Analytic Sketches: Kimatuumbi

1. Kimatuumbi Prosodic Phonology

There are three closely related areas of the phonology of Kimatuumbi which relate to suprasegmental properties, namely Glide Formation which turns the high vowels *i* and *u* into the glides *y* and *w*, processes of tone assignment and tone retraction, and Phrasal Shortening which shortens long vowels in a word which is followed by another word in the phrase.

1.1. Vowel Sequences

One of the most pervasive phonological phenomena in Kimatuumbi is Glide Formation, which changes the high vowels *u* and *i* into the glides *w* and *y* before a vowel. Within a word, *u* and *i* can never stand before another vowel. One context illustrating Glide Formation arises when a noun class prefix is placed before a vowel initial stem. Nouns in Kimatuumbi are lexically or grammatically assigned to different morphological classes, which are marked by the presence of a prefix such as *mi-, li-* or *lu-*. The data in (1) provide examples of these prefixes: the example on the left demonstrates the form of the prefix before a consonant, and the corresponding example on the right demonstrates the prefix before a vowel.

(1)

mi-kaáte	'loaves'	my-oótó	'fires'
li-kuŋuúnda	'filtered beer'	ly-oowá	'beehive'
ki-kálaaŋgo	'frying pan'	ky-uúlá	'frog'
i-kálaaŋgo	'frying pans'	y-uúlá	'frogs'
lu-toóndwa	'star'	lw-aaté	'banana hand'
tu-tóopé	'little handles'	tw-iípɔkó	'little rats'
ku-suúle	'to school'	kw-iisíwá	'to the islands'
mu-kikálaaŋgo	'in a frying pan'	mw-iikálaaŋgo	'in frying pans'

This phonological process of Glide Formation can be formalized as follows.

(2) *Glide Formation*

$$[+hi] \rightarrow [-syl] \; / \; \underset{V}{\_\_} \; V$$

Not only is the high vowel of the prefix replaced by an appropriate glide, but the following vowel also becomes long. One of the side-effects of Glide Formation is that the vowel on the right, the one which triggers the rule, becomes long by what is known as compensatory lengthening. Additional evidence can be mustered to motivate the claim that Glide Formation lengthens the following vowel. In (3) we can see pairs of words with the same stem. The examples on the left show that the stem has an underlying short vowel, which surfaces as short either when there is no prefix or when the prefix vowel is *a*. The example on the right shows the same stem after a prefix which has an underlying high vowel that undergoes Glide Formation.

(3)				
	ma-ótó	‘large fires’	my-oótó	‘fires’
	ma-owá	‘beehives’	ly-oowá	‘beehive’
	até	‘banana hands’	lw-aaté	‘banana hand’
	ka-úlá	‘small frog’	ky-uúlá	‘frog’
	i-pɒkɔ́	‘rats’		
	pa-i-pɒkɔ́	‘where the rats are’	tw-ií-pɒkɔ́	‘little rats’
	i-kálaaŋgo	‘frying pans’		
	pa-i-kálaaŋgo	‘where frying pans are’	mw-ii-kálaaŋgo	‘in frying pans’

A conceivable approach to these vowel length alternations would be to assume that the stem vowel is underlyingly long, and undergoes shortening when the vowel is word initial or preceded by another vowel. This alternative can be ruled out, since there is a lexical contrast between long and short vowels in this position. The nouns in (4) have underlying initial long vowels, and they retain that long vowel both when preceded by a prefix with a high vowel (where Glide Formation applies), when preceded by a prefix ending with *a*, and when there is no prefix.

(4)				
	mw-eémbe	‘mango tree’	eémbe	‘mango fruit’
	my-eémbe	‘mango trees’	ka-eémbe	‘small mango’
	ly-éeke	‘storage shack’	ma-éeke	‘storage shacks’
	lw-áanjú	‘firewood piece’	aanjú	‘firewood’
	ky-ɪímbe	‘knife’	ka-ɪímbe	‘small knife’
	ky-úundó	‘knot’	ma-úundó	‘large knots’
	mw-eéla	‘in money’	eéla	‘money’

This shows that the supposed rule shortening word-initial and postvocalic long vowels is simply incorrect. The examples in (4) undergo Glide Formation, with no compensatory lengthening effect, since the triggering vowel is already long.

