Chapter 4

Vowel hiatus resolution in Kikuyu

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This paper describes and analyzes vowel hiatus resolution in Kikuyu, filling empirical gaps in previous descriptions and addressing differences between our data and earlier published data that may reflect dialectal and/or generational differences. We demonstrate that Kikuyu's superficially very complex system of vowel hiatus resolution can be analyzed straightforwardly using ordered autosegmental rules, most notably *ATR shift*, which captures the observation that, with limited systematic exceptions, when two vowels come together with underlying features [−ATR][+ATR] or [−ATR][−ATR] they surface as [+ATR][−ATR], while underlying sequences [+ATR][−ATR] and [+ATR][+ATR] surface unchanged (in other words, if either vowel is [−ATR] underlyingly, the surface form will be [+ATR][−ATR]). Other rules include fusion, assimilation, diphthongization, and shortening.

1 Introduction

This paper describes vowel hiatus resolution (VHR) in Kikuyu (E.51, Kenya). There exists a significant earlier description (Armstrong 1940; see also Mugane 1997), so one goal of this paper will be to fill gaps in that description and address differences between our data and earlier published data that may reflect dialectal and/or generational differences. We will also present a rule-based phonological analysis of Kikuyu VHR; for an OT analysis of some aspects of this system, see Kuzmik (2020). The vowel inventory of Kikuyu is presented in Table 1 with the feature specifications we assume. Each of the seven short vowels also has a long counterpart.

A variety of factors determine the surface form when vowels come together across a word or morpheme boundary. The factors that we have determined to

Mary Paster & Jackson Kuzmik. 2024. Vowel hiatus resolution in Kikuyu. In James Essegbey, Brent Henderson, Fiona McLaughlin & Michael Diercks (eds.), *Pushing the boundaries: Selected papers from the 51–52 Annual Conference on African Linguistics*, 75–107. Berlin: Language Science Press. DOI: 10.5281/zenodo.14038737

Table 1: Kikuyu vowel features

	/i/	/e/	/ɛ/	/a/	/ɔ/	/o/	/u/
[±high]	+	-	-	-	-	-	+
[±low]	-	-	-	+	-	-	-
[±ATR]	+	+	-	-	-	+	+
[±back]	-	-	-	+	+	+	+
[±round]	-	-	-	-	+	+	+

be relevant in Kikuyu are listed in (1) (see Casali 2011 for discussion of these and other factors that influence VHR outcomes across languages).

(1) **Factors in Kikuyu VHR outcomes**

- V_1 quality & length; V_2 quality & length
- presence/quality/length of V preceding V_1
- presence/type of C (velar vs. non-velar) preceding V_1 segment following V_2
- presence/quality/length of V following V_2
- presence/type of C (nasal vs. oral) following V_2
- boundary type between V_1 and V_2 (morpheme vs. word)

This paper focuses on Kikuyu VHR in a subset of possible contexts: V_1+V_2 across a word boundary, where V_1 is preceded by a consonant (non-velar, where possible) and V_2 is followed by an oral consonant.

2 Data

All data in the paper, except where noted, reflect auditory-impressionistic transcriptions produced by the authors. Some vowel quality distinctions are especially challenging to transcribe in the connected-speech context since asking the speaker to slow down the pronunciation for ease of transcription will in many cases categorically alter the vowels (because hiatus resolution rules do not apply in careful speech). Our speaker therefore patiently repeated the more difficult connected-speech forms for us many times. A large portion of our elicitation time has been spent comparing forms and marking surface vowel sequences as 'same' vs. 'different' as a check on consistency external to individual transcriptions. For example, we transcribed the connected-speech form of 'Mũgo, answer!'

as *móɣóɛ́tékà* and noted that the [oɛ] sequence (derived from underlying ɔ+e) sounded 'the same' as the [oɛ] sequence in *gɛ̀ʃóɛ́hɛ́rà* 'Ngecũ, stand aside!' (from underlying o+ɛ) whereas both were explicitly marked as 'different' from the sequence we transcribed as [oe] in *gèʃòròètékà* 'Gĩcũrũ, answer!'. Although minimal pairs that control for surrounding segments are hard to find in this domain, pairwise comparisons isolating the vowel sequences of interest have increased our confidence in the auditory transcriptions.

Note that the tonal transcriptions have not been cross-checked comprehensively for consistency with a phonological analysis of Kikuyu tone. Especially in the connected speech context, downstep is difficult to identify (both the perceived tonal contour and its representation in a pitch track using Praat differs minimally and unreliably in HH vs. H!H and HLH vs. H!HH sequences). The phonology of downstep is notoriously complex in Kikuyu (see, e.g., Clements & Ford 1981a), and we are not aware of an existing description of tone patterns in the specific syntactic context that represents the bulk of the examples presented in this paper (i.e., a person's name or other nominal used as a vocative followed by a singular imperative form) that might help us to confirm and refine our transcriptions. Existing descriptions also do not address speech rate effects in surface phrase-level tone/intonation. Therefore, we regretfully acknowledge that future research may reveal errors in our tonal transcriptions, particularly with respect to the presence/absence and placement of downsteps. We have opted to tone-mark our data regardless for completeness, but we do not advise using our tonal transcriptions as the sole basis for future analyses of the tone system.

3 Description of the core vowel hiatus resolution pattern

Table 2 summarizes the surface forms corresponding to input V_1+V_2 (short vowel) combinations.[1]

The boxed cells in Table 2 indicate surface vowel combinations produced by our consultant that differ from those reported by Armstrong, which we discuss further below. Some generalizations that can be noted regarding the patterns in Table 2 are: (a) no changes apply when V_1 and V_2 are identical (except we assume they merge into a single long vowel); (b) no changes apply when V_1 is [+ATR]; (c) no changes apply when V_2 is i; (d) *u* as V_2 diphthongizes after a [−ATR] V_1 with

[1]We transcribe and present sequences of identical vowels here as, e.g., ii, ee for ease of identifying correspondences between underlying and surface vowels. We do not intend these to be interpreted as sequences; as will be discussed, our analysis includes a rule that fuses identical adjacent short vowels into a single long vowel.

Table 2: Short V_1 + Short V_2

V_1	i	e	ɛ	a	ɔ	o	u
i	ii	ie	iɛ	ia	iɔ	io	iu
e	ei	ee	eɛ	ea	eɔ	eo	[eu]
ɛ	ɛi	ɛɛ	ɛɛ	ea	eɔ	[eo]	eɔi
a	ai	ɛɛ	ɛɛ	aa	ɔɔ	ɔɔ	ɔi
ɔ	ɔi	oɛ	oɛ	[ɔa]	ɔɔ	ɔɔ	ɔi
o	oi	oe	oɛ	oa	[oɔ]	oo	[ou]
u	ui	ue	uɛ	ua	uɔ	uo	uu

additional changes applying to V_1; (e) the /e/ vs. /ɛ/ and /o/ vs. /ɔ/ contrasts are neutralized before mid vowels of the opposite value for backness; (f) surface mid vowel sequences can be [+ATR][−ATR] but not the reverse.

Below are examples of all combinations of short vowels that undergo a quality change in the context of interest here. In each example, the careful speech form is given on the left, and the connected speech form is on the right. We assume that careful speech reflects the underlying form in terms of vowel quality, but not in all details (e.g., tone). Therefore, the forms to the left of the arrow should not be taken as underlying forms.

(2) V_1+V_2 combinations that undergo quality change (careful speech → connected speech)

a.	ɛ+e → ɛɛ	ŋɔ́ɔ́bɛ́ èɣéðìè	→ ŋɔ́ɔ́bɛ́ɛ́ɣɛ̀ðìɛ̀	‘The cow went.’
		jɔ̀rɔ̀gɛ́ étékà	→ jɔ̀rɔ̀gɛ́ɛ́tékà	‘Njoroge, answer!’
b.	ɛ+a → ea	dɔ̀ɔ̀nìrɛ́ áðùùrì	→ dɔ̀ɔ̀nìréáðúúrì	‘I saw the elders.’
		dòkààrɛ̀kɛ̀ áhóótɛ̀	→ dòkààrɛ̀kèàhóótɛ̀	‘Don’t let her get hungry.’
		dɛ̀ɛ̀tìrɛ́ átùmíà	→ dɛ̀ɛ̀tìréátùmíà	‘I called the women.’ (rem. past)
		rɛ̀kɛ̀ áðìè	→ rɛ̀kéáðìè	‘Let him go.’
c.	ɛ+ɔ → eɔ	kàmààdɛ́ ɔ́hà	→ kàmààdéɔ́hà	‘Kamande, tie!’
		kàmààdɛ́ ɔ́ɣà	→ kàmààdéɔ́ɣà	‘Kamande, lift!’

d.	ɛ+o → eo	ɔ̀ʃɔ́ɔ́kɛ́ ótòɛ̀jɛ̀	→ ɔ̀ʃɔ́ɔ́kèòtòɛ̀jɛ̀	'Then shave us.'
		nààwɛ́ óɣékúúdɛ́káɣɛ́	→ nààwéóɣékúúdɛ́káɣɛ́	'and you continue tying...'
e.	ɛ+u → eɔi	jɔ̀rɔ̀gɛ́ úɣà	→ jɔ̀rɔ̀géɔ́ìɣà	'Njoroge, say something!'
		kàmààdɛ́ úɣà	→ kàmààdéɔ́íɣà	'Kamande, say something!'
f.	a+e → ɛɛ	nyààbùrá étékà	→ nyààbùrɛ́ɛ́tékà	'Nyambura, answer!'
		wáʃíírá ètékà	→ wáʃíírɛ̀ɛ̀tékà	'Waciira, answer!'
g.	a+ɛ → ɛɛ	nyààbùrá ɛ̀hɛ́rà	→ nyààbùrɛ́ɛ́ꜜhɛ́rà	'Nyambura, stand aside!'
		wáʃíírá ɛ̀hɛ́rà	→ wáʃíírɛ́ɛ́ꜜhɛ́rà	'Waciira, stand aside!'
h.	a+ɔ → ɔɔ	tààtà ɔ́ɣà	→ tààtɔ́ɔ́ɣà	'Aunt, lift!'
		nyààbùrá ɔ́hà	→ nyààbùrɔ́ɔ́hà	'Nyambura, tie!'
i.	a+o → ɔɔ	tààtà óyó	→ tààtɔ̀ɔ̀yó	'this aunt'
		nyòògò yá òʃòrò	→ nyòògò yɔ́ɔ́ʃòrò	'porridge pot'
		mòðɛ́nyà óʃìɔ̀	→ mòðɛ́nyɔ̀ɔ̀ʃíɔ́	'that day'
		nà òrɛ́ɛ́hɛ̀	→ nɔ̀ɔ̀rɛ́ɛ́hɛ̀	'and bring...'
j.	a+u → ɔi	tààtà úɣà	→ tààtɔ́ìɣà	'Aunt, say something!'
		bùrá úrà	→ bùrɔ́ìrà	'Rain, come down!'
k.	ɔ+e → oɛ	móɣɔ́ étékà	→ móɣóɛ́tékà	'Mũgo, answer!'
		gèkɔ̀nyɔ́ étékà	→ gèkɔ̀nyóɛ́tékà	'Gĩkonyo, answer!'
l.	ɔ+ɛ → oɛ	gèkɔ̀nyɔ́ ɛ́hɛ́rà	→ gèkɔ̀nyóɛ́hɛ́rà	'Gĩkonyo, stand aside!'
		bɔ̀ɣɔ̀ ɛ́hɛ́rà	→ bɔ̀ɣòɛ́hɛ́rà	'Mbogo, stand aside!'
m.	ɔ+o → ɔɔ	mòtàrɔ́ óʃíɔ̀	→ mòtàrɔ́ɔ́ʃíɔ́	'that drain'
		gèkɔ̀nyɔ́ óhèɣà	→ gèkɔ̀nyɔ́ɔ́hèɣà	'Gĩkonyo, be smart!'

