A mixed height and ATR system of vowels in Rere

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1. Introduction

Vowel height systems combined with ATR contrasts can be various and imply different typologies deriving from harmony patterns (Pulleybank, 2011). Kordofanian or Nuban languages of the Niger-Congo family have been documented to have a generally pervasive height or ATR harmony system based on their vowel inventories and trigger factors (see e.g., Moro: Richart & Rose, 2017; Laru: Abdalla Kuku, 2012; Lumun: Smits, 2017; Tocho: Alaki & Norton, 2013; Acheron: Norton, 2013; Dagik: Vanderelst, 2016; Tima: Bashir, 2013)

Rere, or Koalib, belongs to the Heiban group of Kordofanian language spoken in the Nuba Mountains of southern Sudan by an estimated population of 100,000 (Quint, 2009). Rere is an interesting case to probe the boundary and the relation between height and ATR harmony systems. It will be shown that Rere provides a different perspective to the typology where a non-pervasive vowel harmony pattern was attested in the language. The fact that the present analysis does not completely agree with a previous phonological description by Quint (2009) is likely due to speaker's variation or language contact with Arabic (cf. Tabaq; Hellwig & Schneider-Blum, 2014).

This paper presents data from one male native speaker of Rere, Taitas Kanda. First, I demonstrate the vowel inventories with some phonetic process in comparison to what have been discussed previously in Quint (2009). Second, I investigate the vowel harmony which appears in certain grammatical processes. Third, I discuss which harmony system – height or ATR factor, captures more of the nature of the Rere vowel harmony. Finally, I discuss the typological patterns with neighbor languages and conclude.

2. Rere vowel inventory

2.1. Vowels

Based on our research with Taitas, Rere has eight vowel phonemes: /i, ɪ, ɛ, ɐ, a, u, o, ɔ/ (cf. Quint, 2009). Three more vowel allophones appear: [e, ʊ, ə] after certain consonants and/or at the word-final positions, which will be detailed below.

Table 1 shows all the surface vowel in Rere, comparing to Quint (2009) in Table 2 (reproduced).

Table 1. Vowels in Rere (allophones in parentheses)

		-back		+back
+high	+ATR	i	(ə)	u
	-ATR	ɪ		(ʊ)
-high	+ATR	(e)	ɐ	o
	-ATR	ɛ	a	ɔ

Table 2. Inventory of the vowel phonemes of the Rere dialect (Quint, 2009: P31, Table 5)

VOWELS	Front	Central	Back
High	i		u
Mid	e	ɐ	o
Low	ɛ	a	ɔ

The biggest difference between the current vowel inventory and the vowel inventory from Quint is the transcription of the mid-high front vowel between the high front vowel [i] and the low front vowel [ɛ]. Quint treated it as a mid front vowel [e] regardless of [ATR] features, while the present analysis treated it as a high [-ATR] vowel [ɪ]. This vowel is lower in F1 than a typical mid vowel [e] would be. However, the status of [ɪ] or [e] will be discussed with more evidence provided in the subsequent sections.

Vowel length is not contrastive though perceptible, which is likely an acoustic correlate of lexical prominence; nasalization on vowels is not contrastive either. There is one exception, though, when an extra-long vowel (i.e., notated by V::) is used to express an object at a fair distance, e.g., [kó⌊âw ŋgwá::⌊à] 'that cat (over there)', as compared to [kó⌊âw ŋgwà:⌊à] and [kó⌊âw ŋgwà⌊à], which both stand for 'that cat'. Regular vowels usually have a duration of 60-70 milliseconds while long vowels typically exceed 100 milliseconds and the super long vowel [a::] has 300 ms. The eight vowel phonemes each have their long counterparts, as shown in Table 3. Note that in these examples, the long vowels are all in the penultimate position of the word, it is possible that the vowels get penultimate lengthening due to prosodic effects.

Table 3. Examples of long vowels

iː	[îː]	'drink'	[1]TK01162019-6:07:22.4
ɪː	[ʈīːɾā]	'girl'	TK02012019-6:02:00.9
ɛː	[⌊èːɖèr]	'bowl'	TK02202019-5:12:31.3
ɐː	[éːmù]	'rat'	TK02222019-1:12:42.7
aː	[jáːɾì]	'ash'	TK01162019-3:11:50.7
aːː	[kó⌊âw ŋgwáː⌊à]	'that cat (over there)'	TK02062019-4:04:17.7
uː	[kúː⌊ù]	'smoke'	TK01162019-3:02:44.5
oː	[ôːɾì]	'red'	TK01162019-4:11:08.0
ɔː	[ʈóːɲò]	'gourd'	TK02202019-5:18:04.7

2.2 Vowel minimal pairs

The following minimal pairs and near-minimal pairs show the contrastive status of the eight vowel phonemes.

a versus **ɐ** versus **ɪ**

kâ⌊	'stone'	TK01112019-7:01:47.9
kê⌊	'sheath'	TK04122019YHSC-2:08:01.6

[1] All the examples can be searched and accessed at http://rere.ucsd.edu/.

kîɭ	‘seed-hole’	TK04192019YHSC-2:04:27.2

o versus **ɔ**

ʈôr	‘child’	TK02012019-5:13:02.0
ʈôr	‘hammer’	TK05172019-2:02:46.9
ɗòŋ	‘group’	TK04122019YHSC-2:13:58.0
ɗɔ̀ŋ	‘back of skull’	TK04122019YHSC-2:12:57.9
kwórtò	‘rich person’	TK04122019YHSC-2:11:34.0
kwɔ́rtɔ̀	‘blacksmith’	TK04122019YHSC-2:11:16.8

o versus **u**

ɭùbòŋ	‘hole in tree’	TK04102019-7
ɭùbùŋ	‘hole on ground’	TK04102019-7
ʈ̪òːròm	‘star’	TK01112019-5:07:56.0
ʈ̪úrùm	‘government’	TK04122019YHSC-2:10:33.6

ɪ versus **ɛ**

ɭéːɾɛ̀	‘sky’	TK04122019YHSC-2:05:01.3
ɭɪ̀ːɾɪ̀	‘seed of gourd’	TK04192019YHSC-2:01:32.1

i versus **ɪ**

ɭîː	‘they will drink’	TK04262019-YH2
ɭɪ̂ː	‘they will wash’	TK04262019-YH2

Next, I show some words that exemplify the three allophones [ʊ, e, ə].

[ʊ] is possibly an allophone of [o], which usually occurs after the palatal fricative [ç], for example, in [çʊ́nɖàŋ] < /çónɖàŋ/ ‘lion’. There is also free variation between [o] and [ʊ], as seen in [ɐʊ́ːɾì] and [ɐóːɾì] ‘be clean’, from different elicitation sessions. For the infinitive form ‘to be clean’, this vowel [ʊ] exhibits an even lower F1 in [ʈ̪ɨ̀ɐʊ́ːɾì]; the difference is 30 Hz (380 - 350 Hz). In other circumstances, [ʊ] is a centralized version of [u], which has a similar F1 to the high vowel [u] but with a much higher F2. For example, it often appears in a closed syllable, as seen in [ʈ̪ʊ́ɭ] < /ʈ̪úɭ/ ‘giraffe’ and [ʈ̪ʊ̂ɭ] < /ʈ̪ûɭ/ ‘porridge’, or it becomes short in [kʊ́ɭàw] ‘cat’ (26 milliseconds), and [ɐʊ̀kʊ́ɭì] ‘edible gourd’ (28 ms). These instances of [ʊ] have an F2 near 1200~1400 Hz, compared to a typical [u] as in [kûːɭù] ‘smoke’, [ɭùbùŋ] ‘hole on ground’, and [kwúrì] ‘he will cut’ with an F2 of 650~800 Hz.

