Two Notes on Kinande Vowel Harmony

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Abstract

This paper documents the acoustic reflexes of ATR harmony in Kinande followed by an analysis of the dominance reversal found in class 5 nominals. The principal findings are that the ATR harmony is reliably reflected in a lowering of the first formant. Depending on the vowel, ATR harmony also affects the second formant. The directional asymmetry noted in previous research is also confirmed. Dominance reversal is analysed within the Optimality Theory framework as the combination of dispreferences for affixal triggers and left-headed harmonic domains.

Keywords: ATR harmony, dominance reversal, weighted constraints

1. Introduction

This paper summarizes the findings of a study of the phonetics and phonology of the ATR/Height harmony in the Bantu language Kinande (D-42) spoken in NE Democratic Republic of Congo (ex-Zaire). This topic has been investigated in an extensive earlier literature that starts with Valinande (1984) and continues up to the recent ultrasound investigation of Gick et al. (2006)[1]. One motivation for the present study is that the same consultant(s) have provided the data for most of the previous phonetic investigations. It is therefore of interest to what extent the earlier findings are replicable. As we shall see, our results are almost the same--a testimony to the care and accuracy of the previous investigations. The paper is organized as follows. In section 2 we summarize the background literature on the Bantu vowel height contrasts and then on the feature [ATR]. We then report the major results of our phonetic study in section 3. Section 4 looks at the phonological expression of [ATR] harmony in Kinande, focussing on the dominance reversal in class-5 nominals.

2. Background

Kinande has preserved the seven-vowel system of proto-Bantu, with a single low vowel /a/ and phonemically contrasting front-back pairs at the three remaining

[1] Hyman (2002) also mentions Bbembo (1982) and Kahindo (1981), which we have not seen.

heights. Following the terminology of the Tervuren tradition, the vowels can be described in terms of four degrees of opening[2].

(1)	į	ų	first
	i	u	second
	e	o	third
	a		fourth

Several phonological phenomena distinguish among the various degrees of height in (1). In Kinande as well as many other Bantu languages the first series forms a group distinct from the second in virtue of the well known height harmony found in verbal extensions (see Hyman 1998 for illuminating discussion of the history of this phenomenon). Mid root vowels /e/ and /o/ call for a mid vowel realization *-er* of the applicative *-ir*. Harmony in the reversive *-ul* is both phonologically and lexically more restricted, occurring after just root vowel /o/ in a handful of verbs. On the other hand, the suffixes with the degree one vowels such as the recent past *-įr-e* do not participate in this height harmony (2b).

(2) a.	e-ri-lim-ír-a	'to work for'	e-rí-bib-úl-a	'to unsow'
	e-rí-tum-ír-a	'to send for'	e-ri-lung-úl-a	'to straighten'
	e-ri-hek-ér-a	'to carry for'	e-ri-seng-úl-a	'to unpack'
	e-ri-log-ér-a	'to bewitch for'	e-rí-boh-ól-a	'to untie'

[2] An alternative system transcribes the seven-vowel system as degree one /i,u/, degree two /ɪ,ʊ/, degree three /ɛ,ɔ/, and degree four /a/.

e-ri-hat-ír-a 'to peel for' e-rí-mat-úl-a 'to release'

(Mutaka 1995)

b. mó-twa-boh-í̹r-e 'we tied yesterday' [mọ́-twạ-bọh-ị̂r-e]

mó-twá-hék-i̹r-e 'we carried yesterday' [mọ́-twạ́-hẹ́k-ịr-e]

Comparable narrowing of the contrast among the two interior series in a four-height system is found in Romance languages such as French (cf. *cède*, but *céder* 'yield') or the loanword vocabulary of Catalan (Cabré 2007) where the normally open realization of a stressed mid vowel seen in ['tɛksəs] 'Texas and ['tɔfu] 'tofu' is blocked by harmony to a following unstressed close mid vowel: ['eseks] 'Essex', ['boston] 'Boston'.

The degree-one vowels /i̹/ and /u̹/ are also distinguished from /i/ and /u/ as the site of palatalization in a number of Bantu languages (Schadeberg 2003). On the other hand, the hiatus resolution strategies of devocalization vs. deletion distinguish the nonlow vowels from [a] in Kinande (Valinande 1985).

(3)	é-n-goko	'chicken'	é-n-gokw eyi	'these chickens'
	é-m-bene	'goat'	é-m-beny eyi	'these goats'
	ẹ-mị̂-rịkị	'rope'	ẹ-mị̂-rịky eyi	'these ropes'
	a-ká-h-a	'he is giving'	a-ká-h ó-mw-ána	'he is giving to the child'

A first-second vs. third-fourth cut is made when the vowel inventory in (1) reduces to a five-vowel system: the first and second series merge into a high vowel class (Hyman 1998, Schadeberg 2003:147) suggesting that, as implied by the transcriptions in (1), the first and second series are [+high] with a subsidiary [ATR] distinction. This point is illustrated by the Kinande-Runyakore cognates in (4), data from Kaji (2004).[3]

(4)	Kinande		Runyakore	
[i̧]	o̧-mú̧-sî̧sa	[i]	o-mu-si	'vein'
	ȩ-ri̧-sî̧nga		o-ku-sîinga	'to defeat'
[i]	o-mú-tima		e-ki-tíma	'pit'
	o-mú-ti		o-mu-ti	'tree'
[u̧]	ȩ-yî̧-sú̧ka	[u]	e-fúka	'hoe'
	ȩ-ki̧-tú̧		e-ki-cu	'cloud'
[u]	e-rí-lúma		o-ku-rúma	'to bite'
	e-ri-gúla		o-ku-gura	'to buy'
[e]	e-rí-bére	[e]	ii-béère	'breast'
[o]	e-kí-koba	[o]	e-ki-kóba	'animal skin'

Finally, depending on their vowel inventory, Bantu languages can express the open-close distinction in mid vowels in loanword adaptation. In Lingala, where ATR mid vowels contrast but high vowels do not, open and close mid

[3] Interestingly, in five-vowel Chimwini (Kisseberth and Abasheikh 2004) the height harmony process is extended to the recent past: *soom-éel-e* '(s)he read'.

vowels in French loanwords are more or less faithfully adapted as [±ATR] mid vowels (data from Ashem Tem 2004).[4]

(5)	French		Lingala
	Belge	[ɛ]	bɛ́lɛsi
	colle	[ɔ]	kɔlu
	vélo	[e]	vélo
	bureau	[o]	biló

On the other hand, Kinande appears to adapt both open and close French mid vowels as /e/ and /o/ (though data are limited).

(6)	French		Kinande	
	cassette	[ɛ]	a-ka-séte	'cassette'
	sacoche	[ɔ]	e-sakósa	'bag'
	congé	[e]	e-konzé	'break'
	ciseau	[o]	ẹ-sịsó	'scissors'

These differing adaptations indicate that the vowels are not simply relative positions along a continous phonetic dimension (cf. Ito et. al. for a different

[4] Archangeli and Pulleyblank (1994) report a similar adaptation pattern for English loans into Yoruba. We cite some examples here from Ojo's (1977) study: *kɔ́pì* 'copy', *jɛ́ɛ̀mù* 'gem' vs. *bèbî* 'baby', *borokéèdì* 'brocade.'

result concerning the front-back dimension in high vowels in loans from Japanese into Korean). Rather, a real distinction must be drawn such that Lingala [e], [o] are not equivalent to Kinande [i], [u] even though both occupy intermediate positions between the highest first series and the open mid third series.[5]

Another factor that argues for three degrees of height with a subsidiary ATR distinction rather than a single dimension of four degrees is the other harmony process that Kinande is famous for--[ATR] harmony. In position before a first series /i̧/ or /u̧/, each of the remaining five vowels shifts to an audibly distinct allophone. In the case of the second degree /i/ and /u/, the latter shift to higher vowels that are auditorily equivalent to the first series /i̧/ and /u̧/, thus neutralizing a contrast (see below). This height shift is quite productive and is triggered by various suffixes including the recent past *-i̧r-e* and the agentive *-i̧*.

