

CHAPTER 3

CASE STUDY ON SHIMAKONDE

3.1. BACKGROUND

This chapter will focus on the three opaque phonological interactions found in Makonde, a Bantu language of the P.23 sub-grouping. The most closely related languages are Mwera, Yao, Mkhwa and Maatumbi (Guthrie, 1948; Manus 2003) and it is spoken by approximately 1.2 million people in northeast Mozambique and southwest Tanzania (Manus, 2003). Two varieties of Makonde are of particular interest: *Shímákoonde*, documented in Liphola (2001), primarily spoken in south east Mozambique, and *Símákoonde*, documented in Manus (2003), spoken on the island of Unguja, Zanzibar and the main port city of Tanga. Differences between the two varieties are minimal with respect to the phonological processes discussed below and are noted when relevant. Additional data from other varieties of Makonde, Chimaraba and Chimahuta (Odden, 1990), are used when appropriate.

Briefly, there are three processes – vowel reduction, vowel coalescence and vowel harmony – that all interact opaquely with each other. Vowel harmony over-applies with respect to vowel reduction; vowel reduction under-applies with respect to vowel coalescence; and vowel harmony also under-applies with respect to vowel coalescence. I argue that the overarching generalization that these distinct cases of opacity embody is that Shimakonde reflects an input-output mapping that can be accounted for with Diagonal Correspondence Theory (DCT; chapter 2).

The organization of this chapter is as follows: §3.2 details vowel reduction in

Shimakonde referencing its stress system and vowel inventory while §3.3 and §3.4 discuss the harmony and coalescence processes respectively. §3.5 shows how these three processes interacting opaquely and §3.6 shows why the Shimakonde data are problematic for surface-based approaches to phonology, particularly OT. Finally, in §3.7 I show how the opaque relationships can be accounted for with DCT.

3.2. VOWEL REDUCTION

Discussing the details of vowel reduction in Shimakonde requires an understanding of the vowel inventory and stress system.

3.2.1. Stress

Shimakonde words have penultimate stress realized as vowel lengthening in citations forms. The vowel of the root is long when it is in the penult (1a), but short when unstressed (1b,c). Suffix vowels that are otherwise short are also lengthened in the penultimate syllable (1b,c).

(1) Vowel lengthening

- a) kú-píínd-a ‘to bend’
- b) kú-pínd-ííka ‘to be bent’
- c) kú-pínd-ík-ííl-a ‘to be bent for’

Long vowels can also result from adjacent hetero-morphemic short vowels. When the vowels differ coalescence or glide-formation occurs (§3.4) but when the two vowels are

the same, the result is simply a long vowel. The existence of unstressed long vowels suggests that the process in (1) is stressed syllable lengthening as opposed to pre-tonic shortening.

(2) Shimakonde vowel fusion yielding non-penultimate long vowels

- a) /tu-nda-akaáta/ tunda**a**akaáta ‘we will take a bit’ (cf. akaáta ‘take a bit!’)
- b) /va-nda-alal-a/ vanda**a**álaála ‘they will be beautiful’ (cf. alaala ‘be beautiful!’)
- c) /va-nda-amat-a/ vánda**a**amaáta ‘they filter’ (L. p.193)

Finally, lengthening is a post-lexical process as evidenced by the fact that when two or more words are combined into an (intonational) phrase, only the penultimate syllable of the whole phrase is lengthened (3):

(3) Post-lexical application (from Chimaraba and Chimahuta dialects)

- a) /kú-pínd-a málombe/ kúpínda máloombe ‘to bend maize’
(Odden, 1990)
*kúpíinda máloombe (only as citation forms)
- b) /kú-kolom-a li-kolomódi/ kúkoloma likolomoódi ‘to cough (a cough)’
(Odden, 1990)

3.2.2. Vowel system

In the stressed penultimate syllable, all five of Shimakonde’s vowels can be realized:

(4) Minimal pairs for Shimakonde vowels

- a) kúpááta ‘to get’
- b) kúpééeta ‘to sift’
- c) kúpííita ‘to pass’
- d) kúpóóota ‘to twist’
- e) kúpúúuta ‘to wash’

Length is not contrastive within a morpheme, so Shimakonde has a five-vowel system characteristic of many other Bantu languages such as Punu (Blanchon, 1995), Yaka (Ruttenberg, 1971; Hyman 1998), Kongo (Hyman, 1999), Luganda (Katamba, 1993), Zulu (Downing, 1990), and Pende (Niyonkuru, 1978):

(5) Shimakonde’s 5 vowels

i u
e o
a

3.2.3 The process of reduction

Limiting the quality of vowels that can appear in pre-tonic syllables is a process of vowel reduction where mid vowels (*e*, *o*) are optionally reduced to *a* (e.g. the mid vowel *e* of the root *pet* is preserved in tonic position, but is reduced to *a* in pre-tonic position (6b)). When reduction applies, only the peripheral vowels – *i*, *u* and *a* – can be realized in pre-tonic syllables.

(6) Vowel reduction

- a) kú-piit-a kú-pitáána ‘to pass (each other)’
- b) kú-puút-a kú-pútáána ‘to wash (each other)’
- c) ku-péét-a kú-pátáána ‘to sift (each other)’
- d) ku-poót-a kú-pátáána ‘to twist (each other)’
- e) kú-páát-a kú-pátáána ‘to get (each other)’

Contrasting *kú-pátáána* ‘to sift each other’ (6b) and *kú-páátáána* ‘to get each other’, for example, exhibits the neutralizing nature of reduction.

3.2.4 Reduction as complete neutralization

Supporting the idea that Shimakonde reduction is not simply the result of phonetic implementation or articulatory ease is the fact that the neutralization in Shimakonde is complete, even in citation form. Production data provided by Liphola (2001) shows that reduced mid vowels are acoustically indistinguishable from underlying /a/ in duration and formant frequency (7). Data from perception experiments similarly show that the reduced mid vowels are auditorily indistinguishable from underlying /a/ as well.

(7) Acoustic data from Liphola (2001)

	Duration (ms)	F1	F2
/a/ [a]	125	741	1558
/e/ [a]		761	1542
/o/ [a]		814	1575
/e/ [e]	129	749	1703
/o/ [o]	120	777	1380

While Liphola's measurements of elicited speech suggests that there is phonetic identity between reduced /e/→[a] and underlying /a/→[a], it would be surprising if all of the reduced vowels in (9) – particularly the vowel between reduced and unreduced pre-tonic vowels (e.g. the 2nd *a* in kú-páávélélééla) – showed no phonetic trace of having been an underlying mid-vowel. Unfortunately, the phonetic measurements were only done on simple examples such as those in (6). Furthermore, no sociolinguistic, dialectal or discourse factors have been reported as the source for this variation. So, it is not clear whether the alternants (e.g. those in 9) are in free variation or whether the reduced or partially reduced forms are used in fast-speech, for example. As noted above, citation production in the elicitation experiment can yield a reduced form, so even a speech-style account would be incomplete

3.2.5. Variability and CORE

Despite the phonetic completeness of the neutralization, reduction is variable. Mid vowels reduced to *a* and unreduced mid vowels are in variation in pre-penultimate position:

(8) Vowel reduction¹

	<u>Reduced</u>	<u>Unreduced</u>	
a)	kúpátáána	~ kúpétáána	'to sift each other'
b)	kú-pátáána	~ kú-pótáána	'to twist each other'

¹ The reduction documented for Simakonde (Manus, 2003) is slightly different and the rest of this section reflects the Shimakonde variety. In Simakonde reduction is obligatory for pre-tonic *e* while it does not apply to pre-tonic *o* (e.g. /-tend-/ kútándééla 'do something to someone' vs. /-tot-/ kútóteedya 'faire cuire' p.143). It is not clear that this generalization always holds, however: /-bom-/ kúbámóóka 'to be destroyed' (p. 168). Indeed, the reported data seems to reflect some freedom and variation similar to that reported in Shimakonde, though there is not enough data to assess the actual behavior.

Variation is neither all-or-nothing nor locally optional (e.g. Wilson & Riggle, 2004) in that it does not apply to either all or none of the reducible vowels (all-or-nothing) nor to each individual vowel independently (locally optional). Instead, reduction is governed by what Liphola (2001) refers to as ‘contiguity of reduction (CORE)’ which states that reduction begins at the left edge and proceeds rightward any number of vowels, so long as there are no gaps. For example, in the verb in (9), either none of the pre-penultimate mid vowels can be reduced (9a), all of the mid vowels may be reduced (9b) or one, two or three contiguous mid vowel may be reduced (9c), while unreduced mid vowels intervening between reduced vowels yields ungrammatical forms (9d).