n.	ɔ+u → ɔi	gèkɔ̀nyɔ́ úɣà	→ gèkɔ̀nyɔ́ꜜíɣà	‘Gĩkonyo, say something!’
		bɔ̀ɣɔ̀ úɣà	→ bɔ̀ɣɔ́íɣà	‘Mbogo, say something!’

As mentioned earlier, there are some differences between our data and Armstrong’s. First, Armstrong (1940: 23) states that *ɔ+a* yields *oa*, though the example she provides is actually an *ɔ+aa* input sequence with a long V_2: *aɣeeta waðiɔmɔ* ***aa****ke* → *aɣeeta waðiɔm****oaa****ke* ‘and he invited his greatest friends…’. Our speaker replicated this example with *ɔ+aa* → *ɔa* (*àɣèètá wáðíɔ̀m****ɔ̀*** ***áá****ke* → *àɣèètá wáðíɔ̀m****ɔ̀à****ke*; see §5.4 below for more on V+V: sequences). For our speaker, *ɔ+a* yields *ɔa*, as shown in (3).

(3)	ɔ+a → ɔa	mòɣɔ̀ áyá	→ mòɣɔ̀àyá	‘these Mũgos’
		mòɣɔ̀ àrìà	→ móɣɔ́árìà	‘Mũgo, speak!’

A second difference from Armstrong is that for our consultant, *ɛ+o* surfaces as *eo*, while Armstrong reports *eɔ*. Some forms from our consultant (replicated from (2d)) are given in (4).

(4) ɛ+o → eo

ɔ̀ʃɔ́ɔ́kɛ́ ótòɛ̀jɛ̀	→ ɔ̀ʃɔ́ɔ́kèòtòɛ̀jɛ̀	‘Then shave us.’
nààwɛ́ óɣékúúdɛ́káɣɛ́	→ nààwéóɣékúúdɛ́káɣɛ́	‘and you continue tying…’

Compare the forms in (4) with Armstrong’s examples (1940: 20), shown in (5a). Our speaker’s replications of those forms are shown in (5b).

(5) a. Armstrong’s examples with ɛ+o → eɔ

ndaaɣorirɛ ota omwɛ	→ ndaaɣorireɔtɔɔmwɛ	‘I bought one bow.’
mocɛɛrɛ oyo	→ mocɛɛreɔyo	‘this rice’
rɛɛhɛ moɣatɛ omwɛ	→ rɛɛhɛ moɣateɔmwɛ	‘Bring one loaf.’
tohɛ ohɔɔrɛri na ðaayo	→ toheɔhɔɔrɛri na ðaayo	‘Grant us tranquility and peace.’

b. Forms replicated by our speaker with ɛ+o → eo

ndààɣòrìrɛ́ ótà ómwɛ́	→ ndààɣòrìrèótɔ̀ɔ̀mwɛ́	‘I bought one bow.’
mòʃɛ́ɛ́rɛ̀ óyó	→ mòʃɛ́ɛ́rèòyó	‘this rice’
rɛ̀ɛ̀hɛ́ mòɣàtɛ̀ ómwɛ́	→ rɛ̀ɛ̀hɛ́ mòɣàtèòmwɛ́	‘Bring one loaf.’
tóhɛ́ òhɔ́ɔ́rɛ́rí nà ðààyò	→ tóhéóhɔ́ɔ́rɛ́rí nà ðààyò	‘Grant us tranquility and peace.’

Another difference is that Armstrong states (1940: 24) that [oɔ] is "in most cases impossible" (occurring only in forms where [o] is the passive suffix), so o+ɔ surfaces as [uɔ]. While this is also true for our speaker for sequences arising across a morpheme boundary within words (infinitive prefix + stem), it is not true for sequences occurring across a word boundary, where our speaker produces [oɔ]. Armstrong does not provide any *o+ɔ* sequences crossing word boundaries, so we do not know whether this discrepancy reflects an actual difference between our consultants' grammars. It may simply reflect a gap in Armstrong's description. The examples in (6) are our transcriptions of forms replicated from Armstrong by our speaker, where both have *o+ɔ → uɔ*.

(6) o+ɔ → uɔ

/ko-ɔya/	→ kùɔ̀yá	'to lift'
(within words)		
/ko-ɔha/	→ kùɔ̀há	'to tie up'

Across word boundaries, for our consultant, *o+ɔ* surfaces unchanged, as shown in (7) (though as we indicate in these examples, it optionally undergoes glide formation, as will be discussed further in §5.1).

(7) o+ɔ → oɔ

gèʃòrò ɔ́hà	→ gèʃòròɔ́hà	'Gĩcũrũ, tie!'
~gèʃòrwɔ́ɔ́hà		
wàjíkó ɔ́yà	→ wàjìkóɔ́yà	'Wanjikũ, lift!'
~wàjìkwɔ́ɔ́yà		

A final discrepancy between our findings and Armstrong's here is that in combinations of short vowels, for our speaker, *o+u* and *e+u* sequences surface as *ou, eu* rather than undergoing mid vowel raising as reported by Armstrong. Some examples are given in (8).

(8) a. o+u → ou

wàjìkó úɣà	→ wàjíkóúɣà	'Wanjikũ, say something!'
kèmààrò úɣà	→ kèmààròúɣà	'Kĩmarũ, say something!'

b. e+u → eu

gèʃóhè úɣà	→ gèʃóhèúɣà	'Gĩcũhĩ, say something!'
kèvàkè úmà	→ kèvàkèúmà	'Kĩbakĩ, come out!'

As with o+ɔ, for *o+u* Armstrong provides examples (1940: 24) where the sequence does change (to *uu*) within words, as it also does for our speaker within words (examples in (9a) are replicated from Armstrong with tone marking added).

Additionally, though Armstrong provides examples of *e+u* changing to *iu* both within and across words, we only find evidence for this change within words (9b).

(9) a. o+u → uu

/to-uɣ-ir-ɛ/	→ tùùɣírɛ́	'we said (today)'
/ko-uɣ-a/	→ kùùɣá	'to say something'

b. e+u → iu

/n-ge-um-a/	→ gíúmà	'I came out.'
/n-ge-uɣ-a/	→ gíúɣà	'I said something.'

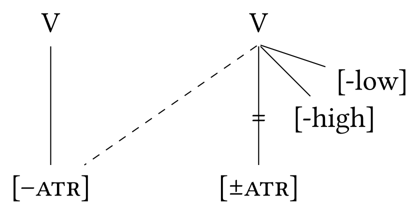
Armstrong cites the example *njok**e** **u**ma* → *njok**iu**ma* 'Njũkĩ, come out!' (1940: 24) with *e+u* surfacing as *iu* across a word boundary, but our speaker produces this form with *eu* (*jò**ké** ꜜ**ú**mà* → *jò**ké**ꜜ**ú**mà*).

4 Generalizations and rules accounting for core vowel hiatus resolution patterns

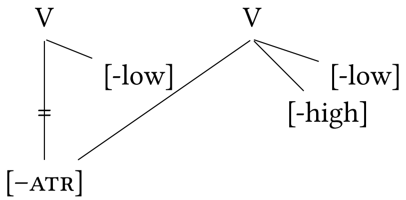
In this section, we state generalizations and rules to account for all of the observed VHR patterns in the context that we focused on in §3 (combinations of short vowels across word boundaries). We assume autosegmental theory, but we present SPE-style rules as a shorthand in instances where autosegmental representations are not crucial to understanding a pattern.

An overarching generalization characterizing the patterns represented by Table 2 concerns the behavior of mid vowels – the only group of vowels for which [±ATR] is contrastive. When a sequence of mid vowels contrasts underlyingly in [±ATR], with two classes of exceptions to be discussed, the underlying sequences [−ATR][+ATR] and [−ATR][−ATR] change to [+ATR][−ATR]. On the other hand, the underlying sequences [+ATR][−ATR] and [+ATR][+ATR] are unchanged. In other words, if either vowel is [−ATR] underlyingly, the surface form will be [+ATR][−ATR]. This state of affairs can be captured via *ATR shift*, shown in (10a-b).[2]

(10) a.



[2]We are thankful to an anonymous reviewer who suggested the *ATR shift* idea, greatly improving the generality of our analysis.

b. 

(10a) spreads [−ATR] from a [−ATR] vowel onto an adjacent [-low, -high] vowel to its right, and [±ATR] is delinked from V_2. Subsequently, the rule in (10b) delinks the shared [−ATR] feature from V_1 when V_1 is [-low] (since /a/ does not lose its [−ATR] feature; this restriction on V_1 is one reason why (10a) and (10b) must be considered separate rules, while a second reason based on rule ordering will become apparent momentarily).