[ʊ] < /o, u/:

çʊ́nɖàŋ	‘lion’	TK02062019-9:08:45.7
ɕʊ́ːɾì	‘be clean’	TK06072019YH
ɕóːɾɪ̀	‘be clean’	TK03082019SCARYH-3
t̪ɨ̀ɕʊ́ːɾì	‘to clean’	TK03082019SCARYH-3
t̪ʊ́ɭ	‘giraffe’	TK02152019-8
t̪ʊ̂ɭ	‘porridge’	TK02152019-8
kʊ́làw	‘cat’	TK02062019-1
ɕʊ̀kʊ́ɭɪ̀	‘edible gourd’	TK04122019YHSC-2:06:50.8

Nearly every instance of /ɪ/ was transcribed as /e/ in Quint (2009). However, some words contain a phonetically realized [e], which is an allophone of /ɛ/ or /ɐ/ colored by its following consonant. For example, in [ɭèj̝] < /ɭɛ̀j/ ‘eye’, the underlying /ɛ/ is higher because of the influence of the following palatal fricative. Similarly, /ɐ/ becomes [e] in [ɐ́jjɐ́] < /ɛ́jjɐ̀/ ‘who’. In other cases, the vowel status is not particularly stable in that the word may be articulated with vowels of variable quality in one occasion versus another occasion, for example, [t̪ê] ‘be cold’ varies with [t̪ɛ̂] in casual versus careful speech.

[e] < /ɛ/:

lèj̝	‘eye’	TK02082019-1:07:40.0
éjjɐ́	‘who’	TK03152019-4:01:04.8
t̪ê	‘be cold’	TK04192019YHSC-2:26:26.5
t̪ɛ̂	‘be cold’	TK05102019-YH

The reduced vowel, schwa, never occurs in monosyllabic words. It is typically derived from any non-low vowels that are too short to reach their target formant values, as in [ʈít̪ə́rà] ‘cup’; it can also be an intrusive vowel without a tonal association occurring between two consonants, for example, [kɛ́ɾəgɛ̀] ‘hand’. In addition, the occurrence of schwa is related to the centralization process (Quint, 2009) where vowels get reduced after /k, ŋ/, as seen in [kəɽìɭ̪ì] ‘nail’ and [ŋərpò] ‘tomorrow’.

[ə]:

ʈít̪ə́rà	‘cup’	TK02202019-5:08:10.3
kɛ́ɾəgɛ̀	‘hand’	TK04192019YHSC-2:26:26.5
kəɽɪ̀ɭ̪ì	‘nail’	TK02082019-4:05:28.8
ŋərpò	‘tomorrow’	TK05012019-3:02:46.4

The distribution of F1 and F2 of the eight vowel phonemes is plotted in Figure 1 based on the mean formant values over the entire duration of each of the eight vowels in the representative words (see Appendix). Ten to twenty instantiations were selected for each vowel.

Figure 1. Mean F1 and F2 of the eight vowel phonemes

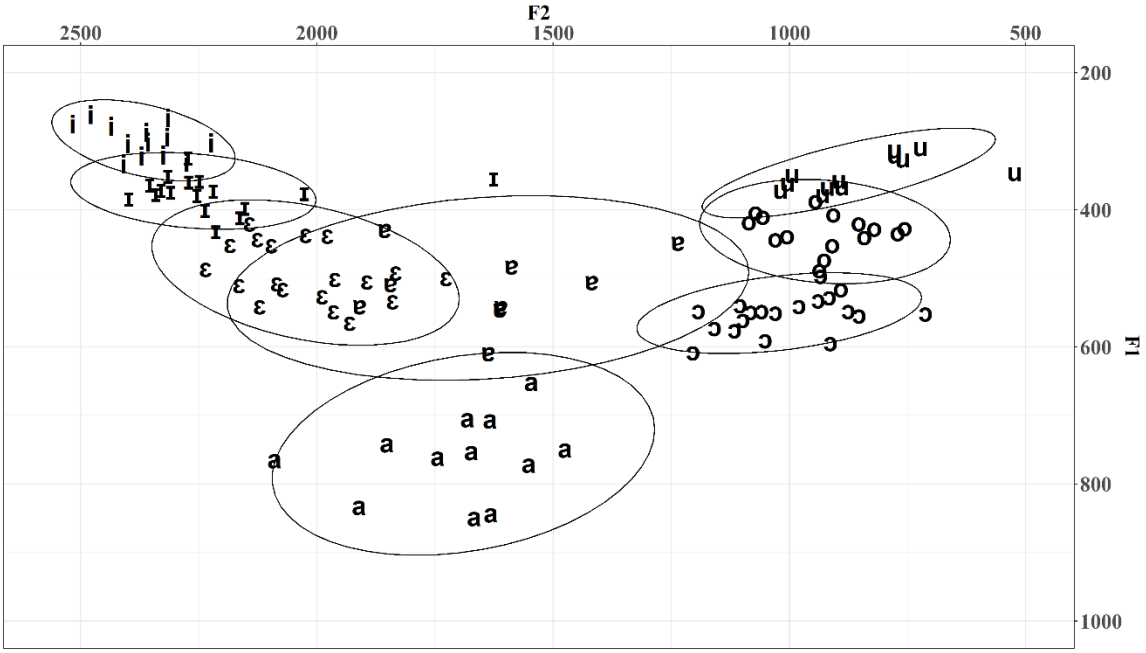


Figure 2 shows the current vowel space based on the average values of F1 and F2 across the same vowel phonemes.

Figure 2. Representative vowel space

2.3 Vowel centralization and labial assimilation

Besides the tendency to centralize after /k, ŋ/, word-final vowels and vowels in closed syllables are often centralized and reduced to be short in duration. For example, [ɪ] in [ʈá:mìn] 'finger' has an F2 of around 1800 Hz, compared to the reference F2 value above 2000 Hz in Figure 2. Likewise, in [nánál̀ò] 'sit', the final vowel [o] reduced to 27 ms and had an F2 of around 1200 Hz and in [ʈ̪ìɗàŋàl̀ò] 'surface', [o] becomes centralized with a relaxed quality and an F2 of 1500 Hz. And in the sentence 'Dog is sleeping', the word-final vowel [o] become its centralized version [ɵ] in the two words, with an F2 of around 1600 Hz.

ʈá:m**ɪ̀**n	'finger'	TK03012019NK-4:00:41.0
nánál̀**ò**	'sit'	TK03152019-YH1:10:06.9
pìrʈ̪ìr ʈ̪ìɗàŋàl̀**ò**	'Wipe the surface! (to PL)'	TK04242019-9
ʈíɲɛ́n kə́r**ɵ́** ʈ̪ìnɖ̪ə̀r**ɵ̀**	'Dog is sleeping'	TK02202019-1:07:09.1

Further, vowel assimilation is seen in labial spreading across boundaries, particularly in connected speech. This phenomenon is referred to as velarization in Quint (2009). The following example provides a case of regressive assimilation: occasionally when the verb is followed by a word that contains a rounded vowel [o], the final vowel [ɛ] in the verb /ɛ́jɛ̀/ 'see' is labio-velarized to be [ɛ́jó]. However, this process seems to be subject to free variation and speech rate because sometimes the vowel [ɛ] in word [ɛ́jɛ̀] retains in some utterances of the same sentence.

ɲí gwɛ̀j**ó** kókòŋò	'I will see Koko'	TK02152019-1
ɲí gwɛ̀j**ɛ́** kókòŋò		
(ŋ̀nɳ̀dúŋé) lɛ́j**ó** kókòŋó ŋòrpò	'They will see Koko tomorrow'	TK02152019-3
lɛ́j**ɛ́** kókòŋó ŋòrpò		
ŋéŋé lɛ́j**ó** kókòŋó ŋòrpò	'You all will see Koko tomorrow'	TK02152019-3
ŋéŋé lɛ́j**ɛ́** kókòŋó ŋòrpò		

Another similar case is that the final centralized vowel in verbs is conditioned by the vowel in the following word. For example, the centralized [ɨ] in [má:nɨ̀] < /má:nì/ 'cook' agrees with the vowel height in [ʈ̪ùl̀ì] 'porridge' whereas the vowel quality change to [ə] in [má:nə̀] < /má:nì/ is affected by [kàɣròŋí] 'chicken'.

ɲí gwmá:n**ɨ́** ʈ̪ùl̀ì nâ kàɣrò	'I cook porridge and chicken'	TK02222019-5:05:56.9
ɲí gwmá:n**ə́** kàɣròŋí nâ ʈ̪ûl̀	'I cook chicken and porridge'	TK02222019-5:07:26.9

3. Vowel change/agreement in grammatical processes

Vowel harmony was documented in Quint (2009) as being a pervasive phenomenon within words to only contain vowels belonging to the same height class. In this section, I present data on two grammatical processes, noun suffixation in instrumental constructions and verbal conjugation in causatives, to investigate the vowel harmony patterns.