(9) Contiguity of Reduction, in more detail

- a) /kú-pélévélél-íl-a/ kú-pélévéléleéla ~ (unreduced) ‘to not reach a full size for’
- b) kú-páláváláleéla ~ (fully reduced)
- c) kú-páláváléleéla ~ (partial reduction)
- kú-pálávéléleéla ~
- kú-pálévéléleéla
- d) *kú-péláváláleéla ~
- *kú-páléváléleéla ~
- *kú-péléváléleéla

3.2.6. Reduction as post-lexical

Evidence that reduction is post-lexical comes from a number of sources. First, reduction

applies across the board and is variable, qualities of traits of post-lexical phonology. Second, the process that defines the domain for reduction, penultimate syllable lengthening, is post-lexical (3). Thus, to assess what may be targeted by reduction, one must first determine the penultimate syllable of the whole intonational phrase, and not just the word. Finally, the minimal amount of data for the reduction of multi-word phrases bears this out:

(10) Post-lexical reduction:

a) /ku-telek-al-a malombe/ kutálákálá máloombe ‘to cook maize for’

Additional data is needed including further examples similar to (10) as well as data on the reduction of coalesced mid vowels resulting from post-lexical coalescence.

3.2.7. Reduction: Positional Neutralization or Positional Licensing?

To this point, I have been informally referring to reduction as pre-tonic neutralization starting at the left edge, proceeding rightward. An alternate characterization of the data in (9) instead posits that mid vowels are licensed by the penultimate syllable and are optionally licensed in contiguous syllables leftward (Downing, 2006 following Walker, 2005). Thus, instead of Contiguity of Reduction, the principle at play could instead conceivably be Contiguity of Licensing (COOL). Thus, in the grammatical form *kúpá[lévéléleél]a*, (9b), the tonic has a mid vowel, as do the three contiguous syllable to its left. Mid vowels outside of this domain are not licensed, and are thus reduced to *a*. By this reasoning, **kúpálévá[léleé]la* is correctly ungrammatical: the domain licensed by the

Further counter-evidence comes from the irreducible nature of the final vowel (12). While these data fall out directly from describing reduction as applying contiguously from the left, stopped by the tonic syllable, a positional licensing account would have to stipulate a completely independent licensing domain for the final vowel (c). Therefore, the data in Shimakonde suggest that positional neutralization (Beckman, 1998) is the more appropriate description.

3.3. HARMONY

Whereas the reduction process discussed above is rare, if not unique, among Bantu languages, Shimakonde exhibits what Hyman (1999) refers to as canonical Bantu vowel height harmony (VHH) which has the following characteristics:

(13) Canonical Bantu VHH

- a) Morphological:
 - i) Root controlled
 - ii) Targets derivational suffixes
 - iii) Does not affect prefixes
 - iv) Does not effect the final vowel
- b) Phonological
 - i) Mid-vowels (e, o) trigger harmony
 - ii) Closed vowels (i, u) subject to harmony
 - iii) Low vowel (a) opaque with respect to harmony
 - iv) Asymmetric wrt to front/round trigger (e does not trigger u→o).

In Shimakonde, when the last vowel in the verb stem is *i*, *u* or *a*, the suffixes' vowels surface as *i* but harmonizes to *e* when following a stem-final mid vowel:

(14) Basic Shimakonde vowel height harmony (VHH)

Applicative Causative Passive

a) High/low vowel root

kú-páát-a	kú-pat-ííl-a	ku-pat-iyy-a	ku-pat-igw-a	‘to get’
kú-píkíít-a	kú-píkíít-ííl-a	ku-pikit-iyy-a	ku-pikit-iyy-a	‘to play’
kú-púút-a	ku-put-ííl-a	ku-put-iyy-a	ku-put-iyy-a	‘to wash’

b) Mid vowel root

kú-téléék-a	kú-télék-éél-a	ku-telek-eeey-a	ku-telek-eeegw-a	‘to cook’
ku-tóót-a	ku-tot-éél-a	ku-tot-eeey-a	ku-tot-eeegw-a	‘to sew’

Also, VHH is iterative in that it doesn't simply apply to suffixes adjacent to the root, but spreads rightward until the final vowel:

(15) VHH iterative (unreduced forms):

- a) ku-peleveel-a ‘to lose balance’
- b) ku-pelevel-eel-a ‘to lose balance for’
- c) ku-pelevel-el-eel-a ‘to well lose balance for’
- d) ku-pelevel-el-el-eeek-a ‘to cause to well lose balance for’

VHH is blocked from spreading to the right of a suffix with an *a* (16a) and when the mid-

vowel is not the final vowel of the stem (16b). There is also a single suffix – the perfective - that is immune to harmony (16c). Historically, the vowel in this suffix is derived from the Proto-Bantu degree on **i* which has since merged with degree two **i*. This particular suffix is immune to VHH in many other Bantu languages as well (e.g. Runyankore; Poletto, 1998: *a-rééb-ire*).

(16) Exceptions to VHH

- | | | | |
|----|---------------|------------------|-------------------------|
| a) | lek-an-ííla | (*lek-an-ééla) | ‘leave for each other’ |
| b) | kú-ténúk-ííla | (*kú-ténúk-ééla) | ‘to imbalance for’ |
| c) | va-pet-iil-e | (*va-pet-eel-e) | ‘when they have sifted’ |
| | va-pínd-ííl-e | | ‘when they have bent’ |

Finally, Shimakonde also exhibits asymmetric harmony with respect to front and round mid vowels.

(17) Shimakonde front/round asymmetry:

- | | | | |
|----|---------------|-------------------|----------------------|
| a) | ku-shim-uuk-a | ‘to be closed’ | |
| | ku-bom-ook-a | ‘to be destroyed’ | (Manus, 2003 p. 168) |
| | ku-pet-uuk-a | *petooka | ‘to be sifted’ |
| b) | ku-shim-iila | ‘to close for’ | |
| | ku-tot-eela | ‘to sew for’ | |
| | ku-pet-eela | ‘to sift for’ | |

3.4. Vowel Coalescence

When two vowels come together without an intervening consonant, Shimakonde exhibits vowel fusion that is also found in most Bantu languages (e.g. Haya, Bemba, Punu, Runyankore; Downing, 1995; Casali, 1998; Poletto, 1998; Hyman, 2003). A number of different vowel combinations fuse to long vowels as shown in (20).

(18) Vowel Coalescence

a) Low+Low → Low (repeated from (2))

/a+a/ → aa

akáát-a ‘move!’ vandaákaata /va-nda-ákat-a/ ‘we will move’

b) Low + mid → mid

/a+e/ → ee

eéka ‘laugh!’ tundeéka /tu-nda-éka/ ‘we will laugh’

/a+o/ → oo

oóma ‘pierce!’ tundoóma /tu-nda-óma/ ‘we will pierce’

c) High + mid → mid

/a+i/ → ee

íípm ‘deny!’ tundeéma /tu-nda-ím-a/ ‘we will deny’

/a+u/ → oo

uúnga ‘tie!’ tundoónga /tu-nda-ung-a/ ‘we will tie’

The data in (b) show that *a* plus a mid vowel coalesce into a long mid vowel, while (c) show that *a* plus a high vowel similarly coalesce to a long mid-vowel. Liphola (2001)

demonstrates the phonetic identity of the examples in (b) and (c) with acoustic data and so this process is neutralizing in the sense that underlying contrasts are lost in the surface.

Finally, coalescence does not occur across word boundaries and is therefore not post-lexical; it does occur between prefix and verb-stem and is therefore word-level:

(19) Fusion as word-level

- | | | |
|-----------------------|------------------|------------------------------------|
| a) /kaleka u-lot-ile/ | kaléká ulotiile | ‘If you want to...’ (Manus, p.202) |
| | * kalékoolotiile | |
| b) /ma-ina/ | méena | ‘Names’ |

When the initial vowel is high and the second vowel is low, fusion results in a glide+long vowel for both nouns (20a) and verbs (20b):

(20) Vowel fusion leading to glide formation:

- | | | |
|---------------|----------|------------|
| a) /sagu-elo/ | ságwéélo | ‘bathroom’ |
| b) /ku-ak-a/ | kwááka | ‘catch’ |
| /ku-imb-a/ | kwíimba | ‘sing’ |

3.5. OPACITY

All three processes described above interact opaquely with each other. To summarize the interaction before going into detail: Reduction counter-bleeds VHH resulting in over-application of VHH, vowel coalescence counter-feeds VHH producing under-application of VHH and coalescence counter-feeds reduction producing under-application of

reduction.