Additional motivation for Glide Formation comes from the verbal paradigm. In (5) we see examples of subject prefixes followed by the verb stem: those on the left illustrate the underlying prefix, and those on the right, before a vowel-initial stem, illustrate Glide Formation.

(5)				
	ni-téliike	‘I cooked’	ny-ʊɔ́bɪliile	‘I expected’
	tu-téliike	‘we cooked’	tw-eékite	‘we laughed’
	ki-tɔ́ʊmbwiike	‘it (7) fell’	ky-oóbite	‘it (7) is lost’
	u-téliike	‘you(sg.) cooked’	w-aákite	‘you(sg.) hunted’

The infinitive form of the verb is given in (6), where it can be seen that underlyingly these stems begin with a short vowel, and application of Glide Formation causes the following vowel to lengthen.

(6)				
	ɔ́bɪlya	‘to expect’	éka	‘to laugh’
	óba	‘to be lost’	áka	‘to hunt’

Furthermore, when these stems are preceded by the vowel *a*, which does not undergo Glide Formation, the stem inital vowel surfaces as short.

(7)

ba-ékite	‘they laughed’
ga-óbɪliilwe	‘they (Cl. 6) are expected’
naaba-óbɪliile	‘I expected them’
ba-óbite	‘they are lost’
a-eké	‘he should laugh’
aga-obíye	‘he should lose them’

Again, the alternative analysis where one assumes the initial vowel of the stems in (6) to be underlyingly long and shortened initially or postvocalically can be ruled out by the examples in (8), where the stem has an underlying long vowel, and the vowel is long in all contexts.

(8)

áandika	‘to write’	tw-áandiike	‘we wrote’
óʊma	‘to win a case’	w-óʊmite	‘you won’
íɪmba	‘to dig’	ny-íɪmbite	‘I dug’
ba-íɪmbite	‘they dug’		
ba-óʊmite	‘they won’		

A further tonal consideration shows that examples such as those in (5) differ from those in (8) in having underlying short vowels. In the past tense illustrated in these examples, every verb has a H tone on the first vowel of the stem: the data in (9) further illustrate this point.

(9)

tu-téliike	‘we cooked’	tu-kéeŋgiimbe	‘we dug tubers’
tu-kálaaŋgite	‘we fried’	tu-káatite	‘we cut’

When the first vowel of the stem is long, it is realized with a falling tone, which is to say that on a long vowel, the H tone appears on the first half of the long vowel. Now notice that there is a tonal difference between those stems which begin with a long vowel and those that begin with a short vowel: the initial syllable in the first group has a falling tone while the initial syllable in the second group has a rising tone.

(10)

a.	tw-óʊmite	‘we won a case’	/ʊʊm-/
	ny-óʊmite	‘I won a case’	
	ba-óʊmite	‘they won a case’	
b.	tw-eékite	‘we laughed’	/ek-/
	ny-eékite	‘I laughed’	
	ba-ékite	‘they laughed’	

When the stem initial vowel is long, it has a falling tone as expected, and that tone is not changed by the addition of a prefix, since applying Glide Formation to the prefix does not cause a change in the length of the following vowel. However, when the initial vowel is underlyingly short but becomes lengthened due to Glide Formation applying to the L toned vowel of the subject prefix, a rising tone – a long vowel whose first half is L toned and whose second half is H toned – is the result. This tonal difference would be possible only if these stems contrast in their vowel length.

There is a small complication in the operation of Glide Formation, which demonstrates the crucial connection between application of Glide Formation and compensatory lengthening of the following vowel. As can be seen in (11), when the prefix with a high vowel is not at the beginning of the word, application of Glide Formation is optional.

(11)	ku-tu-ákya	~	ku-tw-aákya	‘to hunt for us’
	ku-ni-áandika	~	ku-ny-áandika	‘to write me’
	a-lu-ásiime	~	a-lw-aásiime	‘he borrowed it (11) (recent)’
	baa-ki-únite	~	baa-ky-uúnite	‘they harvested it (7) (remote)’

These data show that the following vowel is lengthened only if Glide Formation actually applies. This rules out the possibility of stating lengthening as an independent process from Glide Formation.

In the examples of Glide Formation considered so far, the prefixal vowel and following vowel had a different quality. Data in (12) show what happens when the prefix vowel and following vowel are identical: a single long vowel results, with no glide.