3.1 Suffix of the instrumental case: 'with X' construction

According to Quint, vowels can be divided into two sets: high vowels /i, ɐ, u/, and low vowels /e, ɛ, a, ɔ, o/, as shown by Table 3 (reproduced).

Table 3. Distribution of Koalib vowels by vowel harmony set (Quint, 2009: P34, Table 6)

VOWELS	Front	Central	Back
High	i	ɐ	u
Low	e	a	o
	ɛ		ɔ

The morpheme that indicates the instrumental case in 'with X' alternates between *-ki* and *-ke*, conditioned by the corresponding vowel height set the vowels of the word belongs to. As Quint noted, words only contain vowels of the same set. For example, to compare [kwá:rá⌊gè] 'with the antelope' with [kwɛ̀⌊ùŋgì] 'with the liar'. Also note that here /k/ is realized as [g] after sonorants, so the case suffix becomes [-gi/e].

Based on the present analysis of vowel inventory, I propose that the two sets are instead hypothesized as high vowels /i, ɪ, ɐ, u/, and low vowels /ɛ, a, ɔ, o/, as shown in Table 4.

Table 4. Proposed distribution of Rere vowel harmony sets

VOWELS	Front	Central	Back
High	i		u
	ɪ	ɐ	
Low	ɛ		o
		a	ɔ

Again, the only difference is in the status of the mid-high or mid vowel [ɪ]/[e]. Under the current analysis, it is expected to see that *-ki* will appear after words that contain [ɪ] and that [ɪ] can co-occur with other high vowels /i, ɐ, u/ within a word.

Table 5 shows instrumental suffixation for the two sets of words with either high or low vowels. Table 6 shows the different patterns attested for the mid-high vowel [ɪ]/[e]. The transcription was based on both perception and acoustic measures of their respective F1 and F2 values. Note that the consonant in the suffix /-ki, -kɪ/ is conditioned by and thus alternates for the noun class.

Table 5. Two vowel sets with the instrumental case /-Ci, -Cɪ/

High V	With + X		With + X		With + X
wùrúṯ-ṯì	'larger antelope'	kû:⌊ú-ɣî	'smoke'	kú:rí-ɣî	'mouse'
ŋè⌊úŋ-ŋì	'lie'	ṯúrùm-ðî	'government'	é:mù-wî	'rat'
kɛ́ɳɖèŋ-ɣî	'knife'	gúrùɟí-ɣî	'money'	kí:ríɲ-ɣì	'warthog'
kímìji-kî	'kitchen knife'	jí:ðì-jì	'meat'	ɕùkú⌊ɪ̀-ɣî	'edible gourd'
ɲúr-ɲì	'fruit'	ʈíɲì-rî	'rabbit'	⌊ùbùŋ-⌊î	'ground-hole'

⌊ùr-⌊ì	‘manure’	ì:gé-wì	‘fire’	t̪ú⌊-ðì	‘giraffe’
kî:ɾù-kì	‘small antelope’				
TK04262019-YH1,2		TK05102019-YH			
Low V					
t̪óŋór-ðì	‘elephant’	ʈór-rî	‘child’	lèblét̪-⌊ì	‘cloud’
t̪ò:ròm-ðî	‘star’	ʈɔ́ŋɔ̀r-rì	‘boy’	⌊é:ɾé-⌊ì	‘sky’
⌊óm-⌊ì	‘fish’	kwɔ́rtɔ̀-gì	‘blacksmith’	⌊è:ɖèr-⌊î	‘bowl’
kwór-ɣî	‘man’	ʈór-rî	‘hammer’		
ɗòŋ-⌊ì	‘group’	⌊ɔ̀r⌊ɔ̀⌊ɔ́-⌊ì	‘beetle’		
‘with elephant’ in TK04262019-YH1,2; others in TK05102019-YH					

Table 6. [ɪ] with different suffixes

/ki/	With + X	/kɪ/	With + X	
⌊è-⌊ì	‘eye’	kí⌊-kì	‘seed-hole’	‘with small antelope’ in TK04262019-YH1; others in TK05102019-YH
ŋé:ɽì-ŋî	‘goat’	⌊ì:ɗî-⌊î	‘pine tree’	
		⌊ì:⌊ì-⌊î	‘termite’	

Indeed, we see /u, i, ɐ/ form one group while /o, ɔ, ɛ/ form another group in conditioning the vowel in the instrumental suffix. However, /a/ does not seem to participate in a systematic harmony process (more examples below) and the case with /ɪ/ or /e/ is unclear as it allows both /ki/ and /kɪ/. But it did occur with the high vowel [i] in the suffix, e.g., [⌊è⌊ì] ‘with eye’, [ŋé:ɽìŋî] ‘with goat’.

There are a few exceptions or counterexamples to the vowel height agreement rule. Counterexamples do not agree in height either within the word stem or between stem and suffix. For ‘with lion/ cup/ tree-hole/ light’, the suffix can be considered to agree with the immediately preceding vowel in the stem, though these words contain vowels of different height classes. The [i] in [jé:nìjì] ‘with ears’, [ŋìàŋî] ‘with poison’, and [ŋwíɛ̀ŋŋî] ‘with soot’ is possibly due to the influence of the palatal glide or the velar nasal. Other cases only containing one vowel [o] or [a] in ‘with rich person/ stone’ are hard to explain.

Table 7. Words containing vowels not agreeing on vowel height

çʊ́nɖàŋ-kî	‘with lion’	TK04262019-YH1
ʈì̪ʈèrá-rì	‘with cup’	TK04262019-YH1
⌊ùbòŋ-⌊î	‘with tree-hole’	TK05102019-YH
fórì-ɣî	‘with light’	TK04262019-YH1
jé:nì-jì	‘with ear’	TK05102019-YH
ŋwíɛ̀ŋ-ŋî	‘with soot’	TK04262019-YH1
ŋìà-ŋî	‘with poison’	TK04262019-YH2
kwórtò-ɣì	‘with rich person’	TK05102019-YH
kâ⌊-ɣì	‘with stone’	TK05102019-YH

Note that the phonetic realizations of the suffixed forms were not stable in that the same suffix in the same word can be produced with different vowel qualities, see Table 8.

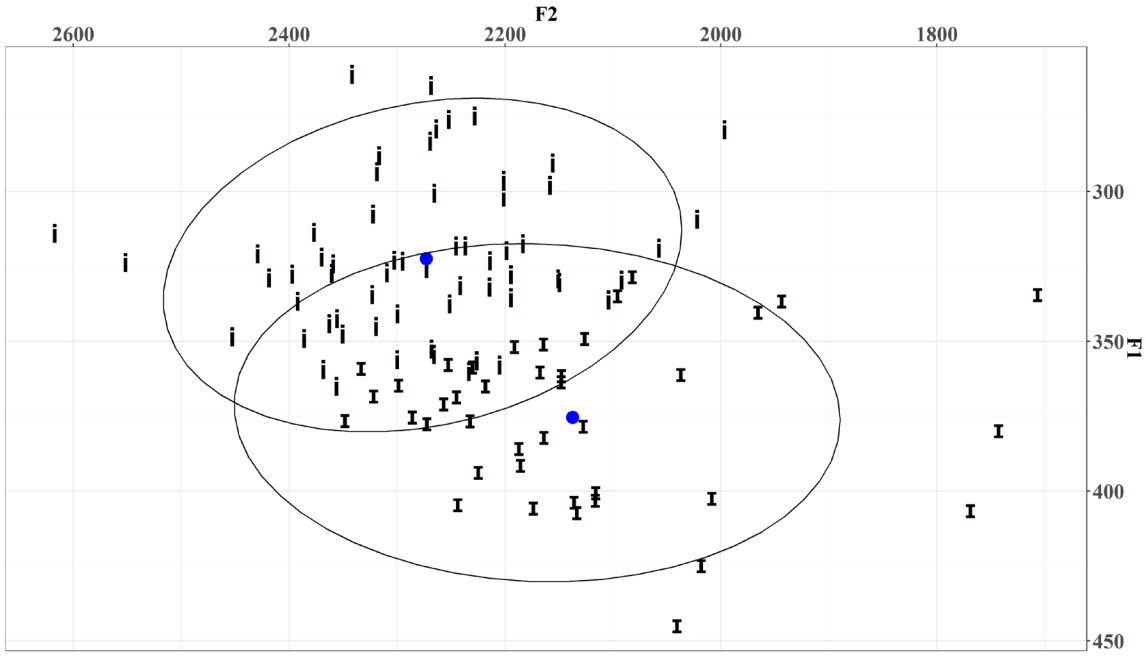
Relatedly, even with the word without suffix, the high vowels [i] and [ɪ] are not steady, for example, [ʈ̪î] ‘arm’ is sometimes pronounced as [ʈ̪î].