(7)	infinitive	recent past	agentive	
	e-ri-lím-a	mǫ̧́-twą̧́-lį̧̂m-i̧r-e	ǫ̧-mu̧-lį̧̂m-i̧	'cultivate'
	e-ri-hék-a	mǫ̧́-twą̧́-hę̧́k-i̧r-e	ǫ̧-mu̧-hę̧́k-i̧	'carry'
	e-ri-húm-a	mǫ̧́-twą̧́-hų̧́m-i̧r-e	ǫ̧-mu̧-hų̧́m-i̧	'beat'

[5] This is the strong intuition of our consultant who is fluent in Lingala and has no trouble distinguishing Kinande degree two [i], [u] from Lingala [e], [o].

The data in (7) provoke several questions. What is the phonetic basis of the harmony? Are there ten distinct vowel heights? If not, what feature underlies the change? A second issue concerns the behavior of the low vowel [a]. Previous literature (e.g. Mutaka 1995) indicates that the harmonic change is less regular for [a] than with the other vowels. Does the low vowel undergo harmony? If not, is it a neutral vowel allowing the harmonic change to pass through, or is it an opaque vowel blocking the change? These are among the questions addressed in the following section.

3. Phonetics

The phonetic basis of the ATR contrast has been investigated by a number of researchers, starting with Ladefoged's (1964) groundbreaking study of several West African Languages: Ladefoged (1964), Halle and Stevens (1969), Lindau (1979), Hess (1992), Tiede (1996), Guion et al. (2004). These investigations have shown that the major articulatory correlate is expansion of the pharyngeal cavity by advancing the tongue root. This gesture has been demonstrated by several experimental techniques including cine-x-radiology (Ladefoged 1964), magnetic resonance imaging (Tiede 1996), and ultra-sound (Gick et al 2006). Extrapolating from an expected increase in the cross-sectional area of the pharynx in the region of 2-4 cm above the glottis, Halle and Stevens (1969) predicted on the basis of theoretical acoustic modeling that the major correlate of advancing the tongue root should be lowering the first formant[6]. In addition, the second formant should be raised in front vowels and lowered in back vowels. Lowering the larynx (Akan) and raising the tongue body in the oral cavity (English) are accompaning enhancement gestures that have been found in some languages (Tiede 1996). In addition, Akan [+ATR] vowels can be associated with breathy voice (Berry 1957). Since we had the luxury of being able to record our consultant's speech under laboratory conditions over an extended period of time, a variety of recordings and acoustic analyses were made. We report here the chief results in the following sections.

3.1 Root Vowels

In order to have a baseline of comparison for the seven vowel phonemes of (1), we constructed a corpus of five verb roots per vowel (see Appendix-A) in the infinitive frame [e-ri-CVC-a] (e.g. *e-ri-lím-a* 'to cultivate'). The data were randomized and repeated four times for a total of 20 observations per vowel. The corpus was recorded in a sound proof booth and analyzed with Praat (Boersma and Weenick 1992-2008), taking measures by hand at the center of the vowel. The results are reported below.

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[6] The first formant in nonlow vowels is the reflex of the Helmholtz resonator formed by the pharyngeal cavity and the oral constriction and is determined by the relative volume of air in these two areas according to the equation $F = c/2\sqrt{A_c/A_b l_b l_c}$ where A_c and A_b denote the areas of the constriction and the (back) pharyngeal cavity and l denotes their lengths. Advancing the tongue root increases the size of the pharyngeal cavity A_b thereby lowering the F value.

(8) first and second formants (mean and standard error)

	i̧	**u̧**	**i**	**u**	**e**	**o**	**a**
F1	293/4.50	320/8.28	442/1.97	444/3.92	572/8.60	581/10.56	797/6.20
F2	2087/9.46	700/16.61	1933/28.59	747/12.94	1782/25.62	959/9.53	1374/7.75

[Figure 1 here]

Four distinct heights are clearly revealed in the first formant measures, with front and back vowels at essentially the same relative positions. For the first and second series vowels, we see that the postulated [+ATR] [i̧] and [u̧] occupy more peripheral positions in the vowel space compared to [-ATR] [i] and [u], differing principally in F1 but also in F2 in the direction predicted by Halle and Stevens' (1969) model. Our data largely coincide with the scatter plot reported by Gick et al (2006:12) except that for our speaker [a] has a lower center of gravity and much less variation. The chart below shows the vowels plotted according to the Bark scale to give a more accurate indication of their relative positions in auditory space. The second and third series are actually a bit closer to one another but still adequately distinguished.

[Figure 2 here]

3.2 ȩ-ri̧- vs e-ri-

In (9) we show the formant values for the augment *e-* and the infinitive prefix *ri-* as a function of the root vowel for this set of 35 verbs (four repetitions).

(9) a. first and second formants (mean and standard error)

	rį̧-	**ri-**	**ę̧-**	**e-**
F1	331/5.36	478/2.23	374/3.57	618/2.40
F2	2062/21.83	1712/10.61	1994/15.03	1794/9.96

b. tests of significance (one-way anovas)

F1	**df**	**F**	**P**
rį̧- vs. ri-	1, 143	901.25	< 0.0001
ę̧- vs. ri-	1, 143	614.78	< 0.0001
ę̧- vs. e-	1, 143	3033.33	< 0.0001
ę̧- vs. rį̧-	1,80	43.52	< 0.0001

F2	**df**	**F**	**P**
rį̧- vs. ri-	1, 143	259.89	< 0.0001
ę̧- vs. ri-	1, 143	388	< 0.0001
ę̧- vs. e-	1, 143	263.31	< 0.0001
ę̧- vs. rį̧-	1, 80	1.44	0.2327

[Figure 3 here]

The *ri*- prefix takes on two quite distinct values: a mean of 331 Hz when the root has first-degree [i̘] or [u̘] and 478 Hz with the remaining vowels. These values approximate the F1 measures for the corresponding root vowels (293 Hz and 442 Hz, respectively) from (8). The *e*- augment varies as a function of the same root vowel difference that *ri*- does. More interestingly, in the presence of a series-one root vowel [i̘] or [u̘], the F1 value of the augment (371 Hz) is intermediate between [i̘] and [i]. This realization of the augment, which we transcribe as [e̘], is significantly different from both the [ri-] and [ri̘-] variants of the infinitive prefix ($p < 0.0001$ in both cases). Here again our results match those of Gick et al (2006). As they observe, this finding is conclusive evidence that the assimilation is not simply one degree of tongue height--otherwise harmonized [e̘] should not pass over [i]. But it makes perfect sense if the Kinande vowels harmonize for tongue-root position. As Figure 3 makes clear, there is a movement of the [+ATR] variants towards the periphery of the vowel space with respect to F2 as well.