The result of (10a-b) is that, in any sequence of two mid vowels where V_1 is [−ATR], V_1 will have no [±ATR] feature while the [−ATR] feature underlyingly associated to V_1 will surface on V_2. The context-free rule in (11) later fills in the default value [+ATR] on V_1 (this rule should be interpreted as *feature-filling* only, so it does not apply to a vowel that already has a [±ATR] value).

(11) V → [+ATR]

The combined effect of (10a-b) and (11) is that the underlying sequences [−ATR][+ATR], [−ATR][−ATR], and [+ATR][−ATR] surface as [+ATR][−ATR], while underlying [+ATR][+ATR] surfaces unchanged as [+ATR][+ATR]. These rules predict that (1) no sequence of mid vowels should surface as [−ATR][+ATR]; (2) no underlying sequence of mid vowels should surface as [−ATR][−ATR]; and (3) in any sequence of two mid vowels that contains a [−ATR] mid vowel in the input, [−ATR] should surface on V_2.

We believe it is the case that there is no sequence of mid vowels which surfaces as [−ATR][+ATR]; therefore prediction #1 is correct as far as we are aware. However, as mentioned above, there are two principled exceptions to the ATR shift generalization. Prediction #2 is seemingly violated in cases of total vowel quality assimilation, and prediction #3 is violated by the specific pattern *ɛ + o* → *eo*. Dealing first with this latter complication, we propose the specific rule in (12) that applies to */ɛ+o/*.

(12)
$$\begin{bmatrix} \text{V} \\ -\text{HIGH} \\ -\text{LOW} \\ -\text{ATR} \\ -\text{BACK} \end{bmatrix} \rightarrow [+\text{ATR}] \; / \; \_ \begin{bmatrix} \text{V} \\ -\text{HIGH} \\ -\text{LOW} \\ +\text{ATR} \\ +\text{BACK} \end{bmatrix}$$

The rule in (12) precedes (10a), bleeding the ATR shift rule by removing the [−ATR] feature from V_1. This accounts for one set of apparent exceptions to ATR shift.

The other exception involves sequences that appear to surface as identical [−ATR] vowels: *ɛ+e, ɛ+ɛ* → *ɛɛ*; and *ɔ+o, ɔ+ɔ* → *ɔɔ*. According to (10a-b) and (11), these should surface as **eɛ, *oɔ*. We propose that what prevents these sequences from undergoing ATR shift is that they are not 'sequences' at the stage in the derivation where (10b) applies, delinking [−ATR] from V_2. Prior to (10b), these sequences will have fused into a single long vowel and therefore do not meet the structural description for (10b) to apply, since (10b) requires two adjacent vowels. The fusion rule applies to all sequences of adjacent identical vowels (not only to the mid vowels of interest here) and is given in (13).

(13) $V_i + V_i \rightarrow V_i\text{ː}$

The fusion rule in (13) must be ordered between (10a) and (10b) to produce the correct surface forms (which is one argument for why (10a) and (10b) cannot be combined into a single rule). Sample derivations are given in Table 3 to illustrate:

Table 3: Sample derivations

Correct ordering		Fusion too early		Fusion too late	
Underlying form	/ɛe/	Underlying form	/ɛe/	Underlying form	/ɛe/
ATR shift (10a)	ɛɛ	Fusion (13)	N/A	ATR shift (10a)	ɛɛ
Fusion (13)	ɛː	ATR shift (10a)	ɛɛ	Delinking (10b)	*eɛ
Delinking (10b)	N/A	Delinking (10b)	*eɛ	Fusion (13)	N/A

Another generalization regarding Table 2, similar to but arguably distinct from ATR shift, is that in *ɛ+a* sequences, *ɛ* raises to *e*, yielding *ea*. We account for this with the rule in (14).

(14) $\begin{bmatrix} \text{V} \\ -\textsc{high} \\ -\textsc{low} \\ -\textsc{atr} \\ -\textsc{back} \end{bmatrix} \rightarrow [+\textsc{atr}] \ / \ \_\begin{bmatrix} \text{V} \\ +\textsc{low} \end{bmatrix}$

The target must be limited to [−back] vowels, as it is formulated here, since *ɔ+a* does not change to *oa.* [3]

[3]A reviewer suggested that *ɛ+a* → *ea* can be subsumed under ATR shift, but we believe it must be

Also regarding /a/, recall from Table 2 that when a precedes any mid vowel, it assimilates to [-low] and to the backness/roundness of the triggering vowel while retaining its [−ATR] feature (so *a+o* and *a+ɔ* surface as *ɔɔ*, while *a+e* and *a+ɛ* surface as *ɛɛ*). If this rule is ordered after ATR shift, it can be formulated as total vowel feature assimilation, as in (15).

(15) $$\begin{bmatrix} \text{V} \\ +\textsc{low} \end{bmatrix} \rightarrow \text{V}_i \;/\; \_ \begin{bmatrix} \text{V}_\text{I} \\ -\textsc{high} \\ -\textsc{low} \end{bmatrix}$$

The rule in (15) is equivalent to spreading all vowel quality features from V_2 (when V_2 is mid) onto V_1 when V_1 is /a/. As long as the [−ATR] feature has already spread from /a/ onto V_2 via the earlier application of ATR shift, the [−ATR] feature will correctly be retained when /a/ totally assimilates to V_2 via (15). We are thus accounting for *a+o, a+e → ɔː , ɛː* in three steps: (1) *ao, ae → aɔ, aɛ* via ATR shift; (2) *aɔ, aɛ → ɔɔ, ɛɛ* via a-assimilation (15); and (3) *ɔɔ, ɛɛ → ɔː , ɛː* via fusion.

Some complex changes apply to input V_1+u sequences where V_1 is [-high, -ATR]: *ɛu* changes to *eɔi*, *au* changes to *ɔi*, and *ɔu* changes to *ɔi*. One generalization we can make is that in all of these cases, *u* undergoes diphthongization, changing to *ɔi*. We account for this via the rule in (16) [4] , where dashes indicate inserted items. We are expressing this rule using an autosegmental representation to illustrate how the diphthongization manipulates feature values already present in the underlying vowels, but this is not intended as a departure from the rest of

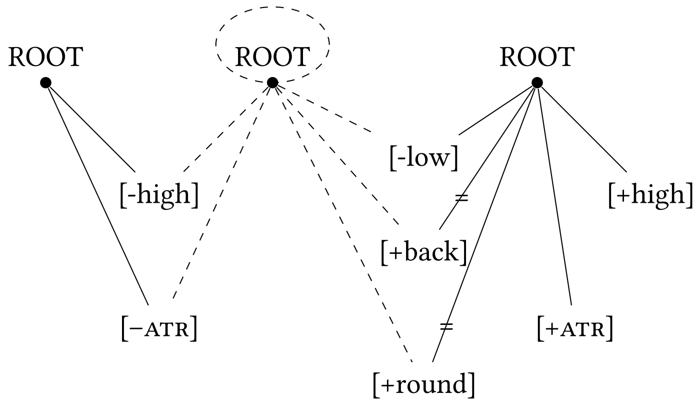
a separate rule. Recall that (10b) was limited such that /a/ does not trigger or undergo delinking. If delinking were formulated such that V_2 could be any [-high] vowel (i.e., if V_2 could be /a/), this would incorrectly predict that /ɔ+a/ should surface as **oa* rather than *ɔa*. This is why we have excluded /a/ from triggering delinking, necessitating the additional rule in (14) to account for /ɛ+a/ → *ea*. Accounting for this pattern via delinking would make incorrect predictions (i.e., delinking cannot be allowed to change /ɔ+a/ → oa with the derived oa later changing back to [ɔa], since underlying /o+a/ does not change to [ɔa]; ATR shift also cannot be restricted to applying only when V_1 is [-back], since ATR shift does apply in other cases where V_1 is /ɔ/, e.g., /ɔ+e/ → *oɛ*).

This rule could be seen as a shorthand for multiple rules, one inserting the root node and one or more others filling in its features. Nothing within the analysis hinges on the question of whether one or multiple rules are represented here. In these derivations, for ATR shift we give intermediate output forms rather than stating "N/A" even though ATR shift makes no change to the segments listed as outputs of the previous rule. This is because ATR shift does apply in each case, spreading [−ATR] from V_1 to V_2. The identity of the segments does not change, but the [−ATR] feature crucially takes on the doubly-linked representation that feeds delinking.

[4]This rule could be seen as a shorthand for multiple rules, one inserting the root node and one or more others filling in its features. Nothing within the analysis hinges on the question of whether one or multiple rules are represented here.

our analysis since, as mentioned above, we have assumed autosegmental theory throughout and have used SPE notation for simplicity elsewhere.

(16)



In effect, this rule inserts a new root node between V_1 and *u*, then fills in the [-high] and [−ATR] values of the new vowel via spreading of these features from V_1 and the [-low], [+back], and [+round] features from *u* (with the latter two delinking from *u*). We assume the features [-back] and [-round] are later inserted by default and associated to the root node that formerly represented *u*. The output is a sequence of (V_1+*ɔi*), where V_1 surfaces unchanged while *u* has changed to *ɔi* via (16) followed by default insertion of [-back] and [-round].

Following the change of *u* to *ɔi*, further rules apply to the triggering V_1. When V_1 is *ɛ*, the *ɛ* changes to *e* via ATR shift and delinking, yielding the sequence *eɔi*. When V_1 is *ɔ* or *a*, V_1 appears to be deleted (*au* and *ɔu* both surface as *ɔi* rather than **aɔi*, **ɔɔi*). These sequences can all be accounted for with an ordering in which diphthongization (16) applies, followed by *a*-assimilation (15), ATR shift (10a), fusion (13), delinking (10b), and finally a rule to be introduced in §5.4 that shortens a long vowel before another vowel. The effects of these rules are shown in Table 4.[5]

[5]In these derivations, for ATR shift we give intermediate output forms rather than stating "N/A" even though ATR shift makes no change to the segments listed as outputs of the previous rule. This is because ATR shift does apply in each case, spreading [−ATR] from V_1 to V_2. The identity of the segments does not change, but the [−ATR] feature crucially takes on the doubly-linked representation that feeds delinking.