Table 8. Words with both forms of suffix

kwɔ́àj-ɣî	kwɔ́àj-ɣî	‘with slave’	TK04262019-YH1
kwá:rá[-ɣì	kwá:rá[-ɣì	‘with biggest antelope’	TK04262019-YH1
ʈ̪ù[-kì	ʈ̪ù[-kì	‘with porridge’	TK05102019-YH
ʈ̪ú[ùŋ-rî	ʈ̪ú[ùŋ-rî	‘with silo’	TK05102019-YH
kɛ́ɲ-ɣî	kɛ́ɲ-ɣî	‘with salad’	TK05102019-YH
ʈì:ɾà-ɽî	ʈì:ɾà-ɽî	‘with girl’	TK05102019-YH
kɨ́mòw-ɣî	kɨ́mòw-ɣî	‘with snake’	TK05102019-YH
ʈ̪ɪ́-ðì	ʈ̪ɪ́-ðì	‘with arm’	TK05102019-YH
ám[à-wî	ám[à-wî	‘with trap’	TK05102019-YH

So far, we have seen that not only [ɪ] can occur with both high or low vowels and followed by /Ci/ or /Cɪ/, but other vowels belonging to the two different sets can also co-occur. This is at odds with Quint’s description that all words only allow vowels of the same height group. To further probe the distinction between the vowel qualities in the two alternants of the instrumental case, I plotted the distribution of the mean F1 and F2 values for each [i, ɪ] based on the transcriptions of the words from above.

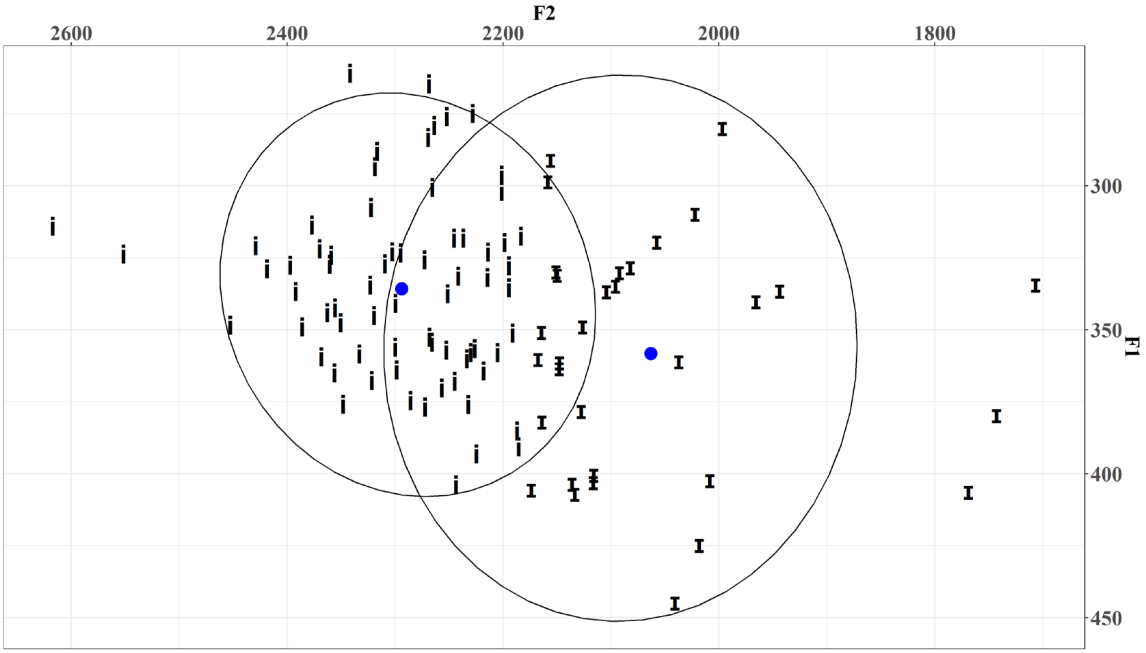
Figure 3. Mean F1 and F2 of [i, ɪ] in /Ci, Cɪ/ based on transcription. The blue dots show the center mean F1 and F2 values of [i, ɪ] across all tokens. The values are shown in the following table.



	mean F1	mean F2	mean F3	mean F2-F1
i	322.17	2276.07	2828.24	1953.90
ɪ	374.35	2136.40	2725.71	1762.05

Alternatively, to preclude subjective biases on the transcription, I used an unsupervised machine classification approach (Stehr, 2018) to separate out the two clusters of two vowels [i, ɪ] by specifying two centers in the parameter of K-means algorithm. The corresponding plot is shown in Figure 4.

Figure 4. Mean F1 and F2 of [i, ɪ] in /ki, kɪ/ based on k-mean clustering at two centers. The blue dots show the center mean F1 and F2 values of [i, ɪ] across all tokens. The values are shown in the following table.



	mean F1	mean F2	mean F3	mean F2-F1
i	338.15	2275.85	2869.08	1937.70
ɪ	355.67	2069.75	2564.42	1714.08

The biggest difference between human perception (by the author) and the computational analysis is the driving factor. I relied more on the difference of F1, or the height between the two vowels while the machine weighed more on the linear difference of F2 between the two vowels. The main takeaway is that the regular [i] is more concentrated with a lower F1 and higher F2 whereas [ɪ] is more variable with a slightly higher F1 and lower F2. Following these analyses, the current vowel harmony sets are revised and shown in Table 9.

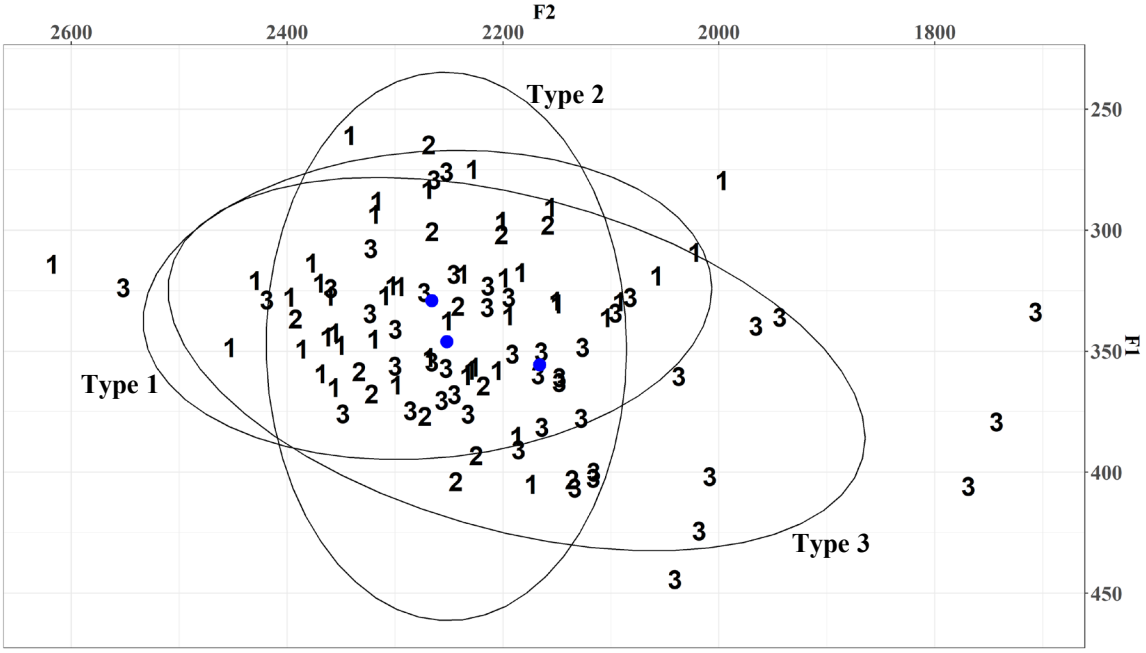
Table 9. Attested distribution of Rere vowel harmony sets (pattern of vowels in doubt are in brackets)

VOWELS	Front	Central	Back
High	i		u
	[ɪ]	ɐ	
Low	[ɪ]		o
	ɛ	[a]	ɔ

Similar to the case with instrumental suffixes, there is evidence suggesting an alternation between [i] and [ɪ] in the tense-aspect-mood suffixes depending on the vowel of the root. For example, [kwɛ́rnì] 'he will play (musical instrument)', to compare with [kwɛ́rnì] 'he will finish', or [kɛ́rnì] 'they will play (musical instrument)', versus [kɛ́rnì] 'they will finish'. This implies that [ɪ] can pattern as a low vowel.