3.5.1. VHH and Reduction: over-application

The opaque interaction of VHH and reduction is shown in (21). The vowel in the suffix harmonizes to *e* because of the mid vowel in the UR of the root, which is reduced to *a* in the SR.

(21) Opaque interaction

- a) /va-ndá-tot-íl-a/ va-nda-tát-ééla ‘they will sow for’
b) /va-nda-šém-íla/ va-nda-šám-ééla ‘they will call for’

In a rule-based approach, the two rules are in a counter-bleeding relationship:

(22) VHH-Reduction opacity as counter-bleeding

	/va-nda-šém-íl-a/		/va-nda-šém-íl-a/
Harmony	va-nda-šém-ééla	Reduction	va-nda-šám-ííl-a
Reduction	va-nda-šám-ééla	Harmony	n/a
	[va-nda-šám-ééla]		*[va-nda-šám-ííla]

Further evidence that harmony interacts with reduction comes from the feeding relationship between the two for different underlying representations where the high vowel of the causative suffix /idy/ surfaces with a reduced vowel.

(23) Examples of harmony feeding reduction

a) /kú-tót-ídy-an-a/ → kútótódyana → kútátádyana
‘they cause each other to sew’

Reduction only applies to mid-vowels whereas in (23) it applies to what underlyingly is a high vowel. The high vowel suffix must therefore also be subject to the VHH triggered by the mid-vowel in the root.

The examples in (22) are cases of over-application opacity in that the VHH over-applies in the surface form because the trigger of harmony – the root’s mid-vowel – does not appear. Thus change of the suffix vowel from /i/ to [e] is an over-application of the process in question.

3.5.2. Reduction and Coalescence

As shown above, two different combinations of vowels coalesce into a long mid vowel and though the phonetic realization is the same, the two combinations interact differently with respect to reduction (and harmony; §3.5.3). Reduction can apply to a mid vowel that results from the coalescence of a low and mid-vowel:

(24) Transparent interaction of coalescence and reduction.

a) /va-nda-ék-an-a/ vandaákáána ‘they will laugh each other’
 /va-nda-ép-an-a/ vandaápaána ‘they will harvest each other’
b) /va-nda-ód-an-a/ vandaádaána ‘they will follow each other’

Reduction of this sort and vowel coalescence are in a transparent mutually feeding relationship since *a+a* also fuses to long *a*. Mutually-feeding relationships can also be understood as a rule relationship where ordering doesn't matter:

(25) Rule ordering of coalescence and reduction:

	/va-nda-ek-an-a/		/va-nda-ek-an-a/
Coalescence	vandeekana	Reduction	va-nda-ak-an-a
Reduction	vandaakana	Coalescence	vandaakana
	[vandaákaána]		[vandaákaána]

The other interaction – of low+high vowel coalescence and reduction – is opaque, however, as mid vowels formed by the coalescence of a high and low vowel are resistant to reduction and stay mid:

(26) Non-reduction of mid vowels resulting from low+high vowels

a)	/va-nda-ím-an-a/	vandeémaána	*vandaámaána	‘they will deny each other’
	/va-nda-itík-a/	vandeétiika	*vandaátiika	‘they will respond’
b)	/va-nda-úkand-a/	vandoókaanda		‘the will wash’
	/va-nda-úkul-a/	vandoókuúla		‘they will dig’

Despite being in pre-tonic position where mid vowels are usually reduced to *a*, as in (6), the mid vowels formed by the fusion of *a* and *i/u* always surface as *ee/oo*. Coalescence

counter-feeds reduction since reduction does not affect high vowels (cf. *kúpitáána* ‘to pass each other’):

(27) Non-reduction of mid vowels resulting from low+high vowels

	/va-nda-ím-an-a/		/va-nda-ím-an-a/
Reduction	--	Coalescence	vandeémaána
Coalescence	vandeémaána	Reduction	vandaámaána
	[vandeémaána]		[*vandaámaána]

The surface forms, e.g. *vandeémaána*, exhibit under-application of reduction and the relationship can be construed as an opaque chain shift (§1.4). This chain shift presents a well-known problem for OT as shown below (§3.7; see also Kirchner, 1996).

(28) Reduction/coalescence opacity as chain shift

a) a+i → ee	b) ee → aa	c) a+i ↗ aa
A → B	B → C	A ↗ C

3.5.3. Coalescence and VHH

The final case of opacity results from the interaction of coalescence and VHH. As with the interaction of coalescence and reduction, the coalescence of low and mid vowels interacts transparently with VHH while the coalescence of low and high vowels yields an opaque relationship.

In the interaction of the coalescence of low+mid and VHH the resulting mid

vowel triggers VHH in the suffix: The coalesced mid vowel surfaces as *a* in (29a) because reduction also applies, while the mid vowel that results from the VHH can surface as mid because it is in tonic position. However, as noted above, reduction is variable and the unreduced form more clearly shows the VHH (29b).

(29) Interaction of low+mid coalescence and VHH:

- a) /vanda-ep-íla/ vandaápeéla ~ (reduced) ‘they will harvest for’
- b) vandeépeéla (unreduced)

As rules, the two can apply simultaneously – there is no crucial rule ordering – feeding or otherwise – because of the VHH-triggering *e* in the UR stem:

(30) Transparent rule ordering of coalescence and VHH:

	/vanda-ep-íla/		/vanda-ep-íla/
a) Coalescence	vandeepila	b) VHH	vandaepela
VHH	vandeepela	Coalescence	vandeepela
(Reduction	vandaapela)	(Reduction	vandaapela)
	[vandaápeéla]		[vandaápeéla]

In direct contrast with the transparent interaction of low+mid vowel coalescence and VHH, the mid vowel that results from the coalescence of a low+high vowel does not trigger harmony as the suffix, normally susceptible to harmony, surfaces as high:

(31) Interaction of low+high coalescence and VHH:

- | | | | |
|----|-----------------|-------------|---------------------|
| a) | /vandá-im-il-a/ | vandeemíila | ‘they will dig’ |
| | /vandá-itík-a/ | vandeétiika | ‘they will respond’ |

(32) Opaque rule ordering of coalescence and VHH:

	/vandá-îm-íla/		/vandá-im-íla/
a) VHH	--	b) Coalescence	vandeepiila
Coalescence	vandeeiila	VHH	vandeepeela
	[vandeémíila]		[*vandéémeéla]

The contrast between the two types of opacity (also discussed in chapter one) involving reduction is particularly interesting because one is over-application opacity and the other is under-application. Also, the two cases of under-application opacity involving coalescence have perhaps a bit of counter-intuitive ramification: Long mid vowels that never reduce do **not** trigger harmony, while those that can reduce to *a* **always** trigger harmony.

3.5.4 Interim Summary

Examples of the opaque interactions are as follows:

(33) Opaque interaction in Shimakonde:

- | | | | | |
|----|--------------------|-------------------|---------------------|-------------------|
| a) | VHH + reduction: | /va-nda-ŷem-il-a/ | vandaŷameela | Over-application |
| b) | VHH + coal.: | /va-nda-im-il-a/ | vandee <i>i</i> ila | Under-application |
| c) | coal. + reduction: | /va-nda-im-an-a/ | vandee <i>a</i> ana | Under-application |

The interactions are summarized in table 1 in terms of their extrinsic rule ordering:

Rule 1	Rule 2	Surface result	Rule interaction
Opaque			
VHH	Reduction	over	Counter-bleeding & Feeding
VHH	a+i coalescence	under	Counter-feeding
Reduction	a+i coalescence	under	Counter-feeding
Transparent			
VHH	a+e coalescence		Mutually-feeding
Reduction	a+e coalescence		Mutually-feeding

A common observation underlies all three opaque relationships, independent of the actual type of opacity involved. The observation is that whether a process applies or not is dictated by the UR, rather than the SR. Thus in (a), the realization of the affix as mid is dictated by the mid vowel in the UR of the stem. Similarly in (b), the realization of the affix as high is also dictated by the lack of a mid vowel in the UR of the stem. Finally, whether a vowel can reduce or not in (c) is also based on whether the vowel is mid in the input. A characterization of opacity in Shimakonde would capture ideally all three generalizations with the same formal mechanism.