As mentioned above, voice quality has been found to enhance the ATR contrast in some languages. We tested for this factor by measuring H1-H2 in the mid-vowel augment of the prefix. No significant difference was found between the two harmonic contexts.

3.3 o̘-mu̘- vs. o-mu-

In order to determine whether the back vowel /o/ behaves in the same manner with respect to the "crossover" effect noted for /e/, we recorded and measured two repetitions of twenty class-3 nouns that have the augment plus class marker *o-mu-* (see Appendix B for list). The results, shown below in (10), indicate a parallel behavior. The mean F1 values of the augment lowers from 528 Hz in the [-ATR] context to 397 in the [+ATR] context, passing over the [-ATR] high vowel [u] (441 Hz.). However, the difference is barely significant. On the other hand, the differences in F2 are significant for [o̧]- vs. [u]. There is thus a complementarity: [u̧] vs. [u] is distinguished by F1 while [o̧] vs. [u] is distinguished primarily by F2.

(10) a. first and second formant (mean and standard error)

	mu̧-	**mu-**	**o̧-**	**o-**
F1	328/9.77	441/14.09	397/10.61	528/8.41
F2	872/58.07	920/28.56	773/9.23	858/7.37

b. statistics

F1	**df**	**F**	**P**
mu̧- vs. mu-	1,38	43.56	< 0.0001
o̧- vs. mu-	1, 38	6.27	< 0.0166
o̧- vs. o-	1, 38	93.21	< 0.0001
o̧- vs. mu,-	1, 38	22.86	< 0.0001

F2	df	F	P
mų- vs. mu-	1,38	0.378	0.54
o̧- vs. mu-	1,38	29.82	<0.0001
o̧- vs. o-	1,38	51.97	<0.0001
o̧- vs. mų-	1,38	21.19	<0.0001

[Figure 4 here]

3.4 The Low Vowel

There is some question from the previous literature as to whether the low vowel [a] participates in the right-to-left harmony or is simply a transparent (neutral) vowel. Gick et al. (2006) find conclusive evidence (from ultra-sound) that the low vowel harmonizes for their speaker. We were therefore interested in whether this finding could be replicated. Once again, our results coincide with theirs.

To investigate the behavior of [a], we selected ten verbs in each of the following three root templates: [CICaC], [CI̧CaC], and [CaC]. They were placed in the infinitive frame [E-rI-root-a] and the recent past [mO-twA-root-i̧r-e] ('we VERBED yesterday'). The 30 verbs (see Appendix C) were randomized and recorded in four successive blocks to give 120 measures for a CaC syllable in the neutral [E-rI-root-a] and in the harmonic [mO-twA-root-i̧r-e] context of a following [+ATR] [i̧]. The results appear below in (11). In all three root contexts (i.e. [CICaC], [CI̧CaC], and [CaC]), the differences are highly significant. The F1 mean value of c. 690 Hz. for the [a̧] [+ATR] vowel places it at a point almost equidistant between [a] (797) and the degree two vowels [e] (572) and [o] (581) seen in (4). There is no significant difference in F2.

(11) a. F1 measures for root [a] in two suffixal contexts (mean and standard error)

	[-ATR]	**[+ATR]**
CaC	807/4.69	694/6.50
Ci̧CaC	783/9.25	680/11.36
CiCaC	805/10.47	697/13.12

b. statistics for CaC roots in -i̧r-e vs. -ir-a

[Ca̧C] vs. [CaC]	**df**	**F**	**P**
F1	1,38	200.99	$<<0.0001$
F2	1,38	1.96	0.1961

[Figure 5 here]

To judge from the plot reported in Gick et al (2006), their speaker's [+ATR] low vowel occupies an F1 region between 440-600 Hz where it overlaps the [-ATR] mid vowels, especially [e]. As mentioned earlier, our speaker's low vowels (both

[-ATR] [a] and [+ATR] [a̧]) are more widely separated from his mid vowels. He also has no trouble distinguishing the [a̧] from [a] in his own speech.

3.5 CVC-i̧r-e vs. CVC-ir-a

Having established that all of the vowels harmonize for [ATR] when preceding a [+ATR] high vowel, we wanted to get a sense of the relative spacing of the vowels in comparable contexts. Since the noun class prefixes are restricted to either high or low vowels and the augment is a nonhigh vowel, it is not possible to find both the high and nonhigh vowels in the same prefixal context. We therefore measured the effect of two suffixes on a CVC root: the [-ATR] applicative suffix *-ir-a* and the [+ATR] recent past *-i̧r-e*. For this measure we gathered a corpus of five roots for each of the seven vowel phonemes (see Appendix D) and placed them in the frames [e-ri-root-ir-a] 'to VERB for' and [mǫ-twa̧-root-i̧r-e] 'we VERBED yesterday'. The words were randomized and recorded with six repetitions. Once again measures were taken by hand from the center of the vowel. The data are displayed in (12). The [+ATR] column reports the formant measures for the CVC root vowel in the *-i̧r-e* context and the [-ATR] column indicates the values obtained in the *-ir-a* context.

(12) a. root vowels in two suffixal contexts (mean and standard error)

	[+ATR]		**[-ATR]**	
	F1	F2	F1	F2

į	277/2.54	1949/63.33	**i**	379/6.24	1722/55.98
ų	290/3.71	804/56.01	**u**	385/6.41	863/24.64
ę	378/6.76	1970/19.27	**e**	488/4.77	1722/48.66
ǫ	412/9.31	1010/19.99	**o**	519/4.84	1005/16.64
ą	635/10.31	1393/45.52	**a**	740/11.53	1347/35.24

b. statistics

F1	**df**	**F**	**P**
į vs. i	1,18	52.20	< 0.0001
ų vs. u	1,18	138.76	< 0.0001
ę vs. e	1,18	43.96	< 0.0001
ǫ vs. o	1,18	43.83	< 0.0001
ą vs. a	1,18	38.50	< 0.0001
ę vs. i	1,18	.70	0.4139
ǫ vs. u	1,18	2.35	0.1441

F2	**df**	**F**	**P**
į vs. i	1,18	7.22	0.0197
ų vs. u	1,18	1.07	0.3158
ę vs. e	1,18	22.30	0.0001
ǫ vs. o	1,18	0.03	0.8586
ą vs. a	1,18	0.64	0.4317

ȩ̣ vs. i	1,18	23.00	0.0002
ọ̧ vs. u	1,18	21.86	0.0002

[Figure 6 here]

The major result is that at each vowel height [-ATR] decreases c. 100 Hz. in F1 when compared with its [+ATR] counterpart. In this context we do not observe the crossing behavior for F1. The [+ATR] [ȩ̣] essentially merges with [-ATR] [i] and [+ATR] [ọ̧] approaches [-ATR] [u] with respect to F1. On the other hand, the [ȩ̣] vs. [i] and [ọ̧] vs. [u] pairs are distinguished by F2. But curiously in this case [ọ̧] occupies a more interior position with respect to [u] in the vowel space. This effect is reported for a number of languages by Ladefoged and Maddieson (1996:305). Also the differences in F1 values of the mid root vowels [ȩ̣] vs. [e] (110 Hz) and [ọ̧] vs. [o] (107 Hz) are less than the differences between the two values for the *e*- and *o*- augments in the infinitival and nominal prefixes discussed above. This difference might indicate that the root vowels are underlying specified for height while the affixes are not and hence the former are not permitted to drift as far from their underlying values.