Furthermore, Inspired by Hellwig and Schneider-Blum (2014), I adopted a third supplemental approach to sort out the vowel quality in the suffix *-Ci/ -Cɪ* by *a priori* labeling them into three groups: words that contain high vowels /i, u, ɐ/, words that contain low vowels /ɛ, a, ɔ/, and words that contain /ɪ/. Figure 5 shows the distribution of the different suffixes by the three groups.

Figure 5. Mean F1 and F2 of [i, ɪ] in /Ci, Cɪ/ divided into three types based on the vowel classes in the words. Type 1: /i, u, ɐ/; type 2: /ɪ/; type 3: /ɛ, a, ɔ/. The blue dots show the respective center means of the three types.



Here, we see that Type 3 which include words with low vowels is more variable and that it can overlap with Type 1, and Type 2 tends to range vertically wide in height, which is consistent with the findings in Table 6 that [ɪ] can pattern as a high vowel and also as a low vowel.

3.2 Causatives, passives

Verbal morphonology is rich in Rere as it is involved in various derivational constructions. For instance, low vowels in the verb stem raise to become high vowels in the presence of a causative suffix *-ni/ -nɪ* (centralized) and a passive infix *-ən-* (cf. Moro: Richart & Rose, 2017). Thus, I present data that show the vowel harmony process where the four low vowels /a, o, ɔ, ɛ/ raise to [ɐ, u, (ʊ,) ɪ, i].

Examples in (1-2) show raising of the central low vowel /a/ in verbs /àŋgɽì/ ‘draw water’ and /mà:nì/ ‘cook’ to the central high vowel [ɐ] under causative constructions, triggered by the suffix *-ni*.

a raises to **ɐ**:

(1) a. ɲí gw-ʈ̪-émɻ̩jí ɲì:rà ʈ̪è-ɽ-**àŋgɽì**
1SG CL-HAB-make girl.PL INF-PL-draw water
TK03012019-3:05:38.2

b. ɲí gw-ʈ̪-**èŋgɽí**-*ní* ɲì:rà
1SG CL-HAB-draw water-CAUS girl.PL
TK03012019-3:07:22.2

‘I make the girls draw water.’

(2) a. ɲí gw-ʈ̪-émɻ̩jí ɲì:rà ʈ̪é-ɽ-**mà:nì**
1SG CL-HAB-make girl.PL INF-PL-cook
TK03012019-3:00:36.2

b. ɲí gw-ʈ̪ɨ-**mè:ní**-*ní* ɲì:rà
1SG CL-HAB-cook-CAUS girl.PL
TK03012019-3:09:45.6

‘I make the girls cook.’

The two sets of sentences (3-4) show that /o/ in adjectives ‘be clean’ and ‘be dry’ changes to [u] in verbs ‘be cleaned’ and ‘be dried’ under passive constructions, possibly triggered by the infix *-ən-*.

o raises to **u**:

(3) a. jìɽéð-í jí-**ɞòrò** TK06072019-YH
clothes.PL-ACC CL-be clean
‘Clothes are clean.’

b. jìɽéð-ì ʈ̪ì-**ɞùr**-*èn*-n**ì** TK06072019-YH
clothes.PL-ACC HAB-clean.PASS
‘Clothes are cleaned.’

(4) a. jíɽɛ̀t gíjó j-**òn̪dò** TK03082019SCARYH-3
clothes.PL DEM CL-be dry
‘The clothes are dry.’

b. jìɽɛ́ð-ì **t̪-ùnd̪-ən-nɪ̀** TK06072019-YH

clothes.PL-ACC HAB-dry.PASS

'Clothes are dried.'

Also note that the vowel [u] in *t̪ì-ɛ**ù**ɾ-ən-nì* (3b) and *t̪-**ù**nd̪-ən-nì* (4b) has a centralized quality that its F2 reaches 1200~1300 Hz.

Another cross-word-boundary vowel height agreement targets the alternation between [o] and [u] in the progressive marker, *ŋgó/ ŋgú*. When the subject is the first person singular, *ɲí* 'I', containing a high vowel [i], *ŋgú* is produced; when the subject is the second person singular, *ŋá* 'you', or a name such as *Koko* that includes [o] as a non-high vowel, *ŋgó* occurs. The vowel in *ŋgó/ŋgú* is probably unspecified in height and alternates between [o] and [u] depending on the vowel in the preceding word. See the examples in (5).

(5) a. ɲí **ŋgú** gw-àβrə̀-ŋà TK03062019-8:04:15.6

1SG PROG CL-run away-2SG

'I am running away from you.'

b. kókò **ŋgó** gw-àβrə̀-ŋà TK03062019-6:02:59.6

Koko PROG CL-run away-2SG

'Koko is running away from you.'

Examples in (6-7) show the low vowel /ɔ/ in the two verbs /ɔ́l̪ɔ̀/'insult' and /ɔ́rɔ́/ 'become' changes to [ʊ] or [u] in causative sentences.

ɔ raises to **u/ʊ**:

(6) a. kw-**ɔ́l̪ɔ̀** TK05102019-YH

CL.3SG-insult.FUT

'He will insult.'

b. ɲí gw-**ùl̪ʊ̀**ð-*nɪ́* ʈɔ̀ŋɔ́r-ɔ́ gwɔ̀r-ɔ̀

1SG CL-insult.FUT-CAUS boy-ACC man-ACC

'I will make the boy insult the man.' TK05312019-YH

(7) a. ɲí gw-ɔ́mɟɛ́ ʈɔ̀ŋɔ́r-ɔ́ àð-**ɔ́rɔ́** gw-ɔ́mnɛ̀

1SG CL-make.PST boy-ACC INF-become CL-something

'I made boy be something.' TK05292019-6

b. ɲí gw-**ùrù**ðən-*nɪ́* ʈɔ̀ŋɔ́r-á kɨ́mɔ̀w

1SG CL-become.FUT-CAUS boy-ACC snake

‘I will make the boy become snake.’ TK05312019-YH

In particular, in (6b), the second [u] in the verb *gw-ùl̪l̪ò̰ð-ní* has a lax quality that its F2 value is around 1450 Hz. Thus, the low vowel [ɔ] can raise to both the high vowel [u] and an allophonic [ʊ], especially in a closed syllable.

The low front vowel /ɛ/ also provides substantial evidence for the vowel harmony process, as seen in verbs ‘go’, ‘wipe’, ‘dance’, ‘hit lightly’, and ‘finish’ with causative suffixation. Note that, without the presence of the *-ni* suffix, /ɛ/ in *kẃ-n̪-**é**l̪**è*** ‘He goes’ raises to [i] in *gw-n̪-**í**l̪**ì*** (8b), while the same vowel in other verbs raises to [ɪ] with the presence of *-ni*. The vowel /ɛ/ raises to might depend on whether the syllable is open or closed, as (9-12) show that [ɪ] occurs in closed syllables while [i] occurs in an open syllable in (8).

ɛ raises to **i/ɪ**:

(8) a. kẃ-n̪-**é**l̪**è** TK02152019SCYHAR-2

CL.3SG-HAB-go

‘He goes.’

b. ɲú gw-n̪-**í**l̪**ì** TK05102019-YH

1SG CL.3SG-HAB-go.CAUS

‘I make him (sb.) go.’

(9) a. kwɔ̀-m-**pè**rn̪**é** t̪ɪɗà-ŋ-ɔ̀l̪ɔ̀ TK04242019-9

CL.3SG-REC-wipe surface-ACC-on

‘He has just wiped the surface.’

b. kẁ-n̪ɪ-**βɪ**rn̪**í**n-*ní* ƭɔ̀ŋɔ́r-ɔ́ t̪ɪɗà-ŋ-ɔ̀l̪ɔ̀ TK05312019-3

CL.3SG-HAB-wipe-CAUS boy-ACC surface-ACC-on

‘He makes the boy wipe the surface.’