3.5.6 The Inadequacy of Surface-based Approaches

The forms in (33) are problematic for any surface based approach to phonology because while the opaque forms motivate rejecting the generalization in question (the first of the two generalization listed in each pair), the transparent forms show that the generalization does hold and does reflect productive phonological knowledge.

The form in (33a) is problematic for any surface based approach because the mid vowel trigger of VHH is no longer present in the surface representation. So, while roots with an underlying and surface vowel of /a/~[a] transparently receive the *-il-* form of the

applicative suffix, the opaque form in (33a) with underlying /e/ and surface [a] takes the *el* form. Thus, contra OT, it is not the surface form of the verb that determines the realization of the suffixes, which are identical for (33a), rather it is the underlying form.

The OT formalism appropriately captures the difficulty that surface based approaches have with over-application through a constraint-ranking problem for the opaque surface form in (33a). As with all cases of over-application, the problem is one of harmonic bounding of the actual form by an ungrammatical transparent form. The constraint ranking for VHH requires HARMONY » FAITH and REDUCE » FAITH², but the actual ranking is immaterial for this opacity because the SR *vandaǰámééla* incurs more faithfulness violations than the transparent, but ungrammatical, form *vandaǰámiíla* without improving the overall harmony³ of the SR in any way. No conceivable ranking of constraints will result in *vandaǰámééla* being a better candidate than *vandaǰámiíla*. This constraint violation pattern does communicate the basic problem: In the surface form, with the VHH trigger reduced to *a*, there is no reason for the suffix to incur a faithfulness violation and surface with a mid-vowel:

(34) Opaque interaction in OT

/va-nda-shém-íla/	ID(HEIGHT) _{PENULT}	HARMONY	REDUCE	ID(HEIGHT)
(a) ← va-nda-shám-eéla	* _i			*
(b) ⊕ va-nda-shám-ííla				*
(c) va-nda-shém-eéla			*	

The transparent feeding interaction in (25a) proves to not be a problem for standard OT:

² The constraints HARMONY and REDUCE are used here temporarily, and are formalized in more detail below when an account of Shimakonde is presented.

³ Harmony in the general OT sense, not in the VHH sense.

(35) Transparent interaction in OT

/kú-tót-ídy-an-a/	REDUCE	HARMONY	ID(HEIGHT)
(a) →kútótádyana			*
(b) kútótídyana	*	*	
(c) kútótédyaana	*		*

The two other opaque relationships are instances of under-application and result in a ranking paradox only when juxtaposing the opaque and transparent forms. Reduction and harmony require some sort of rule or constraint ranking to drive the process. The transparent forms appropriately reflect the application of these processes in the surface form while cases of under-application violate the rule or constraint ranking and the process under-applies.

For example, all the transparent cases of reduction motivate a REDUCE » IDENT(HEIGHT) ranking – otherwise, reduction would never apply. In the opaque forms, however, the same constraint ranking would select the incorrect form:

(36) OT:

/va-nda-ím-an-a/	ID(HEIGHT) _{STRESS}	ONSET	REDUCE	ID(HEIGHT)
(a) vandáímaana		*!		
(b) ⊕vandeémaána			**	
(c) ←vandaámaána				*

So, in contrast with the previous instance of opacity where no constraint ranking possible could generate the correct output, it is only by comparison with existing transparent forms do the forms become opaque since the reverse ranking (of ID(HEIGHT) and REDUCE) would produce the correct opaque form, but the incorrect transparent form:

(37) Constraint ranking to yield opaque form w/ incorrect transparent form

Opaque a) /va-nda-ím-an-a/	FAITH _{STRESS}	ONSET	ID(HEIGHT)	REDUCE
vandaímaana		*!		
→vandeémaána				**
vandaámaána			*	
Transparent b) /va-nda-ek-an-a/				
vandaekana		*!		
vandaakana			*!	
←vandeekana				**

Finally, the other case of under-application – coalescence and harmony – similarly reflects a ranking paradox between transparent and opaque forms. The unreduced forms are shown to facilitate exposition.

(38) Opaque constraint ranking

a) /va-nda-ím-il-a/	ONSET	HARMONY	ID(HEIGHT)
vandaímiila	*		
←vandeémiila		*	**
⊖ vandeemeela			***
b) /va-nda-ek-il-a/			
vandaেকেলা	*!		
vandeekaala		*!	**
→vandeেকেলা			**
c) /va-nda-pet-il-a/			
→vandapeteela			*
vandapetiila		*	

Because of examples like (33a) where harmony is not true of surface forms, basic OT would be required to posit that the harmony process is not a productive generalization of the language. However, the example in (33c) and the productivity of the harmony process suggest otherwise.

3.6 SHIMAKONDE OPACITY AS DC

In this section, I show that the above opaque relationships may be accounted for through the use of diagonal correspondence. The first two sub-sections articulate a formalization of DC harmony and reduction, while the last three account for each of the opaque relationships.

3.6.1 Blocking with Agreement By Correspondence

As discussed above, a crucial problem with previous approaches to harmony via agreement is the inability to account for harmony blocking in a language like Shimakonde, where a vowel sharing the same feature as the harmonic feature acts as a blocker of harmony. While ABC was originally described as being unable to support the blocking of agreement for any situation, this section shows that ABC can, in fact, account for blocking, including of the type found in Shimakonde (Inkelas, 2008; Rhodes, 2008).

The property of non-blocking for the ABC formalization of harmony is based on a global evaluation of correspondence and agreement: Nowhere in (10) is any sort of adjacency required and every segment in the string is evaluated with respect to every other. This leads to some curious pathologies which motivated Hansson (2006, 2007) to argue for globality of correspondence, but locality of agreement where agreement is evaluated only for adjacent corresponding segments. This reformulation can yield blocking.

The pathology he observes is similar to the one raised by Wilson (2003) and McCarthy (2005) of a majority rule effect wherein the number of segments changing dictates what type of harmony is found. For example, in a hypothetical language that has

left-to-right [anterior] agreement among all sibilants, agreement would be enforced by a ranking of CORR- $\check{C} \Leftrightarrow Z$, correspondence amongst all stridents, and ID[ANT]-C_LC_R above ID[ANT]-IO:

(39) Hypothetical sibilant agreement

/tʃ...s/	CORR- $\check{C} \Leftrightarrow Z$	ID[ANT]-C _L C _R	ID[ANT]-IO
→ tʃ _x ...ʃ _x			*
tʃ _x ...s _y	*!		
tʃ _x ...s _x		*!	

If the language has a constraint against \check{z} , * \check{z} , then the behavior of a neutral z as either harmony-transparent or harmony-opaque is dependent on the number of faithfulness violations for sibilants to its right, which is based on their underlying form:

(40) Hypothetical sibilant agreement

/ʃ...z...S...S...S/	* \check{z}	CORR- $\check{C} \Leftrightarrow Z$	ID[ANT]-C _L C _R	ID[ANT]-IO
ʃ _x ...z _y ...ʃ _x ...ʃ _x ...ʃ _x		*!***		
ʃ _x ... \check{z} _x ...ʃ _x ...ʃ _x ...ʃ _x	*!			
→ʃ _x ...z _x ...ʃ _x ...ʃ _x ...ʃ _x			****	?
→ʃ _x ...z _x ...s _x ...s _x ...s _x			****	?