The table in (13) shows the mean differences in F1 in the two harmonic contexts. We see that the values fall over a remarkably small range (95 - 100 Hz), suggesting that a single quantum of pharyngeal expansion is occurring regardless of the position of the tongue body.

(13)

	[+ATR] - [-ATR]
i	101/6.36
u	95/8.24
o	106/10.92
e	110/7.79
a	103/13.65

We also included CVC roots with underlying high [+ATR] vowels in this experiment. The table in (14) reports the F1 and F2 measures for the Ci̧C and Cu̧C roots in the two suffixal contexts *-ir-a* and *-i̧r-e*. Since these roots harmonize a following applicative suffix from *-ir-a* to *-i̧r-a*, there is no phonological difference between the two contexts and so should not be a phonetic difference either. The measures for root vowel [i̧] are essentially identical in the two suffixal contexts. For [u̧] there is a barely significant difference in F1 ($p = 0.043$) but not in F2 ($p = 0.101$). But with such a small sample, this difference is probably not very meaningful. We conclude that [i] and [u] merge with [i̧] and [u̧] in the harmonic context of *-i̧r-e*.

(14)

	-i̧r-e		-ir-a	
	F1	F2	F1	F2
i̧	266/1.78	2043/31.34	263/5.48	2063/49.29
u̧	267/9.15	900/39.37	289/4.40	841/48.56

3.6 CiCaC-ir-a

One of the phonological asymmetries in Kinande harmony is that the nonhigh vowels, in particular [a], fail to harmonize when they follow a [+ATR] high vowel even though high vowel suffixes do harmonize in the same context. We collected a smaller amount of data to confirm this asymmetry, focusing on the applicative suffix *-ir*, which has the [+ATR] variant *-i̧r* when the root contains an /i̧ / or /u̧/. The formant measures in (15) show this for two repetitions of six roots containing [-ATR] high vowels compared to two repetitions of four roots containing [+ATR] high vowels. The values obtained are comparable to the canonical [i̧] vs. [i] difference seen in (8).

(15) formant measures for the applicative suffix *-ir* (mean and standard error) after [±ATR] CIC roots

Root	**F1**	**F2**
Ci̧C	281/3.73	2115/8.67
CiC	421/13.26	2020/13.19

The measures in (16) show the formant values for the *-ir* suffix following four roots of the shape [Ci̧CaC] vs. [CiCaC] (two repetitions). The values obtained are quite close to the 421 Hz from (15) and quite distinct from the 281 Hz. after [Ci̧C] roots. Thus, the low vowel quite clearly blocks the spread of [+ATR]. There is a small difference of c. 30 Hz between [Ci̧CaC] vs. [CiCaC] roots in their effect on the applicative suffix *-ir* as a function of whether the root vowel preceding the /a/ is [±ATR]. This is probably best attributed to phonetic coarticulation. A comparable small but nonsignificant difference (df 1,16, F 3.77, p = 0.0697) in the /a/ root vowel itself supports this interpretation.

(16) a. formant measures for the applicative suffix *-ir* (mean and standard error)

after [±ATR] CICaC roots

Root	**F1**	**F2**
Ci̧CaC	387/9.75	2067/31.81
CiCaC	427/14.15	1915/35.41

b. formant measures for the root [a]

Root	**F1**	**F2**
Ci̧CaC	801/13.58	1395/10.71
CiCaC	831/11.03	1440/16.43

3. 7 Summary

We have found that advancement of the tongue root is reliably reflected in lowering F1 for all vowels. Its effect on F2 is more variable and depends on the particular vowel. Front vowels have raised F2; for the central low vowel [a] there is no difference; and for the back vowels F2 is lowered, though less reliably so. In prefixal contexts the [+ATR] mid vowels pass through the [-ATR] high vowels in F1 and F2, while in the root context they essentially merge in F1 but are still distinct in F2. We have also confirmed the directional asymmetry noted in the earlier literature. Series two, three, and four vowels all show a dramatic shift in F1 when they precede a [+ATR] high vowel. Second-degree /i/ and /u/ shift to first degree /i̧/ and /u̧/ after a first degree vowel while third and fourth degree vowels fail to show the dramatic shift in F1 in the same context but instead display a much smaller difference, which we attribute to carryover coarticulation. The nonhigh third and fourth degree vowels also block ATR-harmony on a following second-degree suffixal vowel, which otherwise harmonizes when it immediately follows a first-degree high [+ATR] vowel.

4. Phonology

Having established that [±ATR] is the relevant dimension for Kinande height harmony and that all vowels participate in the process, we now turn to the phonological representations and rules/constraints that underlie its expression. Three properties situate the process in the overall typology of [ATR] harmony.

First, Kinande ATR harmony exhibits (partial) root control (Clements 1980). All noun class prefixes as well as the augment alternate between [+ATR] and [-ATR] variants depending on whether the root vowel is [+ATR] /i̧/, /ų/ or [-ATR] /i/, /u/, /e/, /o/, /a/.

(17)	1/2	o-mú-lúme	a-bá-lúme	'man'
		o̧-mų́-ka̧li̧	a̧-bá̧-ka̧li̧	'woman'
	3/4	o-mu-húli	e-mi-húli	'nostril'
		o̧-mų́-lí̧ki̧	ȩ-mí̧-lí̧ki̧	'rope'
	5/6	e-rí-tumbi	a-má-tumbi	'night'
		ȩ-rí̧-kų́ha	a̧-má̧-kų́ha	'bone'
	7/8	e-kí-haha	e-bí-haha	'lung'
		ȩ-kí̧-gų́ma	ȩ-bí̧-gų́ma	'fruit'
	9/10	e-n-goni	e-syo-n-goni	'cane'
		ȩ́-m-bų́li̧	ȩ-syó̧-m-bų́li̧	'sheep'

In addition, the verbal suffixes with a high vowel such as applicative -*ir* and reversive -*ul* show two harmonic variants.

(18)	ȩ-rí̧-hų́k-a	'to prepare food'	e-ri-gúl-a	'to buy'
	ȩ-rí̧-hųk-í̧r-a	'to prepare for'	e-ri-gul-ír-a	'to buy for'
	ȩ-rí̧-hųk-ų́l-a	'to dish out food'	e-ri-lung-úl-a	'to straighten'
	ȩ-rí̧-hųk-ųl-í̧r-a	'to dish out for'	e-ri-lung-ul-ír-a	'to straighten for'

But, as we have seen, certain affixes also trigger the harmonic change. In particular, the agentive *-i̧,* the causative (*-is)-i̧*, and the recent past *-i̧r* suffixes have [+ATR] vowels that transform all preceding vowels in the word to [+ATR]. Thus, [+ATR] is the dominant feature and [-ATR] is recessive: [-ATR] roots and affixes mutate in the presence of a [+ATR] high vowel. Finally, there is also a directional asymmetry in Kinande. While [+ATR] freely spreads leftward, introducing [+ATR] nonhigh vowels, [+ATR] does not spread rightward to a nonhigh vowel (recall (16a)). Schlindwein (1987), Mutaka (1995), and Hyman (2002) observe another (parallel) directional asymmetry at word junctures where [i̧] # C[i] remains unchanged while [i] # C[i̧] may be replaced by [i̧] # C[i̧] Compare *o-mútahi* 'branch' but *o-mú-tahi̧ mú̧-kų̧hi̧* 'short branch'.