(10) a. kw-**è**rn̪**ɪ̀** TK05102019-YH

CL.3SG-dance.FUT

‘He will dance.’

b. ɲí gw-n̪-**ɪ**rn̪**í**n-*ní* ɲɔ̀ŋɔ́r-à TK05312019-YH

1SG CL-HAB-dance-CAUS boy.PL-ACC

‘I make boys dance.’

(11) a. kw-**è**rn̪**è** TK05102019-YH

CL.3SG-hit lightly.FUT

‘He will hit lightly.’

b. kẁ-ʈ-**ɪ́rɪ̱ʈɪ́**n-*ní* ʈɔ̀ŋɔ́r-á gwòr-ò

CL.3SG-HAB-hit lightly-CAUS boy-ACC man-ACC

‘He makes the boy hit the man lightly.’ TK06072019-YH

(12) a. kw-**ɛ́rnɛ́** ʈ̱ù⌊-ì ŋèrpò TK05242019-6:14:37.5

CL.3SG-finish.FUT porridge-ACC tomorrow

‘He will finish porridge tomorrow.’

b. kwù-ʈ-**ɪ́rnɪ́**n-*ní* ʈɔ̀ŋɔ́r-á ʈ̱ù⌊-ì TK05312019-3

CL.3SG-HAB-finish-CAUS boy-ACC porridge-ACC

‘He makes the boy finish porridge.’

Next, I show examples which indicate no change in vowel quality for [ɪ] and [ɐ] under causative constructions.

ɪ does not raise to a higher vowel like [i]:

(13) a. ɲí gw-ʈ-ém**ɻ̩ɻ̩**í ʈòr-ó ʈ̱ò-ŋ-**undɪ̀rɪ̀**

1SG CL-HAB-make child-ACC INF-3SG-sleep

TK03082019SCARYH-3

b. ɲí gw-ʈ-**índɪ́rɪ́** ʈòr-ò

1SG CL-HAB-sleep.CAUS child-ACC

TK03082019-6

‘I make the child sleep.’

In contrary to what Quint (2009: P37) has documented that the verb sleep [ìndìrí] (èntèré) changes to [ìndɪrí] in causatives, we did not see changes of vowel quality comparing the sentences in (13). This supports the argument that [ɪ] is a high vowel, instead of a non-high vowel [e]. However, another possible explanation for the absence of the raising of [ɪ] could be that in this synthetic causative construction, the causative suffix *-ni* is not present to trigger raising.

Likewise, [ɐ] does not exhibit height changes in that it already patterns as a high vowel in the corresponding vowel harmony set.

ɐ does not raise to higher vowels such as the phonetic vowel [ə]:

(14) a. kẃ-**wɐ́** ŋɪ̀ɗà ŋèrpò TK06052019-YC:10:39.3

CL.3SG-milk cow tomorrow

‘He will milk cow tomorrow.’

b.	ɲí	gw-**wɛ̀**ðɪn-*ní*	ʈɔ̀ŋɔ́r-à	ŋɪ̀ɖà	TK05312019-YH
	1SG	CL-milk.FUT-CAUS	boy-ACC	cow	

'I will make the boy milk the cow.'

3.3 Possessives

Another potential case for vowel harmony processes is possessive construction. To briefly mention, several kinship terms with possessive suffixes show variation in vowels depending on the person marker, *ɲi* 'I' with a high vowel and *ŋa* 'you' with a low vowel.

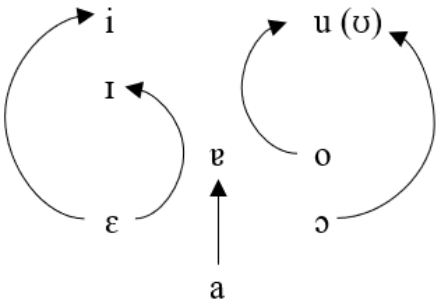
ʈ̪**í**rɪɲ-îr	'my father'	TK02012019-6:07:20.9
ʈ̪**á**rəɲ-â|ò	'your.SG father'	TK03152019NDYC-1:05:38.4
m**ɛ́**ðiɣɛ́ɾ-ì	'my close friend'	TK05172019-3:14:32.0
m**á**ðɪɣ-á|ò	'your.SG close friend'	TK05172019-4
ɛ́ŋgɛ́ɾ-ì	'my sibling'	TK05242019-YH
áŋg-á|ù	'your.SG sibling'	TK05242019-YH

Most of the alternations happen among [a, ɐ, ɛ or ɪ], which corroborates the findings from the above sections on raising patterns triggered by the causative marker. For example, in [ʈ̪**í**rəɲîr] 'my father', the first vowel is perceived as [ɛ] while the acoustics suggest it be a higher vowel with an F1 of 380 Hz and F2 of 2050 Hz.

4. Height harmony vs. ATR harmony

Gathering from the data and analyses from the above sections, the current vowel system with raising patterns are illustrated in the diagram in Figure 6.

Figure 6. Vowel raising patterns in Rere



With an eight-vowel system, we see both within- and cross-ATR and height raising patterns happening in four low vowels /ɛ, a, o, ɔ/. It is thus difficult to attribute the type of harmony system in Rere to a single driving feature: height or ATR contrast. However, the raising schemes shown in (15) suggests that, in accordance with Quint (2009), Rere displays more of a height harmony rather than ATR harmony, which is not very common in Kordofanian languages (but see Moro for a height harmony system; Richart & Rose, 2017). Specifically, the agreement on ATR features is not strictly regulated, the trigger is always a high vowel /i/ or [ɪ] after centralization in causatives, or a schwa-like vowel in passives. The [-ATR] vowels (i.e., if the transcription conveys ATR quality) do not always

raise to [+ATR], but are allowed to raise to higher [-ATR] vowels. Particularly, in the causative constructions at least, in closed syllables, /ɛ/ and /ɔ/ becomes /ɪ/ and /ʊ/ whereas in open syllables, they become /i/ and /u/, respectively, and /o/ goes to /u/ regardless of syllable type.

(15) o → u / __ i (ɪ) ə

ɛ ɔ → i, ɪ u, ʊ / __ i (ɪ) ə

a → ɐ / __ i

Despite the harmony process triggered by causatives, passives, etc., words can contain vowels of different height or of different ATR features, as seen in the instrumental construction. In general, there does not seem to be a pervasive vowel agreement pattern in terms of height or ATR throughout Rere, unlike the other studied Kordofanian languages so far (e.g., Tima, Moro, Laru, Dagik, Acheron, Tocho, Lumun, with more details below).

To summarize, the present paper proposes an asymmetry vowel system between front and back vowels given the patterning of [ɪ] following the other high front vowel [i] and the evidence from vowel raising processes. The nature of the raising patterns needs to be further investigated from more speakers and data. For example, /o/→[u] would be height harmony, but /a/→[ɐ] could be height or ATR or both. /i/→[ɪ] would be triggered by ATR, but the conditioning vowels could be due to height. /ɛ ɔ/→[i u] agrees on both height and ATR, but /ɛ ɔ/→[ɪ ʊ] seems to agree on height only, except that it is conditioned by syllable structure.

5. Typological implications

Considering Rere as having a mixed or ambiguous height and ATR vowel system, its resemblance and differences in comparison to other vowel systems in neighbor languages are discussed in this section.

First, the eight-vowel system in Rere resembles but does not completely accord with the 1IU system discussed in Casali (2017) with seven vowels containing [e, o], which is typically seen in West African languages. Given that disharmonic sequences of ATR vowels, being one of the properties of the 1IU system, are allowed in Rere, a frequency analysis of the distribution of [+ATR] and [-ATR] vowels might give insights to the inventory restrictions of vowels with regards to ATR features.

Second, neighbor languages such as Laru (Abdalla Kuku, 2012), another Heiban language, and other Talodi languages including Dagik (Vanderelst, 2016), Acheron (Norton, 2013), Tocho (Alaki & Norton, 2013), and Lumun (Smits, 2017) also have an eight-vowel inventory. They all differ from Rere mainly in that they have a symmetric vowel system /i, ɪ, u, ʊ, ɛ, ɔ, ə, a/ and exhibit a dominant [+ATR] harmony. Though, Laru has the same raising as Rere of /ɛ ɔ/ to [i u] respectively, but the Talodi languages would raise to their mid allophones [e o]. Also, for Lumun, it was noted in Smits (2017) that the ATR contrasts were only seen in the high vowels with weak or even absent harmonic effects, which only remained clear in minimal pairs, suggesting a retreated ATR-factor. Rere is similar in this sense, for example, when articulating [kwîː] ‘he will drink’ versus [kwîː] ‘he will wash’, the high vowel contrasts were most obvious.