Compare, for example, the different surface forms that arise based on the underlying form of the rightmost sibilant. In this first case, z is harmony-opaque and blocks rightward spreading (the final sibilant is that target of [+anterior] spreading from the preceding s), while in the second case, having a different number of underlying [-anterior] segments renders the z harmony-transparent:

(41) Hypothetical sibilant agreement

/ʃ...z...s...s...ʃ/	*3	CORR-Č↔Z	ID[ANT]-C _L C _R	ID[ANT]-IO
ʃ _x ...z _y ...ʃ _x ...ʃ _x ...ʃ _x		*!***		*
ʃ _x ...ʒ _x ...ʃ _x ...ʃ _x ...ʃ _x	*!			
ʃ _x ...z _x ...ʃ _x ...ʃ _x ...ʃ _x			****	**!
→ʃ _x ...z _x ...s _x ...s _x ...s _x			****	*

(42) Hypothetical sibilant agreement

/ʃ...z...s...ʃ...ʃ/	*3	CORR-Č↔Z	ID[ANT]-C _L C _R	ID[ANT]-IO
ʃ _x ...z _y ...ʃ _x ...ʃ _x ...ʃ _x		*!***		*
ʃ _x ...ʒ _x ...ʃ _x ...ʃ _x ...ʃ _x	*!			
→ʃ _x ...z _x ...ʃ _x ...ʃ _x ...ʃ _x			****	*
ʃ _x ...z _x ...s _x ...s _x ...s _x			****	**!

To remedy this, Hansson argues that Identity should be evaluated locally, with violations based only on adjacent corresponding segments. While this solves the above pathology by selecting (d), the z-blocking candidate, in both of the above cases, another curious blocking phenomenon, mentioned but not fully examined in Hansson (2007) is still possible with this formalization of harmony.

As Hansson (2007) points out, if another segments is more similar to the target than the trigger, then it can also block agreement. While the below example presents this type of blocking as being dependent on the sequence of segments, with [z] blocking the spreading of [anterior] rightward, no such linear relationship is required as shown in the second tableau:

(43) Hypothetical sibilant agreement

/tʃ...z...s/	* ₃	CORR-Š↔Z	CORR-Č↔Z	ID[ANT]-CC	ID[ANT]-IO
→tʃ _x ...z _y ...s _y			**		
tʃ _x ...z _y ...ʃ _x		*!	*		
tʃ _x ...ʒ _x ...ʃ _x	*!			*	**
→tʃ _x ...z _y ...s _x				*	

(44) Blocking sibilant agreement

/tʃ...s...z/	* ₃	CORR-Š↔Z	CORR-Č↔Z	ID[ANT]-CC	ID[ANT]-IO
→tʃ _x ...s _y ...z _y			**		
tʃ _x ...ʃ _x ...z _y		*!	*		
tʃ _x ...ʃ _x ...ʒ _x	*!			*	**
→tʃ _x ...s _x ...z _y				*	

If /z/ were not in the input, then the output would be [tʃ...ʃ] and so ABC, even as reformulated, makes the odd prediction that a non-intervening segment can block the agreement of adjacent segments. Local agreement does not ameliorate the problem; instead, local correspondence is required, which would fix both (84) and (82). Local correspondence establishes correspondence relationships among adjacent participating segments only, instead of agreement holding across all segments.

(45) Blocking via phonotactic constraint of sibilant agreement

/tʃ...z...s/	* ₃	CORR-Š↔Z	CORR-Č↔Z	ID[ANT]-CC	ID[ANT]-IO
tʃ _x ...z _y ...s _y			*		
tʃ _x ...z _y ...ʃ _x		*!	*		
tʃ _x ...ʒ _x ...ʃ _x	*!			*	**
tʃ _x ...z _y ...s _x		*!	*		
→tʃ _x ...z _x ...s _x				**	

(46) Non-blocking of sibilant agreement by non-intervening phonotactic constraint

/tʃ...s...z/	* ₃	CORR-Š↔Z	CORR-Č↔Z	ID[ANT]-CC	ID[ANT]-IO
tʃ _x ...s _y ...z _y			*!		
→tʃ _x ...ʃ _x ...z _x				*	*
tʃ _x ...ʃ _x ...z _x	*!				**
tʃ _x ...s _x ...z _y		*!		*	
tʃ _x ...ʃ _x ...z _y					

3.6.2. Bantu harmony via correspondence theory

So, we can now account for harmony-opaque *a* in languages like Shimakonde (when there is no reduction rendering harmony opaque). Establishing harmony among vowels requires a set of correspondence constraints based on similarity. Since Bantu VHH for 5-vowel systems is among [-low] vowels, the constraint enforcing correspondence among [-low] vowels, CORR-E↔I is ranked highest. Since [high] agreement holds among [-low] consonants, ID-VV[Hi] is ranked next, and since *a* blocks harmony, ID-IO is ranked after that (compare (g) to harmony-transparent (h)). Ranked below these are the remaining correspondence constraints in the family which establish correspondence among [-high] vowels (CORR-A↔E) and all vowels (CORR-A↔I) which are inactive in Shimakonde.

(47) Bantu 5-vowel harmony using Correspondence Theory

/pet-il/	CORR-E↔I	ID-D[Hi]	ID-IO[Hi]	CORR-A↔E	CORR-A↔I
a) →pe _x t-e _x l			*		
b) pe _x t-i _x l		*			
c) pe _x t-i _v l	*				

/pet-an-il/					
d) pe _x t-a _y n-i _x l		*		*	*
e) pe _x t-a _y n-i _y l		*		*	
f) pe _x t-a _x n-i _x l		*			
g)→pe _x t-a _x n-i _y l					*
h) pe _x t-a _x n-e _x l			*		
i) pe _x t-a _y n-e _x l			*	**	
j) pe _x t-a _y n-e _y l				*	
k) pe _x t-a _x n-e _y l				*	

Harmony in Shimakonde, in particular, the harmony-opaque *a*, can be thus accommodated by establishing a correspondence between adjacent [-low] vowels and requiring [high] identity among corresponding segments. This also formally realizes the striking similarity between AGREE and IDENT noted above without resorting to the complicated theoretical machinery needed by Krämer (2001) to get blocking and transparency including constraint conjunction and ad-hoc constraints like BALANCE. In both cases, though, in addition to correspondences among identical input and output elements, the two approaches add a syntagmatic correspondence relationship among segments in the same output string.

3.6.3. DC Harmony

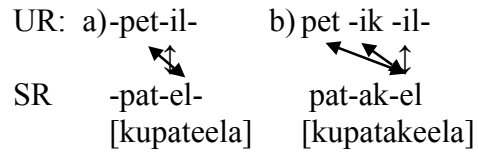
To account for opaque harmony with DC, the following DC constraint is necessary:

(48) Shimakonde Correspondence

- a) CORR-D-E_{STEM}-I_R: Let R be an input string of segments and S be an output string of segments and let X and Y be segments that are [+syllabic, -low] . If X∈R and Y∈S and both are members of the stem, then X is in diagonal correspondence with Y.

This constraint establishes the following correspondence relationships:

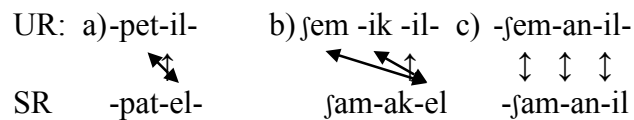
(49) Expanded correspondence in Shimakonde



Here, all of the [-low] vowels in the input and output macrostem are in correspondence with each other (diagonal correspondence also holds for the /-ik-/ suffix, but is not illustrated), so to account for harmony, all of the segments in correspondence can be made to agree with respect to the feature [-high].

These new correspondences are shown for the three crucial harmonic forms, which includes blocking (§2.2,5):

(50) Expanded correspondence in Shimakonde



In (a) and (b), all the [-low] vowels are in correspondence with each other, while in (c), the harmony-opaque low vowel is not in correspondence with the others because they don't share the low feature specification, and the [-low] vowels are not in correspondence because they are too far apart – they are not separated by just consonants.

Shimakonde harmony, and Bantu harmony in general, exhibits a number of asymmetries with respect to harmony that are all related to each other. First, [+high] does not spread, whereas [-high] does; second, spreading is left-to-right; third, affixes

harmonize to the root, but not vice-versa (i.e. the root doesn't harmonize to a prefix). These observations are all essentially the same one and cover the same empirical phenomenon. Expressing this asymmetry by positing [-high] spreads while [+high] does not would be stipulative and beg the question of why [-high] spreads given that for other features, the positive value spreads (e.g. nasalization; Walker, 2000). Expressing this asymmetry as being root-controlled (Clements, 1981), as argued in Bakovic (2000), accounts for all of the asymmetries as well as why only roots can be underlying mid but requires positing two separate domains, a stem including the root + suffixes, and a word consisting of prefixes + stem. With this assumption, [-low] vowels can then be made to agree with respect to [high].