4.1 Class 5 nominals

The OT analysis of Kinande harmony by Archangeli and Pulleyblank (2002) builds on their (1994) parametrized association model. Both analyses attempt to get maximum mileage out of UG grounding/enhancement conditions that distribute the [ATR] feature as a function of oral vowel height. In particular, high vowels favor [+ATR] (presumably to enhance their F1 value) while nonhigh vowels are preferably [-ATR] (for the same reason). The key ingredients of their analysis are summarized in (19).

(19)

- [ATR] is root autosegment
- its association is controlled by grounding relations/markedness constraints favoring [+ATR] high vowels and [-ATR] nonhigh vowels
- right-to-left harmony arises from an undominated alignment constraint while left-to-right harmony is motivated by the preference for [+ATR] high vowels and [-ATR] nonhigh vowels

Their analysis succeeds admirably in expressing Kinande harmony as the product of natural and well attested UG constraints. There is, however, one detail of their account that we take issue with: the prefixal complex *e-ri-* that appears on both class 5 nouns and the infinitival verb. While it is natural to assume, in the absence of any evidence to the contrary, that this morphemic complex receives the same analysis in both nouns and verbs, it has strikingly different properties in these two contexts that justify a different treatment (here we follow Hyman 2002). In the verbs *e-ri-* harmonizes with [+ATR] high root vowels and is [-ATR] elsewhere. But with class 5 nominals it appears as [+ATR] *ȩ̣-rị̧-* unless the root contains a [-ATR] high vowel. In other words, no distinction is drawn between verbal and nominal prefixes when the root contains high vowels, but a consistent distinction is made when the root contains a nonhigh vowel. The data in (20) illustrate.

(20)

verbal prefix		class 5 noun	
ȩ-ri̧-lí̧b-a	'to cover'	ȩ-ri̧-bbí̧llí̧	'sack'
ȩ-ri̧-hú̧k-a	'to cook'	ȩ-rí̧-bú̧	'ember'
e-ri-lím-a	'to cultivate'	e-rí-hiri	'crab'
e-ri-húm-a	'to beat'	e-rí-bugu	'plantain'
e-ri-hék-a	'to carry'	ȩ-rí̧-hembe	'horn'
e-rí-bóh-a	'to tie'	ȩ-rí̧-lólo	'sin'
e-ri-kár-a	'to force'	ȩ-ri̧-sanza	'branch'

The question these data provoke is whether the contrast between the nouns and the verbs lies in the prefix or in the root. Following Mutaka (1995), Archangeli and Pulleyblank (1994, 2002) analyze this contrast by assigning the roots in class 5 nominals a floating [+ATR] autosegment that docks onto the prefix, seeking out a [+high] vowel in preference to a [-high] one in accord with the same markedness preference that governs general left-to-right harmonic spreading.

(21) [+ATR]

ri hembe = ri̧-hembe

But this treatment leads to a number of odd gaps in the overall description of Kinande. First, class 5 roots with nonhigh vowels consistently fail to trigger harmony on other prefixes such as the class 6 plural *a-má-hembe (*a̧-má̧-hembe*) or the diminutive *a-ká-hembe* (*a̧-ká̧-hembe*). Second, there are few if any other class 5 roots with nonhigh vowels that do not trigger [ATR] harmony on the prefix. Archangeli and Pulleyblank (1994) cite *e-ri-so* 'rat's dung'. But our consultant has *ȩ-ŗí-sé,* treating the word like all other class 5 roots with nonhigh vowels.[7] Third, the floating [+ATR] autosegment has no plausible diachronic source since Proto-Bantu is reconstructed with a [±ATR] contrast in the high vowels--not in the nonhigh vowels. Fourth, such floating autosegments are only found in class 5 noun stems.

The analysis is simplified considerably if we distinguish two separate prefixes: class 5 nominal *ŗi-* and verbal *ri-*. According to Schadeberg's (2003:149) reconstruction of Proto-Bantu noun class prefixes, "class 5 i̧- is often replaced by a more canonical CV- prefix li- or di̧-". Since Proto-Bantu **d* regularly appears as /r/ in Kinande, deriving the infinitive from earlier **li-* and the class 5 nominal from **di̧-* is more plausible than postulating the otherwise diachronically aberrant floating [+ATR] autosegment for the nominal roots.[8] Under this

[7] Kambale (1978) gives an alternant class 7 *e-kí-sé* 'manure' (la bouse).

[8] Valinande (1984:56) indicates that the root vowels in such noun stems as *-heré* 'fish', *-Bére* 'breast', *-téma* 'cheek', *-héro* 'cemetary', *-séke* 'reed, *-lolo* 'sin', harmonize to [+ATR] when the class 5 *ŗi-* is added. We recorded and measured these words in the context of class 5 *ŗi-* and diminutive *ka-*. For the mid vowels

alternative account the nominal roots display the same seven-way vowel contrast that the verbs do. As well, prefixes now show a [±ATR] contrast comparable to suffixes.

One consequence of this analytic move is that [+ATR] is no longer exclusively the dominant harmonic feature. When the root contains an [i] or [u], then class 5 *r̹i̹-* appears as *ri-*. This makes [-ATR] active for right-to-left harmony, (a "dominance reversal" in the sense of Bakovic 2000).

(22) a. [+ATR] high vowels

e̹-rí̹-ku̹si̹	'dwarf'
e̹-ri̹-bbí̹llí̹	'sac'
e̹-rí̹-bú̹	'ember'
e̹-rî̹-bú̹ti̹	'hen'
e̹-ri̹-hî̹	'mould'

b. [-ATR] high vowels

e-li-ríngi	'uncultivated field'
e-ri-rúngu	'plain'
e-ri-súngu	'edible rat'

---

there was a statistically barely significant difference ($F = 8.4$, $p = 0.008$) of c. 30 Hz (average 531 Hz in the *r̹i̹-* context and 561 Hz in the *ka-* context). This is comparable to the difference found in [Ci̹CaC] vs. [CiCaC] roots (16b) and is more plausibly attributed to phonetic coarticulation rather than to the ATR vowel harmony that is found in the canonical regressive harmony.

e-rí-hiri 'crab'

e-rí-bugu 'plantain'

In (23) we illustrate the inventory of root types found in class 5 nominals with respect to [+ATR]. Due to [ATR] harmony, the two classes of high vowels cannot combine within a root. But they cooccur more or less freely with nonhigh vowels. Four combinations are expected. We have been able to document three.

(23) a. [+ATR] [-high]

ȩ-rí̧-kú̧ha 'bone'

ȩ-ri̧-rí̧ba 'eddy'

ȩ-rî̧-hî̧ga 'hearth stones'

ȩ-rî̧-hú̧lo 'foam'

ȩ-ri̧-kú̧ke 'unripe fruit'

b. [-ATR] [-high]

e-ri-kínga 'magic spell'

e-rí-kúndo 'knot'

e-ri-ríma 'field'

e-ri-rínda 'seven'

e-rí-tsuro 'jealousy'

e-rí-bumba 'clay'

c. [-high] [+ATR]

ȩ-rį-kǫ́fį 'slap'

ȩ-rį-tǫ́ndį 'drop of water'

ȩ-rį-tsȩngų́ 'a big head'

ȩ-rį-bbȩllų́ 'goiter'

ȩ-rį-tǫ́lų 'thorn'

We are unable to find class 5 roots with a nonhigh vowel followed by a [-ATR] high vowel. This combination is amply attested in other noun classes: *e-ki-bámbáli* 'plateau', e-*kí-bátsi* 'house frame', *e-hángi* 'fortune', *a-má-lali* 'crossed eyes', *a-má-naku* 'craving for meat', *a-ma- sáláli* 'sun rays.' Its absence in class 5 is puzzling.[9]