Last, the state of Rere vowel quality is not always steady, especially in high front vowels, for example, [i̱î] ‘arm’ is sometimes pronounced as [i̱î], [kîːɾù] ‘small antelope’ as [kîːɾù], to name a few. This calls attention to the status of language sustainability and preservation, as brought up for Tabaq (Hellwig & Schneider-Blum, 2014). Tabaq, another Nuba Mountain language, has substantial language contact with Arabic. The vowel system in that language was particularly hard to capture, which shares aspects with Rere. For instance, the short vowel phonemes are subject to centralization, and the same word produced by the same speaker at different occasions could induce differences in acoustics and perception. In addition, Tabaq shows an inconclusive vowel harmony for a short unstressed suffix *-i̱u/ -i̱ʊ*, which is comparable to the instrumental suffix *-ki/ -kɪ* in Rere. Nonetheless, the difference is that Hellwig and Schneider-Blum assumed that the assimilations in vowel height were ad-hoc or local phenomena instead of remnants of an earlier vowel harmony system in Tabaq, while the vowel raising process seems to be stronger in Rere, which I would treat more as a disrupted vowel harmony system.

The data so far might suggest that Rere underwent a significant loss in vowel harmony system rooted from the language contact with Arabi, since Quint insisted that the harmony pattern is pervasive even in loanwords with the same dialect as our speaker. It might be the diachronic reason that we still see some agreements on ATR features in some words, and overall, height agreement is more prominent than ATR harmony.

6. Conclusion

In this paper, I depict the current eight-vowel inventory in Rere and show that the vowel system might be a mixed one – height and ATR systems co-exist with the influence of syllable structure. Two main grammatical processes, noun suffixation with the instrumental case and verbal suffixation with causatives, are discussed with regards to the vowel raising pattern: /ɛ, a, o, ɔ/ → [i, ɪ, ɐ, u, (ʊ)], which has been shown to be more consistent with the features of height harmony.

Further, future work could look closely into the impact of the syllable structure on the production of raised mid vowels and the implications of an alternative transcription ([ɪ] as [e], or [o] as [ʊ]). In addition, we should examine articulatory differences, in reference to the acoustic differences, such as the tongue root retraction, tongue height grooving, and/or constriction of the glottis for voice quality correlates (Starwalt, 2008) for the ATR contrasts in high vowels. Moreover, apart from the low central vowel /ɐ/, phonetically induced schwas were abundant in Rere. Yet the realizations of schwa have not be investigated thoroughly. Future studies could probe this interesting case and investigate its relation to potential vowel assimilation processes.

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Appendix

Representative word list for vowel acoustics

(All the examples used in the paper can be searched and accessed at http://rere.ucsd.edu/)

File	Time	Word	Vowel	F1	F2	F3	IPA
TK01112019-2	598.7818	place of gathering	ɐ	542.50	1612.63	2885.87	èḿərɐ̀
TK01112019-2	599.0821	place of gathering	ɐ	539.22	1610.52	2640.64	èḿərɐ̀
TK04262019-YH1	82.84192	knife	ɐ	538.33	1909.28	2559.49	kɐ́ŋʤɐ̀ŋ
TK04262019-YH1	79.98855	sheath	ɐ	505.47	1844.08	2356.40	kɐ̂l̩
TK04262019-YH1	786.6297	with the lie	ɐ	426.78	1856.35	2154.33	ŋ̀ɐ̀l̩úŋ̀
TK04192019YHSC-2	1240.59	liar	ɐ	445.29	1235.86	2594.94	kwɐ̀l̩ùŋ
TK02082019-1	31.88758	body	ɐ	502.66	1418.02	2557.57	áŋgnà
TK02082019-1	32.0934	body	ɐ	606.60	1637.08	2506.46	áŋgnà
TK02082019-1	34.38117	body	ɐ	480.10	1588.05	2389.88	áŋgnà
TK04262019-YH1	149.9966	seed-hole	ɪ	397.19	2236.46	2862.12	kî l̩
TK04262019-YH1	157.6662	seed of gourd	ɪ	368.48	2329.55	3016.24	l̩ì:ɾì
TK04262019-YH1	157.8728	seed of gourd	ɪ	321.09	2272.09	2910.68	l̩ì:ɾì
TK02012019-6	125.4795	girl	ɪ	360.84	2353.52	3047.55	ʈ̄:ɾā
TK02012019-6	280.9023	girls	ɪ	356.30	2270.92	3178.12	ɲì:ɾà
TK05102019-YH	1041.897	girl	ɪ	355.14	2248.38	2853.53	ʈ̄:ɾā
TK02082019-1	178.6375	arm	ɪ	373.95	2340.49	3220.97	ʈ̪î
TK05102019-YH	2367.609	arm	i	332.69	2409.21	3080.12	ʈ̪î
TK04262019-YH1	1402.284	termite	ɪ	371.42	2309.61	3268.79	l̩ì:l̩ì
TK02082019-7	890.3145	to come	ɪ	351.94	1625.58	2751.31	î:là
TK05102019-YH	1033.062	to come	ɪ	347.52	2315.09	3102.45	ʈ̪ì:l̩à
TK05012019-1	222.1121	to dance	ɪ	394.68	2151.90	2811.66	ʈ̪ìrʈ̪ì
TK04192019YHSC-2	507.8139	lower back	ɪ	381.21	2397.92	2983.28	kì:ɾìɲ
TK04192019YHSC-2	507.9422	lower back	ɪ	408.26	2162.81	2881.44	kì:ɾìɲ
TK04192019YHSC-2	596.2154	lower back	ɪ	375.59	2253.44	2932.54	kì:ɾìɲ
TK04192019YHSC-2	596.324	lower back	ɪ	428.58	2214.14	2735.20	kì:ɾìɲ
TK02062019-7	23.13857	kill	ɪ	369.73	2219.16	2980.48	ʈ́éɲì
TK02082019-2	549.7996	day (short)	ɪ	372.78	2026.41	2817.46	ʈá:mìn
TK05102019-YH	2404.146	be cold	ɛ	440.08	2125.77	2705.47	ðɛ̂
TK04122019YHSC-2	291.6554	sky	ɛ	498.17	1962.04	2854.94	l̩é:ɾè
TK04122019YHSC-2	291.7978	sky	ɛ	489.10	1833.28	2696.22	l̩é:ɾè
TK02082019NKJGQX-3	600.8187	one	ɛ	497.09	1726.61	2535.54	kwɛ́ʈ̀ɛ
TK02082019NKJGQX-3	601.0646	one	ɛ	448.60	2184.04	2949.30	kwɛ́ʈ̀ɛ
TK05102019-YH	2889.276	go	ɛ	507.30	2164.75	3172.16	ɛ̂lɛ̀
TK04172019-5	207.4319	be strong	ɛ	545.42	1965.04	2664.64	pɛ́rl̩ɛ̀
TK04172019-5	275.8844	feel better	ɛ	530.82	1839.98	2684.26	pɛ́rl̩ɛ̀