(12)	k-iígé	‘eyebrow’	/ki-ígé/ (Cl. 7)	(cf. ka-ígé ‘little brow’)
	m-uúnene	‘tree’	/mu-únene/ (Cl. 3)	(cf. kaúnene ‘little tree’)
	l-iimyé	‘slug’	/li-imyé/ (Cl. 5)	(cf. ma-imyé ‘sluge’)
	k-uukumú	‘to Ukumu’	/ku-ukumú/ (Loc.)	(cf. ukumú ‘Ukumu’)

Additional data making the same point are given in (13), using the combination of a verbal prefix plus a verb stem.

(13)	niísiile	‘I went’	/ni-ísiile/
	tuúnite	‘we harvested’	/tu-únite/
	muúlwiike	‘you (pl) descended’	/mu-úlwiike/
	nikiíyite	‘I hid it (Cl.7)’	/ni-ki-íyite/
	baatuútite	‘they pulled us’	/ba-a-tu-útite/

There are two ways one might approach these data. On the one hand, one might posit an independent rule which fuses sequences of identical high vowels into one long vowel; on the other hand, one might apply Glide Formation, generating forms such as *nyiísiile* and *twuúnite*, and then delete the glide by a separate rule. The specific context for deletion of a glide is when it is followed by an identical vowel.

(14) *Glide Deletion*

$$\begin{bmatrix} -\text{cons} \\ -\text{syl} \\ \alpha\text{back} \\ \beta\text{hi} \\ \gamma\text{tense} \end{bmatrix} \rightarrow \varnothing \; / \; \underline{\quad} \; \overset{\text{V}}{\begin{bmatrix} \alpha\text{back} \\ \beta\text{hi} \\ \gamma\text{tense} \end{bmatrix}}$$

Additional data refine the Glide Deletion rule, and support the hypothesis of Glide Formation and Glide Deletion as the mechanism for handling identical vowel fusion, since these data show that the expected glide can actually be found phonetically. When the high vowel is not preceded by a consonant, deletion of the glide is optional and thus one may encounter a phonetic glide in this context.

(15)	/i-ígé/	→	yiígé	~ (opt)	iígé	‘eyebrows’
	/u-uúji/	→	wuúji	~ (opt)	uúji	‘porridge’
	/u-úniilwe/	→	wuúniilwe	~ (opt)	uúniilwe	‘it was harvested’

1.2. Tone Assignment in Verbs

Verbs in Kimatuumbi have no lexical tone contrasts. Instead, tone is assigned to verbs on the basis of morphological characteristics, such as verb tense, interacting with phonological properties of the verb. In one set of verb tenses which includes the infinitive, the future tense and the subjunctive, a H tone is assigned to the first vowel of the stem. When the initial syllable contains a short vowel, this means that the vowel has a H tone, and if the initial syllable is long, this means that the vowel bears a falling tone.

(16)	ŋálaŋaata	'to shine'	káata	'to cut'
	kuki-káata	'to cut it (cl. 7)'	ki-káata	id.
	lyá	'to eat'	kuu-lyá	'to eat it (cl. 3)'
	baa-téleka	'they will cook'	baaga-téleka	'they will cook them (cl. 6)'
	ni-káatite	'I cut (rec.)'	naa-káatite	'I cut (rem.)'

This pattern makes sense if long vowels are treated phonologically as being equivalent to a sequence of identical short vowels, as they are transcribed here.

A more interesting pattern is seen in the subjunctive tense, where a H tone is assigned to the third vowel after the subject prefix. Data in (17) give uncomplicated examples of this pattern, where there are at least three vowels and none of the vowels are long.

(17)	n-teleké	'you (pl.) should cook'
	ni-kemekéme	'I should call out frequently'
	u-gundumúye	'you should scare'
	ba-tyatyakíkiyane	'they should plaster for each other'
	u-gundumúyegundumuye	'you should scare frequently'

(18) shows that if there are only one or two vowels in the verb after the subject prefix, H is assigned to the final vowel of the verb.

(18)	u-lyé	'you should eat'
	ba-temé	'they should chop'

Assignment of H tone can be handled by the following rule.