Table 4: Effects of the rules

Underlying form	/ɛ+u/	Underlying form	/a+u/	Underlying form	/ɔ+u/
Diphthongization (16)	ɛɔi	Diphthongization (16)	aɔi	Diphthongization (16)	ɔɔi
ATR shift (10a)	ɛɔi	ATR shift (10a)	aɔi	ATR shift (10a)	ɔɔi
a-assimilation	N/A	a-assimilation	ɔɔi	a-assimilation	N/A
Fusion (13)	N/A	Fusion (13)	ɔːi	Fusion (13)	ɔːi
Delinking (10b)	eɔi	Delinking (10b)	N/A	Delinking (10b)	N/A
Shortening (§5.4)	N/A	Shortening (§5.4)	ɔi	Shortening (§5.4)	ɔi

The rules presented in this section are sufficient to account for all VHR patterns presented in Table 2. In the next section, we will discuss some complications to this core pattern that arise due to the additional factors and contexts that were listed in §1.

5 Other factors/contexts affecting vowel hiatus resolution

5.1 Segment preceding V_1

The segment preceding a V+V sequence can affect the outcome of VHR. For example, Armstrong reports (1940: 22) that input *iɛ+a* surfaces as *ia* with the *ɛ* elided. Normally *ɛ+a* surfaces as *ea* (as discussed above), so deletion of *ɛ* from *iɛ+a* is conditioned by the preceding *i*. We have not investigated 3-vowel sequences systematically, so it is unclear how general this deletion rule is (in terms of which specific vowels undergo or trigger it). This is a matter for future research. [6]

A consonant preceding the V_1+V_2 sequence also affects VHR, specifically in terms of whether glide formation (GF) applies to V_1 or not. We will demonstrate this by first establishing the general GF pattern (see also Kuzmik 2020 for discussion and an OT analysis of glide formation).

Generally, GF can apply to *o*, changing it to *w* when it precedes any vowel except *o* or *u*. GF is sometimes optional but is obligatory for some forms (we have not yet determined when it is obligatory vs. optional; this may be a lexical property). Examples of *o*+V combinations that undergo GF are shown in (17a); (17b) shows *o*+V combinations where GF does not apply.

[6] Note, however, that the number of combinations makes it impractical to study all three-vowel sequences systematically. If any of the 14 long/short vowels can hypothetically precede all 49 combinations of short vowels across a word boundary, this yields 686 V_1+V_2V_3 combinations; doubling this number to include utterances where the boundary occurs instead after V_2 (V_1V_2+V_3) yields 1372 combinations. Doubling this number to add the within-word context produces a total of 2744 unique combinations.

(17) a. o+i → wii wàjìkó íkòmí → wàjìkwííkòmí 'ten Wanjikũs'
~oi ~ wàjìkòíkòmí
o+e → wee wàjìkó étékà → wàjìkwéétékà 'Wanjikũ, answer!'
~oe ~ wàjìkóétékà
o+ɛ → wɛɛ wàjìkó ɛ́hɛ́rà → wàjìkwɛ́ɛ́hɛ́rà 'Wanjikũ, stand aside!'
~oɛ ~ wàjìkóɛ́hɛ́rà
o+a → waa wàjìkó áyá → wàjìkwááyá 'these Wanjikũs'
~oa ~ wàjìkóáyá
o+ɔ → wɔɔ wàjíkó ɔ́hà → wàjíkwɔ́ɔ́hà 'Wanjikũ, tie!'
~oɔ ~ wàjíkóɔ́hà
b. o+o → oo wàjìkó òyò → wàjìkóóyó 'this Wanjikũ'
*woo *wajikwooyo
o+u → ou wàjìkó úɣà → wàjíkóúɣà 'Wanjikũ, say something!'
*wuu *wajikwuuɣa

As shown in (18), GF can also apply to an *o* that is not underlying but is derived via the raising of *ɔ* before *ɛ* via ATR shift (so GF is ordered after ATR shift).

(18) ɔ+ɛ → oɛ
(→ wɛɛ)
húkɔ́ ɛ́hɛ́rà → húkwɛ́ɛ́hɛ́rà 'mole, stand aside!'
~húkóɛ́hɛ́rà
mèhèèdɔ́ èná → mèhèèdwɛ̀ɛ̀nà 'four ropes'
~mèhèèdòɛ̀nà
jɔ̀mɔ̀ ɛ́hɛ́rà → jɔ̀mwɛ́ɛ́ꜜhɛ́rà 'Njomo, stand aside!'
~jɔ̀mɔ́ɛ́ꜜhɛ́rà

Some vowels other than *o* also undergo GF, but less robustly. In contrast to Mugane's report (1997: 9) that *i* and *u* do not undergo GF, *i* does undergo GF in some cases, but apparently only before *u*, as can be seen by comparing (19a) vs. (19b).

(19) a. mwààgì úmà → mwààgyúúmà 'Mwangi, come out!'
*mwaagiuma
mwààgì úɣà → mwààgyúúɣà 'Mwangi, say something!'
*mwaagiuɣa
wààbìtí úɣà → wààbìtyúúɣà 'Wambiti, say something!'
~wààbìtíúɣà
gèðèèjí úɣà → gèðèèjyúúɣà 'Gĩthĩnji, say something!'
~gèðèèjíúɣà

	kàríòkí úɣà	→ kàríòkyúúɣà	‘Kariũki, say something!’
		~kàríòkìúɣà	
	kèmání úmà	→ kèmányúúmà	‘Kĩmani, come out!’
		~kèmáníꜜúmà	
	kàɣɔ̀ʃí úɣà	→ kàɣɔ̀ʃꜜyúúɣà	‘Kagoci, say something!’
		~kàɣɔ̀ʃíꜜúɣà	
	kàrémí úɣà	→ kàrémꜜyúúɣà	‘Karĩmi, say something!’
		~kàrémìúɣà	
b.	mwààgì íkòmí	→ mwààgííkòmí	‘ten Mwangis’
		*mwaagyiikomi	
	mwààgì étékà	→ mwààgìètékà	‘Mwangi, answer!’
		*mwààgyèètékà	
	mwààgì ɛ́hɛ́rà	→ mwààgíɛ́hɛ́rà	‘Mwangi, stand aside!’
		*mwaagyɛɛhɛra	
	mwààgì áyá	→ mwààgìàyá	‘these Mwangis’
		*mwaagyaaya	
	mwààgì ɔ́hà	→ mwààgíɔ́hà	‘Mwangi, tie!’
		*mwaagyɔɔha	
	mwààgì òyò	→ mwààgìòyó	‘this Mwangi’
		*mwaagyooyo	

Similarly, *u* seems to undergo glide formation most readily before *i* (20a), though it also applies before non-round vowels (20b). We do not have examples of it applying before *ɔ, o,* or *u* (20c).

(20)	a.	kàrúúgú íkòmí	→ kàrùùgwììkòmí	‘ten Karungus’
			*karuuguikomi	
		màfùkù ìkòmí	→ màfùkwììkòmí	‘ten books’
			*mafukuikomi	
		kààbútú íkòmí	→ kààbútwííkòmí	‘ten Kambutus’
			*kààbútúíkòmí	
	b.	kàrúúgú étékà	→ kàrúúgwèètékà	‘Karungu, answer!’
			~kàrúúgùètékà	
		kàrúúgú ɛ́hɛ́rà	→ kàrúúgwɛ́ɛ́hɛ̀rà	‘Karungu, stand aside!’
			~kàrúúgúɛ́ꜜhɛ́rà	
		kàrúúgú àtáánó	→ kàrùùgwààtáánó	‘five Karungus’
			~kàrùùgùàtáánó	
	c.	kàrúúgú ɔ́hà	→ kàrúúgùɔ́hà	‘Karungu, tie!’
			*karuugwɔɔha	

	kàrúúgú óyó	→ kàrùùgùòyó *karuugwooyo	‘this Karungu’
	kàrúúgú úɣà	→ kàrúúgùúɣà *karuugwuuɣa	‘Karungu, say something!’

We have observed a small number of instances of *e* undergoing GF, as shown in (21a); (21b) shows that GF does not apply to *e* before *e* or *i*.

(21)	a.	kèvàkè ɛ̀hɛ́rà	→ kèvàkyɛ́ɛ́ꜜhɛ́rà ~kèvàkèɛ́ꜜhɛ̀rà	‘Kĩbakĩ, stand aside!’
		kèvàkè áyá	→ kèvàkyààyá ~kèvàkèàyá	‘these Kĩbakĩs’
		gèʃòké áyá	→ gèʃòkyááyá ~gèʃòkéáyá	‘these Gĩcũkĩs’
		kèvàkè ɔ́hà	→ kèvàkyɔ́ɔ́hà ~kèvàkèɔ́hà	‘Kĩbakĩ, tie!’
		kèvàkè óyó	→ kèvàkyòòyó ~kèvàkèòyó	‘this Kĩbakĩ’
		gèʃòké òyò	→ gèʃòkyóóyó ~gèʃòkéóyó	‘this Gĩcũkĩ’
		kèvàkè úɣà	→ kèvàkyúúɣà ~kèvàkèúɣà	‘Kĩbakĩ, say something!’
	b.	kèvàkè étékà	→ kèvàkèètékà *kevakyeeteka	‘Kĩbakĩ, answer!’
		kèvàkè íkòmí	→ kèvàkéíkòmí *kevakyiikomi	‘ten Kĩbakĩs’

Other forms with *e* as V_1 fail to undergo GF, as shown in (22).

(22)	gèʃóhè úɣà	→ gèʃóhèúɣà *geʃohyuuɣa	‘Gĩcũhĩ, say something!’
	gàré úɣà	→ gàréꜜúɣà *garyuuɣa	‘Ngarĩ, say something!’
	mòtè óʃíɔ́	→ mòtèòʃíɔ́ *motyooʃiɔ	‘that tree’
	gèʃòké ɛ́ꜜhɛ́rà	→ gèʃòkéɛ́ꜜhɛ́rà *geʃokyɛɛhɛra	‘Gĩcũkĩ, stand aside!’
	gèʃòké ɔ́hà	→ gèʃòkéꜜɔ́hà *geʃokyɔɔha	‘Gĩcũkĩ, tie!’
	gèʃòké úɣà	→ gèʃòkéꜜúɣà *geʃokyuuɣa	‘Gĩcũkĩ, say something!’

Mugane (1997: 10) reports *mũtyũcio* for '[that] tree' (an orthographic form corresponding to [motyoʃiɔ], although presumably the *o* after the glide is lengthened; the orthography does not indicate vowel length). Our speaker rejects the form with GF for the same phrase, as seen in (22). Note also in comparing (21) with (22) that the final V of the name Gĩcũkĩ variably undergoes GF, seemingly depending on the following vowel but with no clear phonological generalization.