3.6.4. Reduction

In this section I present an account for mid vowel reduction in Shimakonde. Reduction to the low vowel *a*, in lieu of a high or mid vowel may seem odd at first blush. Indeed, Lindblom (1990) argued that reduction was motivated phonetically by the minimization of articulatory effort or not being able to reach extreme articulatory targets during the short duration of a shortened vowel. So, many cases of vowel reduction change vowels to a high, mid or central vowel (e.g. Russian, Kenman 1975; Catalan, Mascaró 1978; Italian; English). However, Crosswhite (2003) highlights an entirely different type of vowel reduction that serves to enhance contrast, limiting perceptually challenging vowels to prominent positions. Whereas the former is typical of languages that shorten unstressed syllables, like English, the latter is typical of languages with length-based correlates of stress that do not shorten unstressed syllables, a typological category in which

Shimakonde squarely falls. Languages of this type favor corner vowels – *i*, *u*, and *a* – in unstressed position. In these systems, non-peripheral vowels typically neutralize to the most perceptually salient, sonorous vowel, *a*, which increases articulatory effort and presents a more extreme articulatory target in direct contrast with the other type of reduction. Shimakonde exhibits precisely this perceptual salience-based pattern of reduction with mid vowels neutralizing to the more perceptually salient *a*.

Another analysis (Barnes, 2002; Downing, 2006), presented in further detail in §3.8 as it has a bearing on the analysis of opacity, is based on an element-theory of the vowel system wherein *e* and *o* are complex vowels combining two elements (*a+i* and *a+u*, respectively) and reduction involves simplifying vowels to a single element. The *a* element represents the aperture node and *i* and *u* represent vowel place and so there are only two heights and reduction represents a loss of color for the open vowels *e*, *a*, *o* (i.e. those that include the *a* element).

In either case, the data for Shimakonde variation, in particular CORE, prove challenging for current OT accounts of variation and optionality. Anttila (1997), Kiparsky (1993), Boersma & Hayes (2001) and Cotzee (2008) all argue that phonological variation is best accounted for with variable constraint ranking. For example, for English *t/d* deletion (Guy, 1994), *cost* may be the most optimal output with MAX » *CMPLXCODA while its variant, *cos* reflects *CMPLXCODA » MAX. In Shimakonde this approach does not work.

For Shimakonde, suppose there is some markedness constraint banning mid vowels in penultimate position. The variable constraint ranking approach would posit that this is variably ranked with respect to a faithfulness constraint maintaining the quality of mid

vowels (ID[LOW]). While this variable alternation between M»F and F»M could account for the variation between full and no reduction (e.g. *kútálákaána* ~ *kútelékaána*) there is no reasonable constraint re-ranking that could generate the partially reduced forms (e.g. *kútelékaána*) (see tableau in 42). This is because each faithfulness violation – each reduction of a pre-tonic mid vowel to *a* - incurs an identical violation of ID(LOW). This is a problem for any type of variation involving more than two variants with a different number of identical faithfulness violations.⁴

(51) Correct evaluation of the opaque form

/ku-telek-an-a/	*[-LOW]/PRE-PENULT	ID(LOW)
(a)→kutelékaána	**	
(b)→katalákaána		**
(c) ? katalékaána	*	*

To account for reduction, recall that the generalization for reduction is that it neutralizes mid and low vowels to low in contiguous syllables starting at the left word edge up until the tonic. The difference between mid and low vowels is the specification of [low], and so reduction involves the substitution of [-LOW] with [+LOW] in the relevant domain. The domain of reduction, abbreviated here as σ , is anchored at the left edge using an undominated alignment constraints, Align (Reduction Domain, edge-L, Wd, edge-L) or ALIGN-L(RED, WD). If the alignment of the right edge of the reduction domain with the tonic were ranked above or below only ID(LOW), then the only variants would be

⁴ A solution using Harmonic Grammar (Smolensky & Legendre, 2006) may also be possible with cumulative violations of a weighted faithfulness constraint outranking markedness when enough violations accrue.

complete or no reduction. However, if there are multiple faithfulness constraints for each syllable in a fixed ranking based on its distance from the penult, then, the ranking of ALIGN-R(RED) with respect to this hierarchy would specify which syllables are in the domain of reduction and those that are outside the domain of reduction, abbreviated here as $\bar{\sigma}$.

(52) Family of faithfulness constraints to account for CORE:

- a) $ID(LOW)/\sigma_{penult} \gg ID(LOW)/\sigma_{penult-1} \gg ID(LOW)/\sigma_{penult-2} \text{ etc } \dots$

I use $*[-LOW]/\bar{\sigma}$ and $ID(LO)/\bar{\sigma}$ as shorthand for this approach to reduction.

3.6.5. Harmony & Reduction Opacity

Having established the constraint for reduction and opaque harmony, the evaluation tableaux for the three forms in (33) are shown in (44)-(46).

First, all *e*'s and *i*'s on the input and output are in correspondence and the [high] specification is shared by all segment in correspondence:

(53) Correct evaluation of the opaque form

$pe_x t-i_x l-$	$ID(LO)/\bar{\sigma}$	$*[-LOW]/\bar{\sigma}$	$CORRD-E \leftrightarrow I$	$ID(HI)-D$	$ID-IO(HI)$
$\rightarrow patee_x l$					*
$pe_x tee_x l$		*!			
$pa_x tii_x l$				*!	
$pa_x taa_x l$	*!				
$pa_x tii_y l$			*!		

Regardless of the number of affixes, the correspondence relationship holds for vowels

outside of the domain of reduction producing the mid vowel allomorph. This also accommodates the feeding relationship between VHH and reduction: underlying *-ik-* surfaces as *-ak-* when it is preceded by a root mid vowel and in the domain of reduction (e.g. ex. 23).

This is a crucial example for an input-based approach because of the existence of the intermediate form *-ek-* in the rule-based derivation of this form. Input-output constraints have problems with intermediate forms which lead to the rejection of two-level constraint (McCarthy, 1996). The difference here is that the input-output constraint is a faithfulness constraint so that it can still be dominated by a markedness constraint (here $*[-\text{LOW}]/\text{ø}$) yielding a feeding relationship and the intermediary form. Further discussion of input-output constraints, is in chapter two.

(54) Correct evaluation of the opaque form with harmony-transparent vowels

$-\text{she}_x\text{m}-\text{i}_x\text{k}-\text{i}_x\text{l}-$	ID(LO)/ $\bar{\text{o}}$	$*[-\text{LOW}]/\text{ø}$	CORRD-E \leftrightarrow I	ID-D(HI)	ID-IO(HI)
$\rightarrow\text{shamakee}_x\text{l}$					*
$\text{she}_x\text{mi}_x\text{ki}_x\text{l}$		*!			
$\text{she}_x\text{mi}_x\text{ki}_x\text{l}$				*!	
$\text{she}_x\text{mi}_x\text{ki}_x\text{l}$	*!				
$\text{shame}_x\text{kee}_x\text{l}$		*!			

This also selects the correct candidate for the form that is problematic for the positional licensing account, where an *a* is in tonic position:

(55) Correct evaluation of the opaque form with harmony-transparent vowels

-she _x m-i _x k-a _x n-	ID(LO)/σ	*[-LOW]/σ	CORRD-E↔I	ID-D(Hi)	ID-IO(Hi)
→[sha] _σ [me _x kaa _x l] _σ					*
shami _x kaa _x l		*!		*	
shame _x kee _x l	*!			*!	

Finally, *a* blocks correspondence among vowels to its right yielding the correct candidate with blocking:

(56) Correct evaluation of the opaque form with harmony-opaque vowels

/pe _x t-a _x n-i _v l/	CORRD-E↔I	ID-D(Hi)	ID-IO(Hi)	CORR-A↔E	CORR-A↔I
→pa _x ta _x nii _v la					*
pa _x ta _x nee _x la			*!		
pa _x ta _x naa _v la			*!		
pa _x ta _x nii _v la					
pa _x ta _x nii _v la	*!				