4.2 Dominance Reversal: an Alternative Analysis

Hyman (2002) discusses two asymmetries that have emerged in the typology of ATR harmony that are relevant for the Kinande dominance reversal. First, there is a bias for anticipatory, right-to-left harmony. Many height harmony systems display just this direction (Andalusian Spanish, Canadian French, Italian metaphony, etc.). If both directions occur, right-to-left harmony is less constrained (pharyngeal spread in Palestinian Arabic (Davis 1995), Catalan loanword phonology (Cabré 2007)). This asymmetry presumably reflects the phonologization of greater anticipatory as opposed to perseverative, carryover

[9] Hyman (2002:29) notes the same gap.

coarticulation for vowel height/place features. It contrasts with the general perseverative bias for F0 coarticulation and rightward tonal spreading. Second, while suffixes may spread their harmonic feature backwards to a root, the spread of a harmonic feature from a prefix to a following root is relatively rare (Krämer 2001). According to Hyman (2002) the dominance reversal seen in Kinande data such as (21) can thus be seen as the summation of two effects: affixes as disfavored triggers (root control) and the dispreference for perseverative spread of vowel height/place features.

Let us now try to develop an OT analysis of dominance reversal, building on the Archangeli and Pulleyblank framework in which UG markedness constraints bear the burden of distributing the [ATR] feature. In (24) we list the markedness constraints that are known to control the structure of ATR harmonic domains, characterized as penalties on the choice of the marked option. We assume that harmonic domains are headed feature structures in the sense of Cole and Kisseberth's (1993 et seq) Optimal Domain Theory and McCarthy's (2003) Span Theory.

(24)

- *Adjacent [ATR] spans (McCarthy 2003)
- *Left-to-Right harmony (penalize left-headed ATR spans, Hyman 2002)
- *ATR span headed by an affixal vowel (root control, Clements 1980)
- *[-ATR] high-vowel spans (Archangeli and Pulleyblank 1994)

- *[+ATR] nonhigh-vowel spans (Archangeli and Pulleyblank 1994)

Let us first consider the violation profiles of words with conflicting [±ATR] inputs with respect to these constraints. (25a) and (25b) show root plus suffixal structures while (25c,d) illustrate infinitive and class 5 nominals, respectively. In each case but the last, [+ATR] heads the harmonic domain (encoded in parentheses) in the winning candidates (marked by the check sign): *ȩ-rį-şįm-į̂r-a* 'to be satisfied for', *mǫ́-twá-ţį̂m-įr-e* 'we deceived', *ȩ-rį-lį̂b-a* 'to cover a hole', *e-rî-hiri* 'crab'. (Bold indicates the head of the harmonic domain)

(25)

a. /şįm-ir/		*Adj Sp	*LR	*Affix	*(**i**)
(**į**)(**i**)		*			*
(**į** į)	√		*		
(i **i**)				*	*
b. /tim-įr/					
(**i**)(**į**)		*			*
(į **į**)	√			*	
(**i** i)			*		*
c. /ri-lįb/					
(**i**)(**į**)		*			*
(į **į**)	√				

(**i** i)			*	*	*
d. /rı̹-hiri/					
(**ı̹**)(i **i**)		*			*
(**ı̹** ı̹ ı̹)			*	*	
(i i **i**)	√				*

With strict domination of constraints, no consistent ranking is possible. In order for (ı̹ ı̹) to win in both of the root+suffix structures (25a,b), the dispreference for [-ATR] high vowel spans must outrank either the dispreference for perseverative mapping (*(**i**)>> *LR) or for affixal heads (*(**i**)>> *Affix). But in the prefix+root structures, in order to achieve dominance reversal with (i i) as the winner in (25d), *(**i**)must rank below either *LR or *Affix. Neither option yields a valid ranking. If *LR >> *(**i**), *Affix then we can derive (i i) for the prefix case (25d); but this ranking blocks root-to-suffix harmony (25a). On the other hand, if we choose *Affix >> *(**i**), *LR, then we lose harmony from the suffix for (25b). It is precisely because dominance reversal involves the combination of both *LR and *Affix that spread of [+ATR] is blocked in the prefix+root structure of (25d). This is a "ganging up" effect in which two lower-ranked constraints *LR and *Affix join forces to defeat the (**ı̹** ı̹ ı̹) candidate that is favored by *(**i**).[10]

[10] We have submitted the violation profile in (25) to OT Soft (Hayes et al 2003). It returns the message "There is no ranking of the proposed constraints which

Two approaches to the analysis of such 'gang' effects appear in the literature: constraint conjunction and weighted constraints. Under the former (proposed originally by Smolensky (1995)), the constraints against perseverative harmony and affixal heads can be conjoined and ranked above the *(**i**) constraint against high [-ATR] spans that otherwise forces their violation. A conjoined constraint is violated only if both conjuncts are violated--precisely the desired effect, as the tableau in (26) illustrates.

(26) ranking: *Affix&LR >> *(**i**), *Adj Sp >> *LR, *Affix

a. /si̧m-ir/	*Affix&LR	*(**i**)	*Adj Sp	*LR	*Affix
(i̧)(i)		*!	*		
>(**i̧** i̧)				*	
(i **i**)		*!			*
b. /tim-i̧r/					
(i)(i̧)		*!	*		
>(i̧ **i̧**)					*
(**i** i)		*!		*	
c. /ri-li̧b/					
(**i**)(**i̧**)		*!	*		
>(i̧ **i̧**)					

yields the correct output". See Sasa (2007) for an alternative interpretation of the Kinande dominance reversal elaborating the ways in which the head of a harmonic span can be determined.

(**i** i)		*!		*	*
d. /rį-hiri/					
(**į**)(i **i**)		*	*!		
(**į** į į)	*!			*	*
>(i i **i**)		*			

In each of the first three cases *(**i**) and *Adjacent Span enforce the dominant ATR harmony regardless of direction and the affixal status of the head of the harmonic domain. In the last case the conjoined constraint eliminates the ATR dominant candidate. The two remaining candidates tie for the presence of a [-ATR] domain headed on a high vowel, leaving it up to the ban on adjacent spans to enforce the dominance reversal.

As for weighted constraints, under this approach each constraint assesses a penalty score. The output is defined as the candidate with the smallest total penalty score. The gang effect is achieved by ensuring that the sum of the penalties assigned by the gang members outweighs the pivot constraint (in our case *(**i**) --the dispreference for [-ATR] spans headed by a high vowel) while at the same time requiring the latter to assign a larger score than the individual gang members. For all but the simplest cases, a computer is required in order to calculate the penalties. The recent literature contains several algorithms that find the appropriate penalty weights, including the Gradual Learning Algorithm of Boersma and Hayes (2001) and the Stochastic Gradient Ascent of Jäger

(2006). In (27) we indicate the weights that these algorithms assigned for the violation profiles in (25). In each case we see the same relative weighting: the dispreference for [-ATR] high vowels is the highest and dispreference for perseverative harmony *LR the lowest. The sum of *LR and *Affix also assesses a greater penalty than *(**i̧**) by itself.