As mentioned earlier, the preceding consonant (if any) affects the likelihood of GF application. In particular, although GF can apply after other consonants, a preceding *k* seems to make GF most likely. (23) shows some representative examples where GF is obligatory (for these particular forms only) after *k* and *g* (23a) but optional after the consonants shown in (23b).

(23)	a.	/k/	màfùkù ìkòmí	→ màfùkwììkòmí (*mafukuikomi)	'ten books'
		/g/	kàrúúgú íkòmí	→ kàrùùgwììkòmí (*karuuguikomi)	'ten Karungus'
	b.	/t/	wààbìtí úɣà	→ wààbìtyúúɣà ~wààbìtíúɣà	'Wambiti, say something!'
		/d/	mòhéédɔ̀ étékà	→ mòhéédòɛ̀tékà ~mòhéédwɛ̀ɛ̀tékà	'rope, answer!
		/dʒ/	gèðèèjí úɣà	→ gèðèèjyúúɣà ~gèðèèjíúɣà	'Gĩthĩnji, say something!'
		/ʃ/	kàɣɔ̀ʃí úɣà	→ kàɣɔ̀ʃꜝyúúɣà ~kàɣɔ̀ʃíꜝúɣà	
		/r/	gèʃòrò ɔ́nà	→ gèʃòròɔ́nà ~gèʃòrwɔ́ɔ́nà	'Gĩcũrũ, see!'
		/m/	wàìrìmó áyá	→ wàìrìmwááyá ~wàìrìmóáyá	'these Wairimũs'
		/n/	kèmání úmà	→ kèmányúúmà ~kèmáníꜝúmà	'Kĩmani, come out!'
		/ŋ/	dòòŋó íkòmí	→ dòòŋwííkòmí ~dòòŋòíkòmí	'ten Ndũng'ũs'

In contrast to the consonants in (23), other consonants when preceding the target vowel appear to inhibit or block GF. Some representative examples are given in (24).

(24)	/ɣ/	bɔ̀ɣɔ̀ ɛ́hɛ́rà	→ bɔ̀ɣòɛ́hɛ́rà (*bɔɣwɛɛhɛra)	'Mbogo, stand aside!'
	/ʃ/	gɛ̀ʃó étèkà	→ gɛ̀ʃóétékà (*gɛʃweeteka)	'Ngecũ, answer!'
	/ð/	kèmɔ̀ðɔ̀ ɛ́hɛ́rà	→ kèmɔ̀ðòɛ́hɛ́rà (*kemɔðwɛɛhɛra)	'Kĩmotho, stand aside!'
	/h/	mòhóhò ɛ́ꜝhɛ́rà	→ mòhóhòɛ̀hɛ́rà (*mohohwɛɛhɛra)	'Mũhoho, stand aside!'[7]
	/r/	mòðúúrí úɣà	→ mòðúúrìúɣà (*moðuuryuuɣa)	'elder, say something!'
	/ny/	gèkɔ̀nyɔ́ ɛ́hɛ́rà	→ gèkɔ̀nyóɛ́hɛ́rà (*gekɔnywɛɛhɛra)	'Gĩkonyo, stand aside!'
	/y/	wàmóyò étèkà	→ wàmóyòétèkà (*wamoyweeteka)	'Wamũyũ, answer!'

Notice that some consonants (*r*, *ʃ*) appear on the lists in both (23) and (24), as licensing/triggering GF but also inhibiting/blocking it. This is due to an interaction between the consonant and the specific target vowel. While a preceding *r* does not inhibit GF applying to *o*, it does apparently inhibit GF applying to *i* (our consultant attributed this to the fact that the sequence *rw* sounds natural to him but *ry* does not). Conversely, while GF does apply to *i* after *ʃ*, it seems to be inhibited from applying to *o* after *ʃ*. GF is deserving of further study to obtain a clearer picture of the interaction of the various factors that determine when it applies optionally or obligatorily vs. not at all. The purpose of this section has been to give some insight into the phenomenon and some data that complicate or contradict previous descriptions, and to show that the preceding consonant plays a role.

[7] Note that this name is pronounced *mòhóhò* despite its spelling, which implies **mohɔhɔ*.

5.2 Segment following V_2

The segment following V_2 can affect VHR in ways we have not systematically studied. One instance where we can see this is in the difference in the behavior of *a* and *ɔ* when followed by *ɔ*C vs. when followed by *ɔ*V. Recall that *a*+*ɔ* and *ɔ*+*ɔ* both surface as *ɔɔ* when followed by a consonant, as shown in (25).

(25)	a + ɔ → ɔɔ	tààtà ɔ́yà	→ tààtɔ́ɔ́yà	'Aunt, lift!'
		nyààbùrá ɔ́hà	→ nyààbùrɔ́ɔ́hà	'Nyambura, tie!'
	ɔ + ɔ → ɔɔ	gèkɔ̀nyɔ́ ɔ́hà	→ gèkɔ̀nyɔ́ɔ́hà	'Gĩkonyo, tie!'
		mòɣɔ̀ ɔ́yà	→ mó'ɣɔ́ɔ́yà	'Mũgo, lift!'

On the other hand, as noted earlier in §4 in the discussion of *u*-diphthongization, *a* and *ɔ* are deleted when followed by *ɔi* (derived from /u/), as shown in (26).

(26)	a → Ø / __ ɔi	tàà tà úɣà	→ tààtɔ́ìɣà	'Aunt, say something!'
	(from /u/)	bùrá úrà	→ bùrɔ́ìrà	'rain, come down!'
	ɔ → Ø / __ ɔi	gèkɔ̀nyɔ́ úɣà	→ gèkɔ̀nyɔ́'íɣà	'Gĩkonyo, say something!'
	(from /u/)	bɔ̀ɣɔ̀ úɣà	→ bɔ̀ɣɔ́íɣà	'Mbogo, say something!'

Hence, *a*+*ɔ*, *ɔ*+*ɔ* behave differently when followed by a consonant vs. when followed by *i*. In this paper we do not attempt a full account of V+V+V sequences, as noted earlier. However, as was spelled out in the derivations in Table 4, our analysis does account for (26). The key observation is that diphthongization of *u* applies first, feeding total assimilation of *a* to the derived *ɔ* of *ɔi*. The adjacent *ɔ* vowels then fuse into a single long *ɔ*: vowel. The remaining step is that, as will be discussed further in §5.4, the long vowel shortens before another vowel (in this case, *i*).

A consonant following V_2 can also affect VHR, by obscuring its effect. In particular, a nasal consonant following a [+ATR] mid vowel causes the vowel to sound very similar to its [-ATR] counterpart (i.e., *o* and *e* sound like *ɔ* and *ɛ*, respectively, before a nasal). The ATR contrast is still preserved but becomes very subtle and difficult to hear. Due to the confusability of vowels in this context, we have avoided forms with nasals following the V+V sequence where possible in this study.

5.3 Boundary type between V_1 and V_2 (morpheme vs. word)

Earlier we saw examples where the type of boundary (morpheme vs. word) between the two vowels results in different hiatus resolution effects (see examples

(6) and (9) in §3). In the case of word boundaries, the type of syntactic boundary has not proved significant; the VHR effects that occur across word boundaries seem to apply anywhere within the clause (though not across different clauses within an utterance).

In the earlier discussion of the differences between our description and Armstrong's, we showed that while *o+ɔ* surfaces as *oɔ* across a word boundary, it changes to *uɔ* within words across a (within-word) morpheme boundary. Similarly, we saw that while *o+u* surfaces as *ou* across a word boundary, it changes to *uu* across a morpheme boundary, and *e+u* surfaces as *eu* across a word boundary but as *iu* across a morpheme boundary.

In addition to these patterns (which were discussed in §3 in reference to differences from Armstrong's description), there is another combination that behaves differently within words vs. across words, namely *e+o*, which surfaces as *eo* across a word boundary but as *io* across a morpheme boundary (this was not discussed in §3, which focused on behavior across word boundaries, since our data agrees with Armstrong's in that specific context). Examples are given in (27).

(27)	a.	e+o → eo	mòtè óyó	→ mòtèòyó	'this tree'
		(across words)	mòtè òʃíɔ́	→ mòtèòʃíɔ́	'that tree'
			né ótà	→ néótà	'it's a bow'
			né ótùkò	→ néótùkò	'it's night'
	b.	e+o → io	/n-ke-ok-a/	→ gíókà	'I came'
		(within words)	/n-ke-or-a/	→ gíórà	'I got lost'

Interestingly, Armstrong (1940: 24) reports no change to *e+o* even within words (cf. *ŋgeoka* 'I came').

The differences between the across-word vs. within-word contexts show that there are some hiatus resolution rules that apply at the lexical level but not postlexically:

(28) Additional VHR rules that apply only lexically

a. o ⟶ u / __ ɔ

b. o ⟶ u / __ u

c. e ⟶ i / __ u

d. e ⟶ i / __ o

Rules (28b-c) can be collapsed into a single rule, shown in (29).

(29) $$\begin{bmatrix}\text{-HIGH}\\ \text{-LOW}\\ \text{+ATR}\end{bmatrix} \rightarrow \begin{bmatrix}\text{+HIGH}\end{bmatrix} \; / \; \_\begin{bmatrix}\text{+HIGH}\\ \text{+BACK}\end{bmatrix}$$

Note that this rule has to be limited to applying before a [+back] vowel since *i* does not trigger raising (*o+i*, *e+i* do not change to *ui*, *ii* within words; cf. /ko-ìkár-à/ ⟶ *ɣòíkàrà* 'to stay', /n-ke-ikar-a/ ⟶ *gèìkárá* 'I stayed'). It is also not possible to write rules raising *o*, *e* before all [+back, +round] vowels because *o* does not raise before *o* (though this could be explained via the fusion of *o+o* ⟶ *o:* applying before raising) and *e* does not raise before *ɔ* (*eɔ* ⟶ *eɔ* both within and across word boundaries; cf. /n-ke-ɔh-a/ ⟶ *géɔ́hà* 'I tied').

5.4 Vowel length

Armstrong provides few examples of combinations involving long vowels, tending to lump them in with combinations of short vowels despite the fact that they behave somewhat differently, as we show below. Table 5 shows combinations of a short V_1 with a long V_2 across a word boundary (as before, boxed cells indicates differences from Armstrong; question marks indicate combinations we have been unable to elicit).