3.6.6. Coalescence & Harmony

The same idea applies to the opaque interaction of coalescence and harmony: The surface suffix vowels are in correspondence with the underlying root vowel. In the case of *a + e* coalescence, the suffix vowels, which are in correspondence with the underlying *e* must agree with it with respect to the feature [high] and so they surface as *e*. With *a + i* coalescence, the suffix vowels agree with the underlying *i* with respect to the feature [high] and so they surface as *i*. Crucially, the constraint enforcing identity between vowels that are in syntagmatic correspondence (S-IDENT in Krämer 2001; AGREE in Bakovic, 2001; ID-CC in Rose & Walker, 2004; ID-S here to maintain symmetry with ID-IO and ID-D), as opposed to diagonal correspondence, is low ranked. Therefore, VHH is not surface true. This is shown in the following tableaux:

(57) Transparent interaction of $a+e$ coalescence as input-driven

/-nda-e _x p-i _x l-/	CORRD-E↔I	ID(HI)-D	ID-IO(HI)	ID-S(HI)
→ndee _x pee _x l			*	
ndee _x p <i>i</i> i _x l		*!		
ndee _x p <i>i</i> i _v l	*	*!		

(58) Opaque interaction of $a+i$ coalescence using Diagonal Correspondence

/-nda-i _x m-i _x l-/	CORRD-E↔I	ID(HI)-D	ID-IO(HI)	ID-S(HI)
→ndee _x m <i>i</i> i _x l				*
ndee _x m <i>e</i> e _x l		*	*	
ndee _x p <i>i</i> i _v l	*			

3.6.7. Coalescence and Reduction

The opaque interaction of coalescence and reduction does not involve harmony and as such is not directly related to the discussion above with respect to diagonal correspondence. A number of solutions are possible, however – the solution presented here is to have two different types of mid vowels based on the fusion of the different input vowel features.

When $a+i$ fuse, the resulting feature set is [+low & +high, -low] and reduction deletes the [-low], which normally results in a reduced [+low] vowel. However, the remaining [+high] (recall that i and u do not reduce) yields an invalid combination of features [+high, +low]. Despite the illegality of this feature combination, it can be said to be resolved or articulated as an aggregate of the two features; as an e (Gnanadesikan, 1997). This approach captures the essence of the element based approach since it posits two different e 's, a normal [-high, -low] which is the result of $a+e$ fusion, and a [+high, +low] e , which is the result of $a+i$ fusion and is irreducible since it is already [+low] and

reduction has no impact on [+high] vowels.

On the other hand, for *a+e* coalescence, the deletion of [-low] leaves [-high, +low], or *a*.

(59) Feature resolution yielding different results with respect to reduction

	<u>Fusion</u>		<u>Reduction</u>		<u>Result</u>	
a)	a+i	+low / +high, -low	➔	*-low	➔	+high, +low
b)	a+e	+low / -high, -low	➔	*-low	➔	-high, +low

3.7. ALTERNATE APPROACHES

In this section, I briefly discuss a number of alternate approaches to Shimakonde opacity.

3.7.1. Morpheme selection

Some recent approaches to opacity suggest that opaque relationships are not productive as phonological processes and are only the result of allomorph selection (Sanders, 2003; Yip, 2003; Lee, 2004). This would suggest that the underlying form of the root selects the appropriate allomorph; in a form like *ku-fam-eela*, *-el-* is the applicative allomorph selected by the root *fem* while harmony would not be a productive phonological process in the language per se as it is violated in surface forms.

This has the unfortunately consequence of losing a generalization of the language from the main locus of phonological generalizations in the grammar (the constraint ranking in OT) and placing it into a different component – allomorph selection. Whereas some cases of allomorphy, in particular suppletive allomorphy, warrant an independent

allomorph selection process (Paster, 2006) doing so for all cases of allomorphy would miss the powerfully productive generalization that allomorphy is often driven by the phonotactics of a language. If one were to split the difference and argue that some cases of allomorphy are phonotactically driven and therefore part of the phonological grammar, while others are phonotactically arbitrary, the question becomes which type of allomorphy is exhibited by Shimakonde. Because the allomorphy in Shimakonde is ultimately a cross-linguistically common alternation and phonetically natural, ideally it should be captured in a phonological grammar.

Second, while this approach works for the selection of a single allomorph, it is problematic for cases like Shimakonde that exhibit feature spreading across a number of suffixes, which can also be blocked. Given the forms in (50), allomorph selection can logically proceed one of two ways for selecting the appropriate allomorph for the final applicative suffix.

(60) Allomorph selection:

- a) /va-nda-shem-ik-il-a/ vandashamakeela
- b) /va-nda-shem-an-il-a/ vandashamaniila

One option is that it can be selected by the verb root /-fem-/ which would produce the incorrect form for (50b) since /-fem-/ would select the *el* allomorph because of the mid vowel in the stem. This would be incorrect because the *-an-* suffix should block VHH. Alternatively, the adjacent morpheme can choose the appropriate allomorph so the realization of the applicative in (50b) would correctly be *il* because of the adjacent, non-

mid *an* suffix. This ends up being problematic for (50a) however, since the adjacent suffix to the applicative is *ik*, a non mid, which should select the *il* as the allomorph for the applicative.

This empirical shortcoming highlights the more general problem with this approach. It eschews using the phonological grammar for a lexically-driven sub-categorization approach. Doing so prevents the grammar from taking advantage of the representations and constraints that are part of the Phonology and necessary to account for a complex process like harmony that has harmony-transparent and harmony-opaque segments.

Finally, accounting for the opacity involving coalescence and reduction using morpheme selection would involve the counter-intuitive ungrounded requirement that *e*-initial verbs would select the reduced *a*-final allomorph for a prefix like *nda* over the *e* final variant that *i* selects (/ -nda-ep- / → [-nda-ap-] vs. / -nda-im- / → [-nde-em-]).

3.7.2. Strata

An alternate approach involves the use of strata, or levels. This could work for reduction and harmony as harmony applies at the stem level, and reduction at the post-lexical level. Crucially, this level-based approach cannot deal with the coalescence/harmony opacity and the harmony/reduction opacity that serve as the primary motivation for Diagonal Correspondence. If, reduction applies at the stem level, then this should bleed harmony if the interaction is evaluated transparently. This is not the case, however, as seen in a surface form like *ku-pat-eela*; instead, harmony counter-bleeds reduction at the stem level – an opaque relationship that requires an input-based solution.

(61) Incompatibility of a level-based approach with

a)	/vanda-ep-il-a/	b)	/ku-pet-il-a/
Stem:	ep-il-a		pet-il-a
Reduction	ap-il-a		pat-il-a
Harmony	--		--
Word:	vanda-ap-il-a		ku-pat-il-a
[...]			
Output:	*[vandaapiila]		*[kupatiila]

3.7.2 Element-based approach

The facts of Bantu VHH, coalescence, and reduction potentially possibly motivate an alternate representation to the traditional high/low feature proposal to better account for the patterning of the data. The problems with the featural account, summarized in Downing (2006), and noted independently elsewhere (Goldsmith, 1985; Harris, 1994, 1997; Hyman, 1999; Steriade, 1995; Cassali, 1998) are three-fold.

First, the vowel system reflects an opposition between mid vowels (*e, o*) and peripheral vowels (*i, u, a*) with the mid vowels being marked and the peripheral vowels unmarked. However, this does not correspond to a featural distinction in the traditional high/low system which suggests that *i, u* [+high], *a, e, o* [-high], *a* [+low] and *i, u, e, o* [-low] are natural classes. Instead, the peripheral vowels *a, i* and *u* that behave the same with respect to being immune to harmony share no common feature in opposition to the undergoer of harmony, mid [-low, -high] vowels. This problem is manifested in attempting to formalize harmony as the agreement or spreading of [-high] since *a*, which is harmony-opaque, is also [-high].

Second, coalescence is problematic for a traditional vowel representation. Liphola (2001) accounts for the resolution of features in both cases of coalescence by assuming that the mid vowels *e/o* are [-high, -low], high vowels *i/u* are [+high, -low] and the low

vowel *a* is [-high, +low]. Therefore, *a* and *i/u* coalesce into a mid vowel by contributing [-high] and [-low], respectively, while *a* and *e/o* coalesce into a mid-vowel by contributing [-low] and [-high], respectively. This begs the question of why *a* never contributes [+back] in its coalescence with *e* yielding [+back, -high, -low] in any languages and why *a* contributes a different feature to the coalesced vowel for each case.

