates EXPRESS.

Word-medial high vowels, in contrast, are transparent in Ife Yoruba. The high-ranked WSA constraint makes including the entire word in the input feature's domain the optimal way to satisfy the two highest ranked constraints, when the input harmonizing feature can be aligned at the right edge of the word. This is shown in the tableau in (31):

⁶ The complete analysis of IY requires a more specific EXPRESS constraint, namely, EXPRESS-HEAD: the head (word-final) vowel must realize the feature defining the domain. (I am following McCarthy (2004) in assuming that domains – or spans, in McCarthy's terminology – must have heads. See Orié (1997) for arguments that word-final position, at least, is a head in Yoruba.) This constraint accounts for why [high] vowels can be followed by a retracted mid vowel (e.g., idɛ) but not preceded by one (e.g., ebi/*ɛbi). The generalization that EXPRESS-HEAD is intended to formalize is that an input [RTR] value is optimally realized on the word-final vowel *unless* the word-final vowel has the antagonistic [high] feature.

(31) IY word-medial *transparent* High vowel – [RTR] (R) input harmonizing value

/ElubO _R /	*Hi/RTR	WSA	EXPRESS	DEP-ATR	ALIGNRT (ROOT-TR)	MAX- RTR
a. (e <u>lu</u>) _A (bɔ) _R		*!		*		
b. (e <u>l</u> u ɔ) _R	*!					
↻ c. (e <u>l</u> u ɔ) _R			*			

Candidate (31c) is optimal, as it only violates the relatively low-ranked EXPRESS constraint. Candidate (31a), which would be optimal in Standard Yoruba (see tableau (29), above), is non-optimal in Ife Yoruba, as it violates WSA. Candidate (31b), with perfect harmony, violates the grounding constraint.

To sum up this section, the ODT analysis has the following advantages. First, it limits abstractness, as all input morphemes can be specified for a harmonizing feature. Output vowels are also all specified for a harmonizing feature. Underspecification is not necessary to account for the asymmetrical properties of [high] vowels in the system.⁷ Further, the analysis limits arbitrariness, as opaque and transparent vowels violate markedness constraints defining phonetically-grounded antagonistic feature combinations. Finally, the analysis fulfills the desideratum of accounting for why the same vowels are transparent in one dialect of Yoruba and opaque in another through constraint re-ranking. That is, a factorial typology unifies what at first seem like arbitrary and unreconcilable differences in the harmony patterns triggered by high vowels in the two dialects.

5. Bantu verbal reduplication

In this section, we shall briefly look at how OT has given us a new perspective on verbal reduplication in Bantu languages. As in the preceding sections, the emphasis here will be on how work within OT provides a more restrictive and explanatory account of some of the key features of these reduplicative patterns.

Reduplication of the verb stem to indicate that the action of the verb has been done here and there or time and again or in a small way is very common and productive in Bantu languages (see e.g., Mutaka & Hyman 1990, Hyman et al 1999, Downing 2005, 2006, Inkelas & Zoll 2005). It is very common for the reduplicative morpheme to be subject to a disyllabic minimality condition, and also common for the reduplicative morpheme to be maximally disyllabic. A further common feature cross-Bantu is for the second syllable – if the reduplicative morpheme is maximally two syllables – to be filled with the fixed vowel *-a*.

The Swati data in (32) illustrates these properties. Note that the reduplicative morpheme is always exactly two syllables long. When the base stem is longer than two syllables, as in (32b,c, d), only the first two syllables are reduplicated, and the second vowel can either copy the vowel of the base or be filled by a fixed *-a*. When the base stem is shorter than two syllables, as in (32e), an epenthetic *-yi-* occurs following the copy of the Base, showing that the reduplicative morpheme is minimally disyllabic.

