Papers in Historical Phonology
http://journals.ed.ac.uk/pihph
ISSN 2399-6714
Volume 6, 107–146 (2021)
DOI: 10.2218/pihph.6.2021.6693

The emergence of interior vowels and heterosyllabic vowel sequences in Ngwi (Bantu B861, DRC)

SARA PACCHIAROTTI
Ghent University

LORENZO MASELLI
Ghent University

KOEN BOSTOEN
Ghent University

Abstract

In this article, we offer a historical account of the development of two phonemic 'interior' vowels, [ə] and [ɤ], and heterosyllabic vowel sequences in Ngwi, a virtually undescribed West-Coastal Bantu language spoken in the western part of the Democratic Republic of the Congo. While interior vowels phonologized due to the loss of their conditioning environment, most heterosyllabic vowel sequences come from the fission of an erstwhile palatal on-glide diphthong, itself originating in a long [–high] vowel. This origin is exactly the opposite of what has been reported for other language families such as Romance, where certain heterosyllabic vowel sequences of the *iV type evolved into diphthongs. The Ngwi data also show that phonemic interior vowels exist in languages of the Niger-Congo phylum where they had not been reported before. The historical development of heterosyllabic vowel sequences in Ngwi might have parallels in several other Bantu languages from the wider Congo rainforest area, where phonetic and phonological documentation is still embryonic.

1 Introduction

Ngwi [nlo] (a.k.a. Engwíí, Ngwí, Ngul, Nguli, Ngoli, Kingoli) is a West-Coastal Bantu (WCB) language spoken south of the Lower Kasai River (-4.15, 19.08) in the Kwilu Province of the Democratic Republic of the Congo (DRC) (Hammarström 2019, 27; Pacchiarotti et al. 2019, 209). In the updated version of Guthrie's referential classification, Ngwi is inventoried as B861 (Maho 2009). The main objective of this paper is to provide a historically informed account of the emergence of the synchronic vowel system of Ngwi with a special focus on interior vowels and

disyllabic vowel sequences. This is of interest for several reasons. First, the area of the DRC where Ngwi is spoken, the southern Congo Basin, is among the least well-documented linguistic regions of the world (Hammarstrom 2016), and dedicated phonetic/phonological studies are rare (see also Grégoire 2003, 351). In-depth research on the phonetics and phonology of languages such as Ngwi is therefore of great relevance for linguistic inquiry more generally.

Second, more specifically, Ngwi and other languages of the region such as Lwel B862 (Khang Levy 1979), Ding B86 (Mula 1977; Ebalantshim 1980), Yans B85 (Swartenbroeckx 1948; Rottland 1977), Nsambaan B85F (Mfum-Ekong 1979), and Nsong B85d (Koni Muluwa & Bostoen 2019) display phonemic 'interior vowels', that is, non-peripheral vowels located in the interior portion of the vowel space such as [ɨ], [ɯ], [ɜ] [ə] [ɤ], [ø], etc. (Rolle et al. 2017, 100). While interior vowels appear to be common in African languages of the so-called Macro-Sudan Belt, a stretch of land spanning contiguously from the western end of the landmass to the Ethiopian escarpment in the east (Clements & Rialland 2008; Güldemann 2008), recent phonological surveys report them as absent south of this area, including the region of the DRC where Ngwi is spoken (Rolle et al. 2017, 101). In this paper, we provide evidence for the existence of phonemic interior vowels in this understudied area.

Third, a remarkable though poorly understood phonological feature of Bantu languages spoken in or near the Congo rainforest, such as Ngwi, is their extreme tolerance for disyllabic vowel sequences (Grégoire 2003, 352). Besides the creation of phonemic interior vowels, this paper focuses on the origin of heterosyllabic /ɛ.a/ and /i.a/ vowel sequences in Ngwi and thus contributes to the understanding of this understudied phenomenon in western Bantu languages spoken in and around the Congo rainforest. We show that /ɛ.a/ and /i.a/ sequences originate in the consolidation of an erstwhile palatal on-glide diphthong *ya* resulting from the breaking of [aː]. Through language-internal reconstruction, we demonstrate that the natural class of [–high] vowels, which emerged after the restructuring of the seven-vowel system of the protolanguage into a five-vowel system, played a crucial role in the creation of both phonemic interior vowels and heterosyllabic vowel sequences.

In line with its objectives, this paper is organized as follows. In section 2, we give a brief overview of the suprasegmental and phonotactic features of Ngwi which are immediately relevant to the developments discussed in the reminder of this paper. In section 3, we present the synchronic vowel system along with a first exploration of its acoustic vowel space. In section 4, we discuss the innovations which led to the synchronic vowel phonemes and the widespread presence of disyllabic vowel sequences in the language. Specifically, in section 4.1 we show that

the inherited Proto-Bantu seven vowel system was reduced to five vowels. In section 4.2, we outline the historical conditionings for the development of allophonic interior vowels which eventually phonologized, and assess the phonetic groundedness of these phonological changes from a Dispersion Theory perspective. In section 4.3 and subsections therein, we deal with the historical origins of disyllabic /ɛ.a/ and /i.a/ vowel sequences. In section 4.4, we briefly discuss the origins of disyllabic vowel sequences other than /ɛ.a/ and /i.a/. Conclusions are in section 5.