Table 5: Short V_1 with long V_2 across word boundary

	V_2						
V_1	ii	ee	ɛɛ	aa	ɔɔ	oo	uu
i	ii	ie	iɛ	ia	iɔ	io	iuu
e	eii	ee	eɛ	ea	eɔ	eo	euu
ɛ	ɛii	ɛɛ	ɛɛ	ea	eɔ	eo	ɛuu
a	aii	ɛɛ	ɛɛ	aa	ɔɔ	ɔɔ	auu
ɔ	?	oɛ	oɛ	ɔa	ɔɔ	ɔɔ	?
o	?	oe	oɛ	oa	oɔ	oo	?
u	?	?	uɛ	ua	uɔ	uo	?

One systematic difference between our description and Armstrong's concerns the behavior of V+V: sequences where the vowels have identical quality. Armstrong reports (1940: 12) that these surface as "very long" (e.g., *meteeerea* 'those trees') but we consistently find long vowels in this context that sound the same as other long vowels, not "very long" (e.g., *mèt**è** **éé**réá* ⟶ *mèt**èè**réá* 'those trees').

Additionally, in Armstrong's data *ɔ+aa* surfaces as *oaa* (this was discussed earlier in §3 in the context of V+V combinations since Armstrong incorrectly cited the example as an instance of *ɔ+a*). For our speaker, *ɔ+aa* yields *ɔa*.

Another difference concerns long vowels following *o*. Armstrong suggests (1940: 23-24) that all vowels except short *ɔ* and *u* surface unchanged after *o*, implying that long vowels are not shortened in this context, specifically stating (1940: 24, footnote 1) that "*oɔɔ* (*wɔɔ*) and *ouu* (*wuu*) occur," though no examples are cited. We hypothesize that the forms in question are [wɔɔ] and [wuu] (we cannot confirm this since Armstrong cites no examples) and that these may result from a two-step process of shortening and GF (which re-lengthens the V), e.g., *o+ɔɔ* ⟶ *oɔ* ⟶ *wɔɔ*. Otherwise, we have no explanation for why vowels would systematically fail to shorten after *o*, which happens to be the only V that consistently undergoes GF.

A final discrepancy involves whether long *ee* and *oo* undergo shortening. In our data, *ee* and *oo* shorten after another V. According to Armstrong, however, *ɔ+ee* fails to undergo shortening, surfacing as *ɔee* or *oɛɛ* (1940: 21) (e.g., *meheendɔ **ee**rea* ⟶ *meheend**oɛɛ**rea* 'those ropes'), *e+oo* surfaces as *eoo* (1940: 20) (e.g., *maɣua m**e** **oo**ke* ⟶ *maɣua m**eoo**ke* 'honeycombs contain honey'), and *ɛ+oo* surfaces as *ɛoo* or *eɔɔ* (1940: 20) (e.g., *mocɛɛr**ɛ** **oo**rea* ⟶ *mocɛɛr**eɔɔ**ea* 'that rice'). As seen in (30), our speaker produces these sequences as *oɛ*, *eo*, and *eo*, respectively. (30) shows that in most cases a long V_2 undergoes shortening, and most V+Vː combinations have surface forms identical to the corresponding V+V combinations that were presented in §3.

(30) Sequences with long V_2 where the surface form is identical to sequence with short V_2

i + ii → ii	tí ííjí émòɛ̀	→ tííjí émòɛ̀	'this is not one inch'
i + ee → ie	mèìrí èèréá	→ mèìriéréá	'those P. africana trees'
	gààrí èèréá	→ gààriéréá	'that car'
i + ɛɛ → iɛ	kèmàní ɛ́ɛ́tìrɛ́	→ kèmàníɛ́tìrɛ́	'Kimani called'
	tí ɛ́ɛ́ɣà	→ tíɛ̀ɣà	'they (people) are not good'
i + aa → ia	kèmàní áányɔ̀nírɛ́	→ kèmàníányɔ̀nírɛ́	'Kĩmani saw me'
i + ɔɔ → iɔ	kèmàní ɔ́ɔ́nìrɛ́	→ kèmàníɔ́nìrɛ́	'Kĩmani saw (something)'
i + oo → io	mòðùùrì òòréá	→ mòðùùrìòréá	'that elder'
e + ee → ee	mètè ééréá	→ mètèèréá	'those trees'
	gàré èèréá	→ gàrééréá	'that leopard'
e + ɛɛ → eɛ	gèʃóhè ɛ́ɛ́tìrɛ́	→ gèʃóhèɛ́tìrɛ́	'Gĩcũhĩ called'

	né ɛ̀ɛ̀ɣà	→ néɛ̀ɣà	‘they (people) are good’
e + aa → ea	gèʃóhè áányɔ̀nírɛ̀	→ gèʃóhèányɔ̀nírɛ̀	‘Gĩcũhĩ saw me’
	gèʃóhè áárèɔ̀nírɛ̀	→ gèʃóhèárèɔ̀nírɛ̀	‘Gĩcũhĩ saw it (cl. 5)’
e + ɔɔ → eɔ	gèʃóhè ɔ́ɔ́nìrɛ́	→ gèʃóhèɔ́nìrɛ́	‘Gĩcũhĩ saw (something)’
e + oo → eo	gèʃóhè òòréá	→ gèʃóhèòréá	‘that Gĩcũhĩ’
	mòtè óóréá	→ mòtèòréá	‘that tree’
ɛ + ee → ɛɛ	ŋɔ̀ɔ̀bɛ̀ èèréá	→ ŋɔ̀ɔ̀bɛ̀ɛ̀réá	‘that cow’
ɛ + ɛɛ → ɛɛ	ɔ́ɔ́nɛ̀ɛ̀tɛ́ ɛ̀ɛ̀kí	→ ɔ́ɔ́nɛ̀ɛ̀tɛ́ɛ́kì	‘s/he saw doers’
ɛ + aa → ea	mònɛ̀nɛ́ áányɔ̀nírɛ̀	→ mònɛ̀néányɔ̀nírɛ̀	‘the boss saw me’
	jɔ̀rɔ̀gɛ́ áányɔ̀nírɛ̀	→ jɔ̀rɔ̀géányɔ̀nírɛ̀	‘Njoroge saw me’
ɛ + ɔɔ → eɔ	mwèèrɛ́ ɔ́ɔ́kɛ̀	→ mwèèréɔ́kɛ̀	‘tell him to come’
	ɔ́ɔ́nɛ̀ɛ̀tɛ́ ɔ̀ɔ̀tí	→ ɔ́ɔ́nɛ̀ɛ̀téɔ́tì	‘s/he saw baskers’
ɛ + oo → eo	mɔ̀ʃɛ́ɛ́rɛ̀ òòréá	→ mɔ̀ʃɛ́ɛ́rèòréá	‘that rice’
	né déétɛ̀ óòké	→ né déétèòkè	‘I have eaten honey’
a + ee → ɛɛ	mèkààdá èèréá	→ mèkààdɛ́ɛ́réá	‘those ropes’
a + ɛɛ → ɛɛ	ná ɛ́ɛ́kì	→ nɛ́ɛ́kì	‘… and doers’
	nà ɛ̀ɛ̀jánì	→ nɛ̀ɛ̀jánì	‘… and hairdressers’
a + aa → aa	nyààbùrá áányɔ̀nírɛ̀	→ nyààbùráányɔ̀nírɛ̀	‘Nyambura saw me’
a + ɔɔ → ɔɔ	ná ɔ́ɔ́tì	→ nɔ́ɔ́tì	‘… and baskers’
	nà ɔ̀ɔ̀bí	→ nɔ̀ɔ̀bí	‘… and potters’
a + oo → ɔɔ	mòrààtá òòréá	→ mòrààtɔ́ɔ́réá	‘that friend’
	máréééáɣà òòké	→ máréééáɣɔ̀ɔ̀ké	‘they eat honey’
ɔ + ee → oɛ	mèhèèdɔ̀ èèréá	→ mèhèèdòɛ̀réá	‘those ropes’
ɔ + ɛɛ → oɛ	gèkɔ̀nyɔ́ ɛ́ɛ́tìrɛ́	→ gèkɔ̀nyóɛ́tìrɛ́	‘Gĩkonyo called’
ɔ + aa → ɔa	gèkɔ̀nyɔ́ áányɔ̀nírɛ̀	→ gèkɔ̀nyɔ́ányɔ̀nírɛ̀	‘Gĩkonyo saw me’
ɔ + ɔɔ → ɔɔ	gèkɔ̀nyɔ́ ɔ́ɔ́nìrɛ̀	→ gèkɔ̀nyɔ́ɔ́nìrɛ̀	‘Gĩkonyo saw (something)’
ɔ + oo → ɔɔ	gèkɔ̀nyɔ́ òòréá	→ gèkɔ̀nyɔ́ɔ́réá	‘that Gĩkonyo’
o + ee → oe	mèðààdókò èèréá	→ mèðààdókòèréá	‘those wattle trees’
	mètìtó èèréá	→ mètìtóéréá	‘those forests’
o + ɛɛ → oɛ	gèʃòrò ɛ́ɛ́tìrɛ́	→ gèʃòròɛ́tìrɛ́	‘Gĩcũrũ called’
	gɛ̀ʃó ɛ́ɛ́tìrɛ́	→ gɛ̀ʃóɛ́tìrɛ́	‘Ngecũ called’
o + aa → oa	gèʃòrò áányɔ̀nírɛ̀	→ gèʃòròányɔ̀nírɛ̀	‘Gĩcũrũ saw me’
o + ɔɔ → oɔ	gèʃòrò ɔ́ɔ́nìrɛ́	→ gèʃòròɔ́nìrɛ́	‘Gĩcũrũ saw (something)’
o + oo → oo	gèʃòrò óóréá	→ gèʃòròòréá	‘that Gĩcũrũ’
u + ɛɛ → uɛ	mátú ɛ́ɛ́tìrɛ́	→ mátúɛ́tìrɛ́	‘Matu called’
u + aa → ua	mátú áányɔ̀nírɛ̀	→ mátúányɔ̀nírɛ̀	‘Matu saw me’
u + ɔɔ → uɔ	mátú ɔ́ɔ́nìrɛ̀	→ mátúɔ́nìrɛ̀	‘Matu saw (something)’
u + oo → uo	màtù óóréá	→ màtùòréá	‘that Matu’

In contrast, other V+V: sequences yield a different surface form from their V+V counterparts. These are listed in Table 6 along with a characterization of the type of difference(s); representative examples are given in (31).