(27)

	*AdjSpan	*LR	*Affix	*(**i̧**)
GLA	144.99	144.79	145.69	145.89
SGA	10.00	8.19	10.00	11.78

The asymmetrical behavior of the nonhigh vowels with respect to directional harmony can be understood as a gang effect as well. The dispreferences for perseverative LR harmony and for [+ATR] nonhigh vowels join forces to block the formation of a harmonic domain, overpowering the otherwise dominant constraint *Adjacent Spans that motivates harmony. The Constraint conjunction analysis is illustrated in (28) and the weighted constraint analysis appears in (29).

(28)

/Ci̧Ca/	*LR&a̧	*(**i̧**)	*AdjSpan	*LR	*a̧
>(**i̧**)(**a**)			*		
(**i̧** a̧)	*!			*	*

/CaCi̧/					
(**a**)(i̧)			*!		
>(a̧ i̧)					*

(29)

	*AdjSpan	*LR	*Affix	*(**i**)	*a̧
GLA	174.1	176	174.7	177	50
SGA	11.6	10.27	5.43	13.82	4.65

4.3 Exceptions and Complications

For the sake of completeness, we mention two complications to the analysis presented above. First, the concord prefix that appears on numerals that modify a class 4 plural noun has an underlying [+ATR] high vowel /i̧/. But unlike the class 5 /ri̧-/, this prefix passes its [+ATR] specification on to the following numeral stems *biri* 'two' and *ni* 'four' that contain a degree-two high vowel. In other words, this prefix does not reverse the dominance of [+ATR] over [-ATR]

(30)	a-bá-lume ba-biri	'two men'	class 2
	e-mî-ti i̧-bi̧ri̧	'two trees'	class 4
	a-bá-lume ba-sátu	'three men'	class 2
	e-mî-ti i̧-sátu	'three trees'	class 4
	a-bá-lume bbá-ni	'four men'	class 2

e-mî-ti ḭ̂-nḭ 'four trees' class 4

The ḭ- prefix can be analyzed in terms of an undominated/heavily weighted faithfulness constraint for [ATR] tied to this particular morpheme. Perhaps its special behavior is motivated by this prefix's monovocalic shape. Since the preceding word invariably ends in a vowel, the language's extensive reduction of V#V sequences would obscure the presence of this morpheme in the underlying structure.

Second, the concord prefix that appears on adjectives after a class 5 noun behaves like the *ri-* prefix of the infinitive in having an underlying [-ATR] vowel that harmonizes to a following root [+ATR] vowel but is otherwise [-ATR].

(31) ẹ̰-rḭ̂-hembé rî-néne 'a big horn'

ẹ̰-rḭ̂-hembe rḭ-rḭ̂to 'a heavy horn'

It is not unusual for a noun's concord prefix to differ from its own class prefix (as we see with class 3 *mi-* but concord *ḭ-* above). Evidently the Proto-Bantu class 5 *i-* prefix was replaced by *dḭ-* on nominal stems and by *ri-* in the verbal infinitival and adjectival contexts. It is a task for future research to determine if this kind of distinction is made elsewhere in Bantu.

4.4. Summary and Conclusions

In this section we have reviewed the analyses in the literature that account for the directional asymmetry in the Kinande ATR harmony. Our discussion focussed on the contrasting behavior of the infinitive vs. class 5 nominal prefixes and departed from the analyses of Mutaka (1995) and Archangeli and Pulleyblank (1994, 2002) in favor of locating the contrast in the prefixes themselves (following Hyman 2002). The consequence was a dominance reversal in which the normally recessive [-ATR] feature of the high-vowel roots takes precedence over the [+ATR] of the prefix in heading the harmonic domain. We derived this effect as the summation of two generalizations that have emerged from the height-harmony literature: root control and the dispreference for perseverative harmony. The dominance reversal can be formalized in terms of constraint conjunction or in a stochastic OT grammar using weighted constraints. Which of these two modes of departure from the strict domination thesis of classic OT grammars is closer to the truth is a question of intense interest in the current theoretical literature.

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References

Archangeli, D., Pulleyblank, D., 1994. Grounded phonology. MIT Press, Cambridge, Ma.

Archangeli, D., Pulleyblank, D., 2002. Kinande Vowel Harmony: Domains, Grounded Conditions and One-sided Alignment. Phonology 19, 139-88.

Ashem Tem, K. 2004. Bagó ya lingála mambí ma lokóta. Dictionnaire lingala. Éditions Karthala, Paris.

Bakovic, E. 2000. Harmony, dominance, and control. Rutgers University Ph.D. dissertation.

Bbembo, M. 1982. Le kinande, langue bantou de l'est du Zaire (D.2): phonologie et morphologie. Thèse pour le doctorat de 3e cycle, Université de la Sorbonne Nouvelle, Paris 3.

Berry, J. 1957. Vowel Harmony in Twi. Bulletin of the School of Oriental and African Studies 19, 124-30.

Boersma, P., Hayes, B. 2001 Empirical tests of the Gradual Learning Algorithm. Linguistic Inquiry, *21*, 45–86.

Boersma, P., Weenink, D 1992–2008. Praat, A System for Doing Phonetics by Computer. Web site: www.praat.org.

Cabré, T. 2007. Variation in Loanword Vowel Harmony in Eastern Catalan. Unpublished paper read at PapI 7.

Clements, G N. 1980. Vowel Harmony in Nonlinear Generative Phonology. Indiana University Linguistics Club, Bloomington.

Cole, J. Kisseberth, C. 1993. On Domains. In: Cole, J. Kisseberth, C. (Eds.), Perspectives in Phonology. Stanford, CSLI Publications.

Davis, S. 1995. Emphasis Spread in Arabic and Grounded Phonology. Linguistic Inquiry 26, 465-98.

Flemming, E. 2001. Scalar and Categorical Phenomena in a Unified Model of Phonetics and Phonology. Phonology 18, 7-44.

Gick, B, Pulleyblank, D., Campbell, F., Mutaka, N. 2006. Low Vowels and Transparency in Kinande Vowel Harmony. Phonology 23, 1-20.

Guion, S., Post, M. Payne, D. 2004. Phonetic Contrasts of Tongue Root Vowel Contrasts in Maa. Journal of Phonetics 32, 517-42.

Halle, M. Stevens, K. 1969. On the Feature "Advanced Tongue Root." Quarterly Progress Report 94, Research Laboratory of Electronics, MIT, Cambridge, MA. pp. 209-15.

Hayes, B., Cziráky- Londe, Z. 2006. Stochastic Phonological Knowledge: the Case of Hungarian Vowel Harmony. Phonology 23, 59-104.

Hayes, B., Tesar, B., Zuraw, K. 2003. OT Soft 2.1. Software package, http://www.linguistics.ucla.edu/people/hayes/soft

Hyman, L. 1998. The Historical Interpretation of Vowel Harmony in Bantu. In: Hombert, J-M. , Hyman, L. (Eds.), Bantu Historical Linguistics: Theoretical and Empirical Perspectives. CSLI Publications, Stanford University. pp. 235-95.

Hyman, L. 2002. Is there a right-to-left bias in vowel harmony? Paper presented at the 9th International Phonology Meeting, Vienna.

Hess, S. 1992. Assimilatory Effects in a Vowel Harmony System: an Acoustic Analysis of Advanced Tongue Root in Akan. Journal of Phonetics 20, 475-92.

Ito, C., Kang, Y., Kenstowicz, M. 2006. The Adaptation of Japanese Loanwords into Korean. In: Hsieh, F-f. Kenstowicz, M. (Eds.), Studies in Loanword Phonology, MIT Working Papers in Linguistics 54, Department of Linguistics, MIT, Cambridge, MA. pp. 65-104.