(19) *H Tone Assignment*

$v \rightarrow \acute{v}$ / Subj. prefix + V C_0 V C_0 ___ (in the subjunctive, participial)

In case there are long vowels in the first two syllables after the subject prefix, the H tone is assigned to the third vowel as well – however, this pattern is clear only if long vowels are treated as equivalent to a sequence of short vowels, as can be seen by the parellel transcription with vowel length and contour tones being treated as atomic properties, assigned as plus or minus values of features to single vowel segments. Consider the data in (20). In the first example, the H is assigned to the first half of a long vowel, where it is phonetically interpreted as a falling tone. In the second example, the third vowel is in the second half of a long vowel, and thus the H is realized phonetically as a rising tone on a long syllable. In the third example, the H tone is realized as a level H on a short vowel in the second syllable, since the first syllable contains a long vowel, which counts as two vowels. In the final example, the H is realized on the second syllable because the preceding syllable is long which accounts for the first two vowels, and since the H is assigned to the first half of a long vowel, it is realized phonetically as a falling tone.

(20)	i-ŋalaŋáate	=	iŋalaŋâ:te	‘it should shine’
	u-lındıíle	=	ulındĭ:le	‘you should guard’
	u-buundáye	=	ubu:ndáye	‘you should blunt’
	u-keeŋgéembe	=	uke:ŋgê:mbe	‘you should dig tubers’

Description of this pattern is incoherent, unless one treats long vowels as being sequences of identical vowels, and rising and falling tones are really LH versus HL sequences of tones on identical vowels.

In the examples presented above, the three-vowel sequence was contained entirely within the stem. However, an object prefix may appear after the subject prefix, and the vowel of that prefix will be included in the count, so that after an object prefix, the H tone appears on the second vowel of the stem – where it may be realized phonetically as a rising tone if it lands on the second half of a long vowel, or as a falling tone if it lands on the first half of a long vowel.

(21)	u-ki-lyé	‘you should eat it (Cl. 7)’
	mu-u-temé	‘you (pl) should chop it (Cl. 3)’
	mu-u-teméteme	‘you (pl) should chop it (Cl. 3) often’
	ba-ni-teléki	‘they should cook for me’
	u-ki-buúndaye	‘you should blunt it (Cl. 7)’
	u-ni-kaláaŋgi	‘you should fry for me’

Similarly, the aspect prefixes *-ka-* and *-a-* can appear after the subject prefix, and they too are included in the count of vowels after the subject prefix.

(22)	ni-ka-kaláaŋge	‘I should go fry’
	u-ka-gundúmuye	‘you should go scare’
	w-aa-lındíıle	‘you should guard (fut)’
	w-aa-buúndaye	‘you should blunt (fut)’

Finally, when the verb contains both an aspect prefix and an object prefix, the H tone is assigned to the first vowel of the stem – again, the H is assigned consistently to the third vowel after the subject prefix.

(23)	ni-ka-u-kúŋuunde	‘I should go filter it (Cl. 14)’
	ba-ka-t-úundwe	‘they should go untie us’
	w-aa-ni-líndııle	‘you should guard me (fut.)’

This pattern of tone assignment is also found in the participial tense, as can be seen in (24). The examples in (a) show that H is assigned to the final vowel if the verb has only one or two vowels after the subject prefix; those in (b) show straightforward assignment of H to the third vowel; (c) shows how the assignment of tone is based on a phonological decomposition of long vowels into a sequence of two short vowels; (d) shows that the object prefix is also included in the count of vowels. These are exactly the patterns which were encountered in the subjunctive tense.

(24)	a.	ka-ni-lyá	‘while I was eating’
		ka-ni-temá	‘while I was chopping’
	b.	ka-ba-teleká	‘while they were cooking’
		ka-ni-tematéma	‘while I was chopping frequently’
	c.	ka-tu-lındíıla	‘while we were waiting’
		ka-i-ŋalaŋáata	‘while it was shining’
		ka-ni-buundáya	‘while I was blunting’

d. ka-ny-uu-temá ‘while I was chopping it (Cl. 3)’
ka-ba-ku-telékya ‘while they were cooking for you’
ka-ni-ku-gundúmuya ‘while I was scaring you’

There is an interesting complication to the pattern of tone assignment, where the H surfaces on the second vowel and not the third vowel. Just in case the verb has a long vowel in the penultimate syllable and the tone would have been assigned to the final syllable, H actually is realized on the penult, as a rising tone.