TK20190308SCARYH-3	1042.332	wipe	ɛ	433.89	2023.76	2812.16	pɛ́ɾʈ̪ɛ̀
TK05312019-YH	1303.424	finish!	ɛ	504.58	2085.14	2563.16	ɛ̀rnà
TK05312019-YH	344.8783	hit lightly	ɛ	523.34	1989.15	2732.68	ɛ́ɾʈ̪ɛ̀
TK05312019-YH	345.1533	hit lightly	ɛ	449.09	2096.63	2825.83	ɛ́ɾʈ̪ɛ̀
TK02202019-5	721.478	bowl	ɛ	513.01	2072.46	3016.89	l̩ɛ̀ːɖɛ̀r
TK02202019-5	721.6327	bowl	ɛ	562.24	1930.61	2660.06	l̩ɛ̀ːɖɛ̀r
TK02202019-5	846.6232	bowls	ɛ	502.01	1894.03	2559.93	ŋwɛ̀ːɖɛ̀r
TK01162019-2	27.37836	clouds	ɛ	538.04	2121.05	2835.88	ŋwʌ̄blɛ̄ʈ̪̄
TK02062019-7	22.93472	kill	ɛ	483.49	2235.63	3005.37	ɽɛ́ɲì
TK05312019-YH	335.8302	dance	ɛ	435.24	1977.83	2663.80	ɛ̀ɾʈ̪ì
TK05312019-YH	354.6539	dance	ɛ	417.25	2142.24	2758.48	ɛ̀ɾʈ̪ì
TK20190308SCARYH-3	460.6662	be clean	o	384.62	944.84	2542.55	ɕóːɾì
TK20190308SCARYH-3	16.70938	be dry	o	401.43	1071.92	2608.28	óɳɖì
TK02012019-6	24.45517	star	o	404.41	906.87	2236.87	ʈ̪ōːrōm
TK02012019-6	24.57553	star	o	424.12	755.85	2137.84	ʈ̪ōːrōm
TK02152019-8	12.29974	child	o	449.19	909.62	2472.54	ʈôr
TK01252019-11	36.65192	man	o	431.73	770.98	2422.21	kwôr
TK01252019-11	162.8627	men	o	470.06	926.53	2268.17	lôr
TK01252019-12	214.3865	fish	o	440.33	1029.93	2586.43	l̩óm
TK04102019-7	887.9792	hole in the tree	o	513.27	891.07	2692.80	l̩ùbòŋ
TK02152019NDYC-1	1.427	elephant	o	485.54	936.31	2715.77	ʈ̪óŋôr
TK02152019NDYC-1	1.61	elephant	o	417.42	853.46	2320.26	ʈ̪óŋôr
TK04122019YHSC-2	694.2282	rich person	o	437.32	841.36	2249.44	kwórtò
TK04122019YHSC-2	694.4353	rich person	o	407.61	1056.22	2642.01	kwórtò
TK04122019YHSC-2	707.7859	rich person	o	425.07	820.59	2331.18	kwórtò
TK04122019YHSC-2	707.9936	rich person	o	436.16	1005.20	2642.41	kwórtò
TK04122019YHSC-2	821.0896	group	o	415.50	1085.75	2498.19	dɔ̀ŋ
TK04122019YHSC-2	616.4474	government	u	359.01	1003.71	2596.89	ʈ̪úrùm
TK04122019YHSC-2	616.5784	government	u	355.22	895.20	2476.52	ʈ̪úrùm
TK04192019YHSC-2	402.2606	manure	u	346.35	994.66	2700.18	l̩ùr
TK02152019-8	656.4434	silo	u	375.62	929.26	2507.29	ʈ̪úl̩ùŋ
TK02152019-8	656.6417	silo	u	369.47	1018.80	2538.95	ʈ̪úl̩ùŋ
TK04102019-7	887.1315	hole in ground	u	324.14	760.42	2615.82	l̩ùbùŋ
TK01162019-2	408.3005	smoke	u	307.55	722.39	2622.59	kûːl̩ù
TK01162019-2	408.4941	smoke	u	365.36	919.43	2197.12	kûːl̩ù
TK01162019-2	558.1246	much smoke	u	317.93	777.60	2242.40	kúːl̩ù kûːɾù
TK01162019-2	558.3769	much smoke	u	310.80	777.53	2305.24	kúːl̩ù kûːɾù
TK01162019-2	558.5039	much smoke	u	343.56	523.20	2215.43	kúːl̩ù kûːɾù
TK04172019-6	461.8472	money	u	364.96	888.94	2442.86	gúɾùʃ

TK02152019-8	17.85147	hammer	ɔ	572.95	1115.55	2465.84	ʈôr
TK04262019-YH1	1069.916	with cup	ɔ	536.51	1103.56	2272.18	ʈɔ̀ːɲɛ́rì
TK02012019-6	21.70087	boy	ɔ	546.30	1080.35	2212.47	ʈɔ́ŋɔ̀r
TK02012019-6	21.90352	boy	ɔ	525.31	915.05	2121.98	ʈɔ́ŋɔ̀r
TK04122019YHSC-2	546.8487	beetle 1	ɔ	569.86	1157.85	2366.67	ɭɔ́rɭɔ́ɭɔ̀
TK04122019YHSC-2	547.5294	beetle 1	ɔ	558.15	1097.63	2868.95	ɭɔ́rɭɔ́ɭɔ̀
TK04122019YHSC-2	550.0286	beetle 1	ɔ	544.99	1192.23	2631.05	ɭɔ́rɭɔ́ɭɔ̀
TK04122019YHSC-2	551.4852	beetle 1	ɔ	605.38	1203.23	2891.92	ɭɔ́rɭɔ́ɭɔ̀
TK04122019YHSC-2	552.2872	beetle 1	ɔ	587.87	1050.26	2467.03	ɭɔ́rɭɔ́ɭɔ̀
TK04122019YHSC-2	657.9938	blacksmith	ɔ	537.80	979.22	2359.84	kwɔ́rtɔ̀
TK02082019NKJGQX-3	604.3284	three	ɔ	529.81	938.08	2391.32	ʈɔ́ːɽɔ̀ɭ
TK04192019YHSC-2	318.6932	vocal tract	ɔ	551.44	851.72	2279.99	kwɔ́ːrɔ̀
TK04172019-5	28.3674	become	ɔ	545.20	874.59	2292.89	ɔ́ɾɔ̀
TK04172019-5	49.32752	become	ɔ	591.90	912.17	2640.50	ɔ́ɾɔ̀
TK04122019YHSC-2	761.2023	back of skull	ɔ	547.39	1028.42	2488.97	dɔ̃ŋ
TK04122019YHSC-2	867.9733	beetle 2	ɔ	545.13	1057.77	2553.14	ɭɔ̀mnɔ́kɔ̀
TK04122019YHSC-2	868.3247	beetle 2	ɔ	493.73	932.88	2542.14	ɭɔ̀mnɔ́kɔ̀
TK02202019-5	1083.372	gourd	ɔ	548.86	711.41	2520.81	ʈɔ́ːɲò
TK02082019-7	890.5209	to come	a	830.90	1910.62	2566.47	îːlà
TK02082019-1	34.16241	body	a	747.37	1474.69	2473.66	áŋgnà
TK02082019-1	96.54102	head	a	750.88	1673.00	2366.24	ɳɖà
TK02012019-6	125.6425	girl	a	762.99	2089.55	2598.32	ʈīːrā
TK02082019-2	142.8639	foot	a	769.30	1551.40	2092.08	káːʏà
TK02082019-2	31.56263	leg	a	841.88	1631.32	2598.63	ɭàːɾà
TK02082019-2	31.72821	leg	a	739.51	1851.85	2569.85	ɭàːɾà
TK02082019-2	353.1068	finger	a	704.49	1633.13	2185.43	ɭáːmìn
TK02082019-2	272.285	finger	a	846.85	1667.03	2461.74	ɭáːmìn
TK02082019-2	353.4199	finger	a	702.88	1681.21	2725.73	ɭáːmìn
TK02082019-2	549.6058	day (short)	a	759.03	1744.38	2527.67	ʈáːmìn
TK02222019-4	57.33018	cook	a	538.26	1451.32	2550.30	máːnì
TK03062019-1	372.297	meat	i	321.37	2371.55	2999.95	jíːðì
TK03062019-1	372.464	meat	i	265.46	2315.29	2897.44	jíːðì
TK04192019YHSC-2	468.8137	warthog	i	301.06	2357.34	2462.10	kìːɾìɲ
TK04192019YHSC-2	468.9486	warthog	i	301.57	2224.04	2925.84	kìːɾìɲ
TK01162019-6	444.171	drink	i	277.85	2435.63	3267.88	îː
TK05032019-4	1.38849	rabbit	i	303.53	2400.55	3209.52	ʈíɲì
TK05032019-4	26.5549	rabbits	i	319.56	2325.07	3062.60	ɲíɲì
TK03152019-YH1	406.6002	hit	i	293.68	2316.45	2990.98	pî
TK03152019-YH1	435.8942	fly	i	274.44	2517.08	3160.95	dǐːʈî
TK03152019-YH1	437.7274	fly	i	286.15	2361.03	3103.54	dǐːʈî
TK05032019-4	694.8993	catch	i	260.72	2478.75	3189.06	íːðì
TK02082019-2	885.7431	thumb (ox)	i	330.12	2275.51	2657.18	ɲíðɾì