Jäger, G. 2006. Maximum entropy models and Stochastic Optimality Theory. In: Grimshaw, J., Maling, J. Manning, C. Simpson, J. Zaenen, A. (Eds.) *Architectures, rules, and preferences: A festschrift for Joan Bresnan.* Stanford, CA, CSLI.

Kahindo, L. 1981. Desrciption syntaxique du nande. Thèse pour le doctorat de 3 cycle, Université René Décartes, Paris V. Sciences Humaines, Sorbonne

Kaji, S. 2004. A Runyakore Vocabulary. Research Institute for Languages and Cultures of Asia and Africa, Tokyo University of Foregn Studies. Asian and African, Lexicon no. 44.

Kambale, K. 1978. Lexique nande-français français-nande. Editions du Secrétariat Géneral de l'Episcopat du Zaïre, Kinshasa-Gombe.

Kisseberth, C., Abasheikh, M. 2004. The Chimwini lexicon exemplified. Asian and African Lexicon no. 45. Research Institute for Languages and Cultures of Asia and Africa, Tokyo University of Foreign Studies.

Krämer, M. 2001. Vowel Harmony and Correspondence Theory. Doctoral dissertation, University of Düsseldorf.

Ladefoged, P. 1964. A Phonetic study of West African languages: an auditory-instrumental study. Cambridge: Cambridge University Press.

Ladefoged, P., Maddieson, I. 1996. The Sound's of the world's languages. Blackwell, Cambridge, MA.

Lindau, M. 1979. The Feature Expanded. Journal of Phonetics 7, 163-76.

McCarthy, J. 2004. Headed Spans and Autosegmental Spreading. Rutgers Optimality Archive 685.

Mutaka, N. 1995. Vowel Harmony in Kinande. Journal of West African Languages 25:2, 41-55.

Mutaka, N., Kavutirwaki, K. 2006. Kinande-English Dictionary. Bruxelles, Tervuren

Ojo, V. 1977. English-Yoruba Contact in Nigeria. Ph.D. dissertation. Tübingen, Eberhard-Karls Universität.

Sasa, T. 2007. A Span Theoretic Account of Kinande Dominance and Dominance Reversal. Poster presented at 15th Manchester Phonology Meeting.

Schadeberg, T. 2003. Historical linguistics. In: Nurse, D., Philippson, G (Eds.), The Bantu Languages. Routlege, London. pp. 143-63.

Schlindwein, D. 1987. P-bearing Units: a Study of Kinande Vowel Harmony. Proceedings of NELS 17, 551-67.

Smolensky, P. 1995. On the internal structure of the constraint component Con of UG. Handout from talk, University of Arizona. ROA-86.

Tiede, M. 1996. An MRI-Based Study of Pharyngeal Volume Contrasts in Akan and English. Journal of Phonetics 24, 399-421.

Valinande, N. 1984. The Structure of Kinande. Georgetown University Ph.D. dissertation.

Appendixes (most data from Mutaka and Kavutirwaki 2006)

A. Root Vowels

eríbáka	'catch'
erihába	'speak badly'
erisába	'ask'
eritáha	'return home'
eríkála	'be strong'
eríbéta	'hit'
erihéka	'carry'
eriséka	'laugh'
erítéha	'draw'
erítéka	'put'
eríbíba	'sow'
eríhíga	'hunt'
erisíga	'wager'
eritíma	'deceive'
eríkíka	'bar a river'
ȩri̧pí̧pa	'tremble'
ȩri̧hí̧ka	'bewitch'
ȩrí̧sí̧sa	'cut hair'
ȩrí̧tí̧ta	'pay dowry'
ȩri̧kí̧na	'be black'
ȩrí̧kí̧ma	'climb down'
eribóba	'be damp'
eríhóla	'die'
erisósa	'resemble'
erítóga	'fall'
erikóta	'grow old'
eríbúga	'finish'

B. Class 3 Nouns

o̧mú̧sí̧sa	'tendon'
omúsúsa	'taro leaves'
omúsanga	'flower'
o̧mu̧hí̧ndo	'end'
omúhimbi	'leg, calf'
o̧mu̧bí̧ri̧	'work'
omuhúli	'nostril'
o̧mú̧hú̧mbo	'drumstick'
omúkéká	'mat'
o̧mú̧lí̧ki̧	'rope'
omukése	'jaw'
omúkíra	'tail'
omuméro	'throat'
o̧mú̧kú̧nyo	'fold'
o̧mu̧lȩ́ru̧	'nosebleed'
omulíro	'fire'
o̧mu̧sí̧ke	'shore'
o̧mu̧lú̧mbi̧	'fog'
o̧mu̧lú̧bo	'animal track'
omutémbe	'wild plant'

eríhúma	'complain'
erisúha	'be outmoded'
eritúta	'be afraid'
eríkúka	'pick'
ȩrí̧bú̧ga	'say'
ȩrí̧hú̧ka	'cook'
ȩrî̧sú̧ka	'be trapped'
ȩrí̧tú̧ha	'pay'
ȩrí̧kú̧ka	'become dirty'

C. <u>(CI)CaC roots</u>

ȩri̧li̧bána	'disappear'
ȩrí̧bi̧sáma	'hide'
ȩri̧gu̧máta	'fill mouth'
ȩri̧hi̧máta	'massage'
ȩri̧kála	'sit down'
ȩrí̧ku̧káma	'kneel'
ȩrí̧si̧gála	'remain'
ȩri̧hi̧ndána	'meet'
ȩrí̧tu̧láma	'be inside out'
ȩrí̧ku̧mbáta	'embrace'
eríhitána	'get angry'
erîtába	'respond'
eritunáma	'squat'
erítsumánga	'scold'
erisubála	'urinate'
erílumánga	nibble'
erilingána	'be equal'
erîmána	'stop'
eríhutála	'hurt self'
eríbundáma	'crouch'
eríbbáka	'take flight'
erihába	speak badly'
erisába	'ask'
eritáha	'return home'
eríkága	'refuse'
eribátsa	'cut to point'
eriháta	'pluck'
erísáka	'tattoo'

D CVC roots in -ir-a, -i̧r-e

erisába	'ask'
erísáka	'tattoo'
eríbbáka	'take flight'
eritáha	'return home'
eribátsa	'cut in pieces'
erihéka	'carry'
eriséka	'laugh'
eritéha	'dip into'
eritéka	'put'
eribbéta	'slap'
eríhîga	'want'
eríkîka	'bar the way'
eritîma	'deceive'
erísîga	'abandon'
eríbîha	'lie'
erisóha	'sin'
erisósa	'resemble'
eritóka	'be able'
eritóga	'fall'
eribóha	'tie'
eríbúga	'finish'
erihúma	'hit'
eríkúka	'pick up'
erisúha	'be outmoded'
erítsúma	'curse'
ȩri̧hî̧ka	'arrive'
ȩrîlî̧ba	'cover hole'
ȩri̧pî̧pa	'shiver'

eritáka	'boil'	ȩri̧pî̧tsa	'collapse'
erikáta	'stretch'	ȩri̧sî̧ma	'thank'
		ȩrí̧hú̧ka	'cook'
		ȩrí̧sú̧ka	'be trapped'
		ȩrí̧bú̧ga	'speak'
		ȩri̧kú̧ka	'become salty'
		ȩrí̧tsú̧ka	begin'