(25) u-kaáte ‘you should cut’ *u-kaaté
u-toóle ‘you should take’ *u-toolé
kani-kaáta ‘while I was taking’ *kani-kaatá

This apparent exception can be explained by assigning H to the third vowel, as expected, and then applying a rule which retracts H tone from a final syllable to the second half of a preceding long syllable.

(26) *H Tone Retraction*
vv c v́ # → vv́ c v #

In certain other verb tenses, a H tone is assigned to the second vowel of a stem, which includes the vowel of any object prefix. Examples of this pattern are seen in (27) using the ‘when-habitual’ tense. Here too, the pattern of tone assignment provides evidence for treating long vowels as a sequence of identical vowels, so that if the first vowel is long the H is realized on the first syllable as a rising tone, and if the first vowel is short and the second long, the H is realised on the second syllable with a falling tone.

(27) patú-lyá ‘when we eat’
paá-ki-lyá ‘when he eats it (Cl. 7)’
paá-temá ‘when he chops’
pabá-kunákuna ‘when they grated coconuts frequently’
paá-ki-téma ‘when he chops it (Cl. 7)’
paní-kaáta ‘when I cut’
paá-ni-káatya ‘when he cuts for me’
paú-lındíıla ‘when you guard’
paá-ki-líndııla ‘when he guards it (Cl. 7)’

This same pattern is found in the relative clause habitual tense and the habitual.

(28) ywaá-teléka ‘the one who cooks’
ywaá-kutélekya ‘the one who cooks for you’
ywaá-kaáta ‘the one who cuts’
ywaá-lındíıla ‘the one who waits’
baká-teléka ‘if they cook’
baká-kutélekya ‘if they cook for you’
tuká-goónja ‘if we sleep’

1.3. Phrasal Shortening

There is a general rule in Kimatuumbi that when a word is followed by a modifier in its phrase, long vowels in the first word are shortened. Examples of this can be seen in (29), where the noun in its cita-

tion form has a long vowel, but when it is followed by a modifier such as a possessive pronoun, an adjective, a relative clause or a determiner, the long vowel is shortened.

(29)	kikóloombe	'cleaning shell'
	kikólombe čaáŋgɔ	'my cleaning shell'
	mikaáte	'loaves'
	mikaté mikólɔ mikóló	'large loaves'
	lukaámba	'string'
	lukambá lwalúpɔwáaniiké	'string which broke'
	mbooópo	'machete'
	mbopó ye	'the machete'

The syntactic relation between the word that undergoes shortening and the following word is crucial. If the two words are not in the head-modifier relation, then there is no vowel shortening.

(30) $[_{NP}$ kikóloombé[1] $_{NP}]$ $[_{VP}$ čaapówaaniike $_{VP}]$
shell broken

'The shell is broken'

$[_{VP}$ naampéi $[_{NP}$ kikóloombe $_{NP}]$ $[_{NP}$ Mamboóndo $_{NP}]$ $_{VP}]$
I-him-gave shell Mamboondo

'I gave Mamboondo the shell'

$[_{VP}$ naakibwéni $[_{NP}$ kikóloombe $_{NP}]$ líilí $_{VP}]$
I-it-saw shell neg

'I didn't see the shell'

This rule also applies to verbs, when they are followed by objects or any other word.

(31)	nika-kálaaŋga	'I will go fry'
	nika-kálaŋga lí	'I will not go fry'
	nika-kálaŋga kinjáambú	'I will go fry cassava'
	nika-kálaŋga yóopáta eéla	'I will go fry to get money'

We will formalize this process as follows, forgoing a detailed account of how the syntactic conditions are to be imposed on this rule.

(32) *Phrasal Shortening*
VV → V / __ ... # X

1.4. Interaction between processes

Now we turn to the interaction between the phonological processes motivated above. Recall that there is a rule retracting a H tone from a final syllable to an immediately preceding long penult, so that where one would have expected (on analogy to *uteleké*) that the subjunctive form should be **ukoomwé* because the final vowel is the third vowel, the actual form is *ukoómwe*. However, a long vowel which is de-

[1] The word-final H tone is assigned by a rule which will not be considered here.

rived by the compensatory lengthening side effect of Glide Formation does not trigger this tone retraction process.