(31) Combinations where long V_2 yields a different surface form from short V_2

i + uu → iuu	tí úúbúðé	→ tíúúbúðé	'those are not dregs'
	tí úúmèrò	→ tíúúꜝmérò	'this is not an exit'
e + ii → eii	né ííjì	→ néííjì	'this is an inch'
	né ííjìní	→ néííjìní	'this is an engine'
e + uu → euu	né úúbùðè	→ néúúbùðè	'those are dregs'
ɛ + ii → ɛii	ɔ́ɔ́nìrɛ́ ííjìní	→ ɔ̀ɔ̀nìrɛ́ííjìní	's/he saw an engine'
ɛ + uu → ɛuu	ɔ́ɔ́nɛ̀ɛ̀tɛ́ úúgùmáníá	→ ɔ́ɔ́nɛ̀tɛ́úúgùmáníá	'he saw corruption'
a + ii → aii	dɔ̀ɔ̀ná ííjìnì	→ dɔ̀ɔ̀náííjìnì	'I saw an engine'
	ná ꜝííjìnì	→ náꜝííjìnì	'... and an engine'
a + uu → auu	ná úúbùðè	→ náùùbùðè	'... and dregs'
	nà ùùðí	→ nàùùðí	'... and thread'

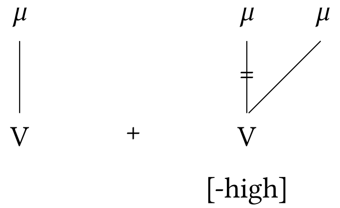
Table 6: Type of difference between V+V: and V+V surface forms

V1+ V2 quality	Output w/ long V2	Output w/ short V2	Type of difference
ɛ+i	ɛii	ɛi	mora count
a+i	aii	ai	mora count
i+u	iuu	iu	mora count
e+u	euu	eu	mora count
a+u	auu	ɔi	mora count; application of quality change
ɛ+u	ɛuu	eɔi	application of quality change

All *ii*-initial words we have found are borrowed, and the long *ii* may derive from pre-nasal lengthening. This probably does not account for the failure of shortening, however, since, as we will show below, high vowels also do not undergo shortening in V_1 position, as non-high vowels do. Also, the long *uu* in words like *ùùðí* results from combining the cl. 14 prefix *u-* with an *u*-initial stem and still does not shorten (cf. forms in (30) with initial non-high long vowels containing the cl. 14 prefix that do shorten, such as *ooke* 'honey').

Clements and Ford's account of downstep in Kikuyu contains some discussion of long vowel shortening (1981b: 202-205). In their analysis, shortening is driven by the fusion of adjacent vowels into a single syllable, combined with a restriction that long vowels generally do not share a syllabic nucleus with other vowels. In terms of moraic theory and constraint-based phonology, we might attribute this generalization to a restriction where syllables are maximally bimoraic. Our analysis is not incompatible with a syllable-based approach, but for simplicity we account for shortening via the rule in (32), which does not refer to syllables.

(32)



The failure of *ii* and *uu* to shorten is captured by the fact that the rule in (32) applies only to [-high] vowels. The change of *i* + *ii* ⟶ *ii* must therefore be handled separately. In general, for our speaker, sequences of V+V: where the quality of the vowels is identical surface as V: and there are not instances of an extra-long V: : (contrary to Armstrong's description). A syllable-based approach, which we do not attempt here, might subsume all of these facts under a set of generalizations regarding which combinations of vowels (based on their quality) are eligible to fuse into a single syllable, and this in turn could be used to restrict shortening (because shortening would only apply when the vowel sequence occurs within a single syllable). The identification of the vowel pairs that can fuse into a single syllable would be based on which vowels shorten, so the reasoning would be circular, but this might enable a coherent and unified analysis of syllable-driven shortening that does not treat *i* + *ii* ⟶ *ii* separately from the shortening of non-high long vowels after another vowel. We leave this for future work (and note that Clements & Ford 1981b also did not propose a predictive generalization regarding which vowel sequences fuse vs. which sequences remain in separate syllables).

An important fact to note is that while V length can be difficult to distinguish auditorily, it is clearly the V+V: context and not simply the connected speech context that induces shortening in word-initial long vowels, since the vowels still surface as long in isolation when elicited in connected speech, as demonstrated in (33).

(33) Words with initial long vowels pronounced in isolation in connected speech

ííjí	‘inch’	*iji
ééréá	‘those (cl. 4)’	*erea
ɛ́ɛ́tìrɛ́	‘he called’	*ɛtirɛ
áányɔ̀nírɛ̀	‘he saw me’	*anyɔnirɛ
ɔ̀ɔ̀tí	‘baskers’	*ɔti
òòké	‘honey’	*oke
úúbúðé	‘dregs’	*ubuðe

The forms in (34) with *ɛuu*, *auu* combinations show that diphthongization to *ɔi* applies only to short *u*, not to long *uu*. These forms cannot surface with **eɔi*, **ɔi*.

(34)

ɔ́ɔ́nɛ̀ɛ̀tɛ́ úúgùmáníá	→ ɔ́ɔ́nɛ̀tɛ́úúgùmáníá *ɔɔnɛteɔigumania	‘he saw corruption’
ná úúbùðè	→ náùùbùðè *nɔibuðe	‘… and dregs’

V: +V combinations show significantly different behavior from V+V and V+V: combinations. Table 7 shows the VHR outcomes for all combinations with a long V_1. Note that Armstrong does not comment on these combinations, so no comparison is possible between our description and Armstrong’s here.[8,9]

Since shortening applies to non-high vowels before any vowel, we propose the rule in (35), which is the mirror image of the rule in (32).

(35)

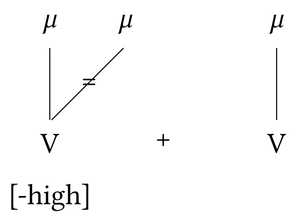


Table 8 gives a summary of differences in VHR outcomes when V_1 is long vs. when it is short.

[8]The *aa*-final nouns we have identified (*báá* ‘dew’ and *dàà* ‘louse’) exceptionally resist shortening before *u*, for reasons we have not established. Due to the otherwise general shortening pattern and the small number of lexical items involved, we suspect this cell should be filled with *au* but do not have examples to confirm this.

[9]Our one *oo*-final noun, *móó* ‘*M. hildebrandtii* tree’, does not undergo shortening in any context. We hypothesize that there is something special about this noun, perhaps having to do with its CV: shape (see also footnote 12), and that if we are able to identify other nouns with final *oo*, they will undergo shortening.

Table 7: Long V_1 + Short V_2

V_1↓ V_2→	i	e	ɛ	a	ɔ	o	u
ii	ii	iie	iiɛ	iia	iiɔ	iio	iiu
ee	ei	ee	eɛ	ea	eɔ	eo	eu
ɛɛ	ɛi	ɛɛ	ɛɛ	ɛa	eɔ	eo	ɛu
aa	ai	aɛɛ	aɛɛ	aa	aɔɔ	aɔɔ	?
ɔɔ	ɔi	oɛ	oɛ	ɔa	ɔɔ	ɔɔ	ɔu
oo	?	?	?	?	?	?	?
uu	uui	uue	uuɛ	uua	uuɔ	uuo	uu

Table 8: Difference of VHR outcomes when V_1 is long vs. short

V1+ V2 quality	Output w/ long V2	Output w/ short V2	Type of difference
i+V	iiV (except ii)	iV	mora count
u+V	uuV (except uu)	uV	mora count
ɛ+a	ɛa	ea	application of quality change
ɛ+u	ɛu	eɔi	mora count; application of quality change
a+e, a+ɛ	aɛɛ	ɛɛ	mora count; application of quality change
a+o, a+ɔ	aɔɔ	ɔɔ	mora count; application of quality change
a+u	a(a?)u (see above)	ɔi	mora count (?); application of quality change
ɔ+u	ɔu	ɔi	mora count; application of quality change

Some of these differences can be explained by the shortening rule in (35) applying late in the derivation, counterfeeding some of the quality changes described and analyzed in §3, §4, if we analyze those rules as applying only to short vowels. For example, ordering the *ɛa* ⟶ *ea* raising rule before (35) explains the failure of raising in (36).

(36)	ɛɛ + a → ɛa	mòðɛ́ɛ̀ áyá	→ mòðɛ́àyá	'these Mũthees'
		mòðɛ́ɛ̀ áɣérà	→ mòðɛ́ꜜáɣérà	'Mũthee, be nice!'

The mirror image shortening rule in (32), in contrast, applies earlier and feeds most of the quality changes, as in the examples below where the shortened vowel is the trigger (37a) or the target (37b).

(37)	a.	ɛ + aa → ea	jɔ̀rɔ̀gɛ́ áányɔ̀nírɛ̀	→ jɔ̀rɔ̀géányɔ̀nírɛ̀	'Njoroge saw me'
		ɔ + ɛɛ → oɛ	gèkɔ̀nyɔ́ ɛ́ɛ́tìrɛ́	→ gèkɔ̀nyóɛ́tìrɛ́	'Gĩkonyo called'
	b.	ɛ + ee → ɛɛ	ŋɔ̀ɔ̀bɛ̀ èèréá	→ ŋɔ̀ɔ̀bɛ̀ɛ̀réá	'that cow'
		ɔ + oo → ɔɔ	gèkɔ̀nyɔ́ òòréá	→ gèkɔ̀nyɔ́ɔ́réá	'that Gĩkonyo'
		ɔ + ee → oɛ	mèhèèdɔ̀ èèréá	→ mèhèèdòɛ̀réá	'those ropes'

The relative ordering of the two shortening rules also allows us to make sense of some perhaps unexpected surface forms when *aa* is followed by a mid vowel, shown in (38).