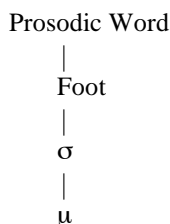
(32) Swati verbal reduplication (Downing 2005; only stems are cited)

<i>Unreduplicated stem</i>	<i>Gloss</i>	<i>Reduplicated stem</i>
(a) -tfú:t _{sa}	move house	- <u>tfutsá</u> -tfu:t _{sa}
(b) -tfutsé:la	move for	- <u>tfutse</u> -tfutsé:la ~ - <u>tfutsa</u> -tfutsé:la
(c) -khulumísa:na	talk to ea. other	- <u>khulu</u> -khulumísa:na
(d) -lindzi:sa	make someone wait	- <u>lindzi</u> -lindzi:sa ~ <u>lindza</u> -lindzi:sa
(e) -phá	give	- <u>phayí</u> :-pha

⁷ See Pulleyblank (1996) for detailed discussion of the role of underspecification in alternative analyses of the Yoruba vowel harmony system.

Work like McCarthy & Prince (1986, 1993), McCarthy (2000), Prince & Smolensky (1993/2004) argue that disyllabic minimality (and maximality) requirements on reduplicative morphemes fall out from the Prosodic Hierarchy in (33):

(33) Prosodic Hierarchy

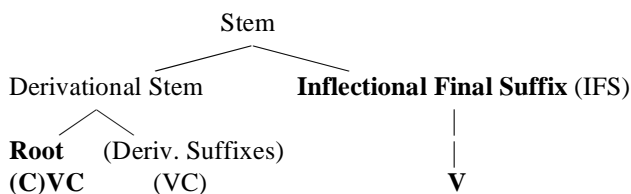


In this Hierarchy, each Prosodic Word must contain at least one stress Foot, and each stress Foot must contain minimally (and maximally) two moras or two syllables. Therefore, a disyllabic minimality requirement can be enforced by requiring the morpheme to be parsed into a minimal stress Foot.

However, as work beginning with Mutaka & Hyman (1990) points out, there is a serious problem with this Foot-based approach to disyllabic minimality in Bantu languages (even though this is the approach they adopt). As we can see from the Swati data in (32), stress (indicated by the long vowel) only occurs on the penult of the reduplicative complex. There is never separate stress on the reduplicative morpheme. The reduplicative morpheme is, therefore, not a stress Foot. The Prosodic Hierarchy, then, does not provide the motivation for the disyllabic minimality condition in Swati. These same observations can be made for the many other Bantu languages with a disyllabic size condition on the reduplicative morpheme (Downing 2005). It is equally problematic to try to account for the fixed final *-a*, because it is not the phonological default vowel in most Bantu languages. However, Downing (2000) argues that it is a morphological default vowel: it is the most common inflectional final suffix for Bantu verbs. The analytical problem, then, is to explain why the second syllable of the reduplicative morpheme should be filled with a particular fixed verb ending as the default choice.

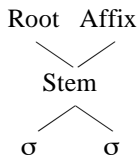
Downing (2005, 2006) demonstrates that both disyllabic minimality and fixed final *-a* fall out, if the reduplicative morpheme is required to be a canonical Bantu verb stem. Bantu verb stems consist of a string of canonically monosyllabic morphemes: a Root (canonically CVC-), optional derivational suffixes (extensions; canonically -VC) and an Inflectional Suffix (canonically -V):

(34) Verb Stem Structure (Doke 1943, 1954; Meeussen 1967; Mutaka 1994; Myers 1987, 1998; Peng 1991) – obligatory morphemes are bolded



As the verb stem is minimally bimorphemic (Root + Inflectional Final Suffix), and each of these morphemes is canonically monosyllabic, it is unsurprising that the verb stem should be minimally disyllabic. The representation in (35) formalizes this correlation between morphological complexity and prosodic minimality:

(35) CANONICAL STEM: Prosodic Stems are minimally disyllabic (Downing 2005, 2006)



Stems are morphologically branching.

Therefore, stems must branch at the syllabic level.

If we define reduplicative morphemes as verb stems which form a stem-stem compound with their Base, as work like Downing (2000, 20003, 2006); Hyman et al. (1999) and Inkelas & Zoll (2005) proposes, then the CANONICAL STEM constraint in (35) allows us to define explicitly why monosyllabic reduplicative morphemes are ill formed. Stems must branch into two syllables, one per morpheme in the Canonical Stem. Because reduplicative morphemes are stems, they must also satisfy this minimality requirement. The CANONICAL STEM (35) constraint also allows us to explain why the second syllable of the reduplicative morpheme is filled by *-a*. This is the canonical stem position which is filled by the IFS, and *-a* is the default IFS.