(33)	áka	'to hunt'	waaké	'you should hunt'
	éka	'to laugh'	weeké	'you should laugh'
	íya	'to hide something'	wiiyé	'you should hide'

We can explain these examples by assuming that Glide Formation applies after H Tone Retraction. At the stage where H Tone Retraction applies, the verb *waaké* has the form *u-aké*, which has no long vowel, and therefore Retraction cannot apply. Latter application of Glide formation yields *waaké*: the opportunity to apply Tone Retraction has passed by.

Contrasting with stems of the form VCV such as *-ake* are stems of the form VVCV, such as *-aame*. In such stems which have an underlying long vowel, Glide Formation is not needed to create a long vowel that triggers Retraction, and as the following data show, Retraction does apply to the H which is expected to be on the final syllable.

(34)	áama	'to emigrate'	waáme	'you should emigrate'
	íɪmba	'to dig'	wɪímbe	'you should dig'

Thus, underlying /u-aamé/ undergoes Retraction to give *uaáme*, which then undergoes Glide Formation resulting in surface *waáme*.

Another process which affects vowel length is Phrasal Shortening. The examples in (35) are nouns which have an underlying final H tone that is preceded by a penultimate long syllable. When the noun stands alone, the long vowel is unaffected, and the final H tone is retracted, thus /mboopó/ → [mboópo] 'machete'. When the noun is followed by a modifier, the vowel is shortened, and therefore the H tone remains in its underlying position, on the final syllable.

(35)	mboópo	'machete'	mbopó yaáŋgʊ	'my machete'
	kalataási	'paper'	kalatasí ŋgʊlʊ́	'large piece of paper'
	sipitaáli	'hospital'	sipitalí yɪnó	'this hospital'
	ŋkaáte	'loaf'	ŋkatée mmígí	'raw loaf of bread'

A related point can be made with verbs in the subjunctive tense; when the verb stands alone, the vowel remains long so Retraction shifts the final H to the penult, whereas if the verb is followed by a modifier, the vowel is shortened, so there is no retraction.

(36)	ubeénde	'you should shout'
	ubendé ukumú	'you should shout at Ukumu'
	ukoómwe	'you should cough'
	ukomwé lí	'you should not cough'

These data demonstrate that Phrasal Shortening precedes Retraction, since application of Shortening crucially deprives words of the long vowel required by Retraction. We have also seen that Retraction precedes Glide Formation, giving the strict ordering Shortening → Retraction → Glide Formation. The interaction between all three of these processes can be directly investigated, by considering words composed of prefix plus VCV and VVCV stem having a final H tone, followed by a modifier. First we consider stems with underlying short vowels. As seen in (37), such stems retain long surface vowels, and their final H does not alternate in position.

(37)	ly-oowá	‘beehive’	ly-oowá linaántopá	‘heavy beehive’
	lw-aaté	‘banana hand’	lw-aaté lwaáŋgʊ	‘my banana hand’
	w-iiyé	‘you should hide’	w-iiyé kitéleéko	‘you should hide the pot’

Starting from underlying /u-iyé kitéleéko/, Shortening is not applicable because the verb has no long vowels. Retraction would be the next rule applicable, but final H does not retract because the preceding vowel has not become long yet. Finally, Glide Formation applies to give the surface form: at this point the conditions for Retraction and Shortening are found, but the opportunity to apply those rules have already passed.

On the other hand, if the word has the underlying stem shape VVCV, the conditions for H Tone Retraction are satisfied without application of Glide Formation. Thus, such nouns exhibit an alternation in the position of tone depending on phrasal position, but do not have an alternation in vowel length.

(38)	mw-eémbe	‘mango tree’
	mw-eembé waáŋgʊ	‘my mango tree’
	ky-ɪímbe	‘knife’
	ky-ɪɪmbé činaántopá	‘heavy knife’

In its isolation form, the noun *mweémbe* is underlying *mu-eembé*; it undergoes Retraction because of the long vowel, then Glide Formation applies, which has no effect on surface vowel length because the initial vowel is already long. In the phrase *mweembé waáŋgu*, the underlying form first undergoes Shortening, giving *muembé waáŋgu*. Retraction cannot apply to this because it has a short vowel in the penult, and therefore the tone remains on the last syllable. Subsequently, Glide Formation applies, giving the phonetic form.

To summarize, the following rules have been motivated for Kimatuumbi, along with their crucial orderings.

(39)