Finally, the traditional feature system does not explain why reduction results in an [a] rather than an [i]. As discussed above, Shimakonde represents a type of reduction that eliminates complex or perceptually difficult vowels in non-prominent position. A constraint against mid vowels would be equally well accommodated by reducing them to [i], (which also reduces articulatory effort) as by the observed pattern of reducing to [a], yet this is never the case.

Harris and Lindsey (1995, 2000) propose an alternate element-based theory of vowels, which is rooted in the idea that vowels are made of combinations of privative elements, one of which is a head (heads are necessary for Shimakonde). For the five-vowel Bantu system, the elements are A, I and U which combine in the following way (with heads underlined). This representation better captures Crosswhite's generalization that mid vowels reduce because they are perceptibly more complex: mid vowels are representationally more complex (made up of two elements) and are therefore reduced, while the peripheral vowels form a natural class with respect to harmony and share the property of being simplex and having no dependents.

(62) Bantu five-vowel system – element theory

- a = [A]
- i = [I]
- u = [U]
- e = [A, I]
- o = [A, U]

Harmony, then, is the result of dependent elements spreading producing the mid vowel harmony (and never high or low) found in Bantu (54).

(63) Bantu harmony using the element theory of vowels

A /-e...i-/ I I	MAX(A)	SPREAD	ID(A)
(a) A \\ →-e...e- I I			*
(b) -i...i-	*		
(c) -e...i-		*	

Downing (2006) also argues that using this representation for vowels can explain the opacity involving coalescence and harmony. Coalescence yields the surface representations in (55) and ranking the faithfulness of dependent elements above the faithfulness of heads deletes the redundant A-head.

(64) Coalescence using element theory

a) a+i: /[A] + [I]/ → [A, I]

b) a+e: /[A] + [A, I]/ → [A, I]

The opposite ranking, with A as a head, proves problematic for vowel harmony, below.

This ranking of dependent faithfulness over head faithfulness accounts for why vowels are reduced to [a]. If, following Crosswhite, complex vowels are only licensed in prominent position, with complex vowels eliminated in pre-tonic position, then the ranking of dependent faith over head faith results in reduction as being the deletion of heads. So underlying *e* [A, I] and *o* [A, U] reduce to [A] yielding *a*.

This nicely accounts for the opaque interaction of coalescence with harmony. The opacity is due to the fact that (55a) has no dependent element to spread whereas (55b) does because the head-A deletes when in the same vowel as a dependent A:

(65) VHH with a+e coalescence, but not a+i

a) $\begin{array}{c} \underline{A} \ \underline{I} \ \underline{I} \\ | \ | \ | \\ \text{nda-im-il-a} \end{array} \rightarrow \begin{array}{c} \underline{A} \ \underline{I} \ \underline{I} \\ \ \backslash \ / \ | \\ \text{ndeemiila} \end{array}$

b) $\begin{array}{c} \underline{A} \ \underline{I} \ \underline{I} \\ | \ | \ | \\ \text{nda-em-il-a} \\ | \\ A \end{array} \rightarrow \begin{array}{c} \underline{I} \ \underline{I} \\ | \ | \\ \text{ndeemeela} \\ \ \backslash \ / \\ A \end{array}$

This does not account for the opaque interaction between coalescence and reduction, however. As shown above, the coalescence of *a + i* is not subject to reduction. However, the deletion of heads should allow (37a) to reduce to either simplex [A] or simplex [I]

yielding *a* or *i* as the reduced surface form of *a + i* coalescence. Furthermore, Downing (2006) suggests that the opaque interaction between reduction and harmony be accounted for with constraint conjunction – essentially claiming the element-based account is insufficient alone.

Finally, whereas the element theory posits that underlying vowels – both simplex and complex - have heads, the account here results in headless surface vowels. It is not clear whether this asymmetric constraint on underlying vs. surface vowel representation represents a fundamental flaw in the approach or whether the violability of constraints would accommodate this representation. This seems unlikely because if having a head is based on the ranking of a constraint, then richness of the base dictates that un-headed vowels should be included in the candidate set.

So, while changing representations can account for one of the opaque interactions in Shimakonde, it incorrectly predicts the behavior of the other, and resorts to an external theoretical enhancement for the third.

Before concluding the discussion of an element-based account of Shimakonde opacity, it is worth reflecting on what broader generalization is captured by accounting for one of the opaque relationships with this alternate vowel representation. Using the representations in (55) endeavors to explain the disparate VHH behavior of coalesced vowels by positing two different representations for vowels that have the same surface realization – one has two heads, while the other has one.

This essentially accounts for opacity using abstract underlying representations, as done in Dresher (1981) for Latin American Spanish, or Archangeli & Pulleyblank (1994) for Barrow Inupiaq. However, instead of appealing to diachrony to motivate different

underlying forms that neutralize in their surface realization as Dresher does, the two different representations are based on their synchronic source. In other words, this approach says that there are two kinds of surface *ee* vowels, one derived from underlying *i + a* and another derived from *i + e*, which is encoded in their abstract representations by one having two heads and the other having one. This property, which has no phonetic correlate, determines the coalesced vowel's ultimate behavior with respect to harmony (but incorrectly for reduction). That the same surface representation behaves differently depending on the underlying form it was derived from is one of the basic ideas in the solution proposed below. However, instead of adding an abstract, phonetically unrealized component to the representation, this effect is accomplished more directly and in the grammar itself through constraints that make direct reference to the underlying form.

Ultimately, there are compelling reasons to use an element-based approach for Bantu vowel systems. It better captures the natural classes of the vowels with respect to harmony and more closely corresponds to Crosswhite's generalization with respect to reduction. However, there is enough counter-evidence to suggest that this approach is neutral or even less adequate than the traditional feature-based approach. The theory of Shimakonde opacity I advance above in some ways operates independently of the representation chosen; as such, the feature-based approach is used throughout. An element-based representation can be substituted without impacting the general insight.

3.8. CONCLUSION

In this chapter, I showed how the three opaque relationships in Shimakonde – in particular, those involving harmony – were amenable to a solution via DCT. Delving into

detail also highlighted a number of other interesting phenomena.

Reduction in Shimakonde presents a challenge for current theories of variation and requires aligning a domain of reduction with a gradient faithfulness domains emanating from the penultimate syllable. This is in lieu of establishing a licensing domain.

Also, DCT generates the appropriate forms for Shimakonde despite the existence of a feeding relationship and an intermediate form. This is due to the fact the harmony is established with faithfulness constraints, rather than markedness constraints, which would not be able to accommodate the counter-bleeding/feeding relationship in Shimakonde.

Not only does this approach intuitively capture the linguistic generalization involved in Shimakonde, it also avoids the problems the data present for other approaches to opacity. First, the process of vowel reduction is subject to variation – variation between opaque and transparent forms – and applies across the board. The variable nature of this process suggests that it is post-lexical, or late, (Kiparsky, 1985; cf. Guy, 1991) as does its application across multiple words. This presents a challenge for any account of opacity based on multiple tiers of evaluation corresponding to particular domains of process application (Bermudez-Ortero, 1998; Kiparsky, 2000). Since one of the cases of opacity requires that reduction happen “before” coalescence, this necessitates multiple tiers for one single domain – the post-lexical domain – contra a fundamental assumption of stratal OT.

Second, vowel harmony is fully productive and can extend to any number of affixes, as is typical of harmony. This fact is problematic for accounts that suggest that

opaque generalizations are not productive and are only found in stored lexical representations. The fact that harmony targets any number of suffixes is also problematic for approaches of opacity based on morpheme-selection (Sanders, 2003; Lee, 2004). Any account of this sort would require an iterative, or cyclic, process of morpheme selection interleaved with processes of reduction. This abandons OT's principle of parallel evaluation.

Finally, the three cases of opacity are substantively different - two are instances of under-application and the other is a case of over-application. This presents a problem for any account of opacity that can explain one or the other or that treats the different types of opacity as theoretically distinct (e.g. Candidate Chain OT, McCarthy, 2007; Comparative Markedness, McCarthy, 2003). In contrast with a patchwork approach to understanding Shimakonde opacity, I show that all three cases can be explained using the same input-based generalization. The upshot is that the phonology of Shimakonde consists of two types of phonological processes: phontactics-based surface optimization paired with morphophonological input-output mapping. Whereas recent approaches to phonology focus on the former and the ability of the former to account for the latter (e.g. OT), phontactics does not always overlap with morphophonology; Diagonal Correspondence fills this empirical gap with respect to opacity.