The patient reader might now be asking why this analysis is crucially related to Optimality Theory, especially since the Prosodic Hierarchy-based theory of minimality criticized in the preceding paragraphs is well accepted in traditional OT. Recent work on prosodic morphology in OT like McCarthy (2000) has, though, made the strong claim that minimality conditions should fall out from general constraints on the language. That is, templates defining size conditions should be generalized from independent constraints, rather than being specific to a particular prosodic morpheme. This is why one cannot posit the reduplicative minimal disyllable is a stress Foot, unless this is the general stress Foot ‘template’ for the language. A further impetus to rethinking reduplication in OT follows from proposals developed in Urbanczyk (1996) that, in general, the shapes of reduplicative morphemes should follow from their morphological category. That is, they should have the canonical shape of their morphological category. This proposal leads an analyst to examine what morphological category Bantu reduplicative morphemes might belong to, as its fixed properties should follow from its morphological category. This search for general properties of a languages to explain what seems particular to prosodic morphemes is bound to lead to a more explanatory account than pre-OT work on reduplication which was content to label any disyllable a Foot, whether there was independent support in the language for the Foot or not (McCarthy & Prince 1986, 1993, Spring 1991).

To sum up this section, the OT-based ‘generalized template’ approach to disyllabic minimality sketched here has the following advantages over pre-OT accounts. First, it limits abstractness, as it is not possible to posit the reduplicative morpheme is a stress foot to account for disyllabicity condition, when there is no independent evidence for stress footing. It also limits arbitrariness by linking reduplicative form to the canonical form of the morphological category of the reduplicative morpheme. Finally, as Downing (2005) shows, there are three common strategies for filling out the second syllable when monosyllabic Base verb stems are reduplicated: phonological epenthesis, morphological epenthesis or alternative morphological strategy for expressing the same meaning. This range of variation can be accounted for by the relative ranking of CANONICAL STEM (35) with other constraints. That is, in reduplication, as for the other processes discussed, factorial typologies defined by constraint re-ranking can account for attested cross-linguistic variation.

6. Challenges from African language phonology for OT

In conclusion, we have seen that OT gives us a new perspective on familiar problems like tone spread or shift, vowel harmony and reduplication. We have also seen that the OT analyses presented here have several general advantages. They limit the abstractness and arbitrariness of possible analyses. They also force us to take comparative work seriously, as analyses must be tested through factorial typologies.

However, there are certainly challenges that the phonology of African languages poses for future work in OT. For tone, previous work (e.g., Odden 1996, Inkelas 1998) has emphasized the complexity

of morphological and syntactic conditioning on tone patterns of languages like Hausa and Kimatuumbi. As far as I know, very few thorough analyses of the tonal grammar of a single language exist in OT that address these complexities in a comprehensive analysis. (Cassimjee (1998) and Cahill (1999) are notable exceptions.) For both tone and vowel harmony, the ODT theory I have defended here is very controversial, in spite of having been taken up – and renamed Headed Span Theory – by McCarthy (2004). There is certainly more work to be done to test this theory on other prosodic systems. As McCarthy (2004) points out, in fact, the formalization of assimilation – the most basic autosegmental process – remains an unsettled issue in OT. For reduplication, there is also much work to be done to test the claim that reduplicative shape follows from the canonical form of the reduplicative morpheme's morphological category. As Inkelas & Zoll (2005) and Downing (2006) show, it is not always obvious what morphological category to assign a reduplicative morpheme to. The variety of current OT analyses for the well-studied Yoruba genitive reduplicative pattern (Akinlabi 2006, Orié 1998, Pulleyblank 1988, Inkelas & Zoll 2005, Downing 2006) attest to the fact that there are still puzzles to be found in looking at familiar data through the prism of a new theory.

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