(38)	aa + e → aɛɛ	dàà étékà	→ dàɛ́ɛ́tèkà	'louse, answer!'
			*daeteka, *dɛɛteka, *daɛteka	
		báà étékà	→ báꜜɛ́ɛ́tèkà	'dew, answer!'
			*baeteka, *bɛɛteka, *baɛteka	
	aa + ɛ → aɛɛ	báà ɛ́hɛ́rà	→ báɛ̀ɛ̀hɛ́rà	'dew, stand aside!'
			*baɛhɛra, *bɛɛhɛra	
	aa + ɔ → aɔɔ	báà ɔ́hà	→ báꜜɔ́ɔ́hà	'dew, tie!'
			*baɔha, *bɔɔha	
	aa + o → aɔɔ	báà ókà	→ bá ꜜɔ́ɔ́kà	'dew, come!'
			*baoka, *bɔɔka, *baɔka	

Recall that the corresponding sequences behave as follows when both vowels are short (39a) and when V_2 is long (39b).

(39) a. a+e → ɛɛ   b. a+ee → ɛɛ
a+ɛ → ɛɛ   a+ɛɛ → ɛɛ
a+ɔ → ɔɔ   a+ɔɔ → ɔɔ
a+o → ɔɔ   a+oo → ɔɔ

Our explanation for this difference is that in *aa*+V, the second half of the long *aa* interacts with the following mid V, fusing into *ɛɛ* or *ɔɔ* while the initial mora of the *aa* remains associated to the features of *a*. The resulting *a*+V: sequence does not undergo the rule that normally shortens non-high long vowels after another V because that rule already applied earlier in the derivation, as shown in (40).

(40) Derivation of /baa oka/ → baɔɔka

Underlying form	baa oka
Shortening of V+VV	N/A
a+o → ɔɔ	baɔɔka
Shortening of VV+V	N/A
Surface form	baɔɔka

We can identify which of the VHR rules apply before vs. after V:+V ⟶ VV based on the quality changes that do vs. do not apply in V:+V sequences. The changes in (41) affecting V_1 do apply to V:+V sequences, suggesting that ATR shift and delinking should be ordered after the rule that shortens a long vowel before a short vowel.

(41)

a.	ɛ+ɔ → eɔ	mòðɛ́ɛ̀ ɔ́hà	→ mòðé'ɔ́hà	'Mũthee, tie!'
b.	ɛ+o → eo	mòðɛ́ɛ̀ óyó	→ mòðéòyó	'this Mũthee'
		mòðɛ́ɛ̀ ókà	→ mòðé'ókà	'Mũthee, come!'
c.	ɔ+e → oɛ	kàŋɔ́ɔ̀ étékà	→ kàŋó'ɛ́tékà	'Kang'oo, answer!'
d.	ɔ+ɛ → oɛ	kàŋɔ́ɔ̀ ɛ́tɛ̀rɛ́rà	→ kàŋó'ɛ́tɛ́rɛ́rà	'Kang'oo, wait!'

A final discrepancy between V:+V and V+V that needs to be accounted for is that we do not find examples of *u*-diphthongization following a long *ɛɛ*, *aa*, or *ɔɔ* (even if the long vowel is later shortened). As shown in (42), in this context the long V_1 shortens but the *u* surfaces unchanged.

(42)

ɛɛ + u → ɛu	mòðɛ́ɛ̀ úɣà	→ mòðɛ́'úɣà	'Mũthee, say (something)!'
		*moðeɔiɣa, *moðɛɔiɣa	
aa + u → aau	báà úɣà	→ báá'úɣà	'dew, say something!'
		*baɔiɣa, *baaɔiɣa	
ɔɔ + u → ɔu	kàŋɔ́ɔ̀ úɣà	→ kàŋɔ́'úɣà	'Kang'oo, say something!'
		*kaŋɔiɣa, *kaŋɔɔiɣa	

This suggests that the diphthongization rule is triggered specifically by a preceding *short* vowel, and that diphthongization must apply prior to the rule that shortens a long vowel before another vowel.

One last type of combination to consider is V:+V:. These forms are difficult to elicit due to the relative scarcity of long vowels both initially and finally and the syntactic category of words ending and beginning with long vowels. The combinations we have found are consistent with our observations about other combinations involving long vowels, including that non-high vowels undergo shortening when they precede or follow a vowel while high vowels do not, as shown in (43).

(43)	ii + ɛɛ → iiɛ	kèfîì ɛ́ɛ́tìrɛ́	→ kèfííꜜɛ́tìrɛ́	'fog called'
	ii + aa → iia	kèfîì áányɔ̀nírɛ́	→ kèfííꜜányɔ̀nírɛ́	'fog saw me'
	ii + ɔɔ → iiɔ	kèfîì ɔ́ɔ́nìrɛ́	→ kèfííꜜɔ́nìrɛ́	'fog saw (something)'
	uu + ɛɛ → uuɛ	wààbúù ɛ́ɛ́tìrɛ́	→ wààbúúꜜɛ́tìrɛ́	'Wambuu called'
	uu + aa → uua	wààbúù áányɔ̀nírɛ̀	→ wààbúúꜜányɔ̀nírɛ̀	'Wambuu saw me'
	uu + ɔɔ → uuɔ	wààbúù ɔ́ɔ́nìrɛ̀	→ wààbúúꜜɔ́nìrɛ̀	'Wambuu saw (something)'
	uu + oo → uuo	wààbúù óóréá	→ wààbúúòréá	'that Wambuu'

As shown in (44), the one combination we have found involving long *aa* with another V: is consistent with our analysis of the *aa*+V examples provided earlier in (38) (where *aa*+*e* ⟶ *aɛɛ*).

(44)	aa + ee → aɛɛ	báà ééréá → báɛ̀ɛ̀réá	'that dew'
		dàà ééréá → dáɛ̀ɛ̀réá	'that louse'

The derivation of *aa* + *ee* ⟶ *aɛɛ* is explained as in (45).

(45) Derivation of /baa eerea/ → baɛɛrea

Underlying form	baa eerea
Shortening of V+VV	baaerea
a+e → ɛɛ	baɛɛrea
Shortening of VV+V	N/A
Surface form	baɛɛrea

We have elicited two combinations of V:$_i$+V:$_i$ (identical long vowels) and in both cases the surface form is V:$_i$ (a single long vowel that does not sound 'overlong'), as in (46).

(46)	ɛɛ + ɛɛ → ɛɛ	mòðɛ́ɛ̀ ɛ́ɛ́tìrɛ́	→ mòðɛ́ꜜɛ́tìrɛ́	'Mũthee called'
	oo + oo → oo	mòò óóréá	→ móòréá	'that M. hildebrandtii tree'

This is as expected since we have rules that shorten a long vowel both before and after another vowel, so $V{:}_i$+$V{:}_i$ first changes to $V{:}_i$+V_i and then to V_i+V_i.

The only other V:+V: combinations we have found involve *ɛɛ* followed by another long vowel, shown in (47).

(47)	a.	ɛɛ + ɔɔ → eɔ	mòðɛ́ɛ̀ ɔ́ɔ́nìrɛ̀	→ mòðéꜜɔ́nìrɛ̀	'Mũthee saw (something)'
	b.	ɛɛ + oo → eo	mòðɛ́ɛ̀ óóréá	→ mòðéòréá	'that Mũthee'
	c.	ɛɛ + aa → ɛa	mòðɛ́ɛ̀ áányɔ̀nírɛ̀	→ mòðɛ́ꜜányɔ̀nírɛ̀	'Mũthee saw me'

(47a) and (47b) are consistent with the behavior of all other types of combinations (V+V, V+V:, V:+V). The combination *ɛɛ+aa* (47c) behaves like *ɛɛ+a* in failing to undergo the raising (*ɛ+a* ⟶ *ea*) that applies when *ɛ* is underlyingly short (*ɛ+a*, *ɛ+aa*).

6 Conclusion

In this paper we have attempted to provide as comprehensive an analysis as possible of VHR effects in Kikuyu. A number of outstanding issues remain for future research.

First, we have not distinguished diphthongs from vowel sequences that cross a syllable boundary. We perceive that some VV sequences sound shorter than others, suggesting they may be tautosyllabic while others are in separate syllables. However, this is difficult to distinguish, and we have not identified a diagnostic for syllable membership.

Relatedly, we have not addressed the relationship of tone to VHR. Our transcriptions reflect some tone differences between careful and connected speech, but we have not made any claims here about underlying tones. Clements & Ford (1981a: 317-318) show how a rule of tonal absorption can be used to distinguish between lexical items ending in a diphthong vs. heterosyllabic V.V sequences when they have a final LH tone pattern, but we have not yet been able to adapt this or any other tonal diagnostic for use in derived VV sequences originating across a word or morpheme boundary.

One interesting aspect of our findings is the failure of long high vowels to undergo shortening, which may suggest that Kikuyu VHR is not motivated in general by a pressure to produce “optimal” diphthongs. In theory, a high front or back vowel, being “peripheral” in the vowel space, is an ideal start or end point for a diphthong since the accurate perception of a diphthong relies on there being sufficient distance between the two portions of the vowel. Therefore, it is perhaps unexpected that high vowels fail to shorten in order to form diphthongs when combined with other vowels.

Another matter of potential theoretical interest concerns the difference in outputs comparing V:+V sequences with V+V. In an OT account, the change of *ɛa* to *ea* cannot be straightforwardly driven by a markedness constraint like **ɛa* since [ɛa] is the correct output for *ɛɛ+a*. There would need to be a faithfulness constraint that preferentially protects the features of *ɛɛ* over those of *ɛ*. The analytical challenge is that this preferential faithfulness is not manifested across the board but only relative to certain VHR rules (e.g., *ɛɛ* does raise to *e* when it precedes *o* or *ɔ*). It is partly for this reason that we have opted to analyze the system in terms of ordered rules rather than giving a markedness-driven analysis.

Abbreviations

ATR	Advanced tongue root	OT	Optimality Theory
C	Consonant	rem.	Remote
cl.	Noun class	SPE	Sound pattern of English
GF	Glide formation	V	Vowel
H	High tone	V:	Long vowel
L	Low tone	VHR	Vowel hiatus resolution
μ	Mora		

Acknowledgments

We express our deep gratitude to Kĩmani Mbũgua for his patience and generosity as our language consultant. We are also grateful to the participants in the spring 2019 Field Methods class at Pomona College, especially Franco Liu, for their contributions, to Dave Odden for useful advice regarding Kikuyu phonology, and to an anonymous ACAL reviewer for helpful suggestions. The first author’s work on this project has been supported in part by the National Science Foundation Independent Research/Development program; the views expressed in this paper do not necessarily reflect the views of the NSF. All errors are our own.

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