Throughout the paper, we use a phonetically driven transcription of Ngwi based on the International Phonetic Alphabet (IPA), with the exception of <y>, which we use for IPA [j]. In the Africanist tradition, <j> is often used as a grapheme to represent IPA [dʒ]. We note high tone as <á>, low tone as <à>, falling tone as <â>, and rising tone as <ǎ>. Throughout the paper, <.> indicates a syllable break, → means 'surfaces phonetically as', > means historically evolved into, < historically derived from, * introduces a protoform, and ** indicates a phonologically infelicitous form. This phonological account relies on a database of over a thousand lexical entries.

2 (Supra)segmental and phonotactic features of Ngwi

According to the latest and most comprehensive lexicon-based phylogeny of WCB (Pacchiarotti et al. 2019), Ngwi B861 is among the first paraphyletic offshoots of the WCB ancestral node together with Ding B86, Lwel B862, and Nzadi B865, as shown in Map 1. All of these varieties are spoken in the putative WCB homeland area.

Boone (1973, 243–245) identifies two groups of Ngwi speakers separated by and interspersed with intervening Lwel B862, Ding B86 and Nzadi B865 language communities. These are called Western and Eastern Ngwi (see also Maalu-Bungi et al. 2011, 18). This paper focuses on the vowel system of the Eastern variety of Ngwi as spoken in Mangai (-4.02, 19.53), a small town situated on the left bank of the Kasai River; see location of B861 on Map 1. Theses of Congolese students containing phonological data and reported in the literature could no longer be located by us (Bwantsa Kafungu 1966; Obey 1984). The two morphophonological description of the western variety of Ngwi available to us, i.e. Bwantsa Kafungu (1979) and Kumpel Wossey (2001), suggest that there are remarkable differences between the two regiolectal varieties, certainly with respect to phonology. Data for this paper were collected during a one-month fieldwork mission (August–September 2019) within the BantuFirst project (https: https://www.bantufirst.ugent.be/) in Idiofa (-4.96, 19.59), where the first and last authors worked with two native Ngwi speakers originally from Mangai: Mr. Frédéric Mbeam-Oyuu Empenge Itobola (our main consultant) and Mr. Marako Wosama Ejem.

From Belgium, the first author subsequently crosschecked transcribed data and collected additional data in close collaboration with the main consultant. The exact number of Ngwi speakers today is unknown, but is definitely not higher than 10,000, and the language is certainly threatened by lingua francas such as Kongo ya Leta and Lingala.[1] Children born from parents speaking different WCB 'minority' languages, such as Ngwi and Ding, are taught mainly Kongo ya Leta and only a few words in the languages of their parents.

The eastern variety of Ngwi documented here has 37 consonantal phonemes: /p, b, t, d, k, m, n, ɲ, ŋ, f, v, s, ʃ, ʒ, ʁ, pf, ts, dz, tʃ, dʒ, mp, mb, nt, nd, ŋk, ŋg, mf, mv, mpf, nts, ndz, ntʃ, ndʒ, r, w, y, l/. Pre-nasalized plosives, fricatives and affricates only occur at the beginning of noun roots and are the outcome of the historical reanalysis of Proto-Bantu (PB) class (CL)9/10 *N-/*N- homorganic nasal prefixes as part of the simple noun stem, e.g. Ø-*ŋkwɔ̌n* 'crocodile(s)' < BLR 1446 *N-gòndé.[2] The word-internal distribution of consonants is phonotactically restricted: while all consonants except /ʁ/ and /r/ can appear in word- and/or syllable-initial position, only /m/, /n/, /ɲ/, /ŋ/, /r/, /ʁ/, /y/ and /b/ are attested in word- and/or syllable-final position. This left-to-right asymmetry in the occurrence of consonants within the stem is a common phenomenon in the northwestern part of the Bantu-speaking area (Hyman 2008, 331).[3] This asymmetry might be directly related to the fact that stem-initial position is a position of phonetic and phonological prominence not only in other West-Coastal Bantu varieties (cf. Paulian 1975 for the Teke variety Kukuya), but also in other northwestern Bantu languages and Niger-Congo languages further north and west (cf. Van de Velde & Idiatov 2016; Lionnet & Hyman 2018, 651–655; Hyman et al. 2019, 196–199 and references therein).

Ngwi tone has a considerable functional load (King 1967; Wang 1967; Surendran & Niyogi 2006; Oh et al. 2013). There are two primary tones or tonemes: High (H) and Low (L), which can combine to form R(ising) and F(alling) contour tones.[4] These four tonemes are lexically contrastive as

---

[1] According to Niendéka & Djedje (1986, 42), the so-called "groupement Bangoli" of Oveke, the administrative territory uniting the Ngwi people, counted 8,401 inhabitants in the 1980s. However, not all people who identify ethnically as being Ngwi still speak the Ngwi language.

[2] BLR stands for Bantu Lexical Reconstructions 2/3, a database with approximately 10,000 Bantu reconstructed forms with various time depths (not all go back to PB) (Coupez et al. 1998; Bastin et al. 2002; Bostoen & Bastin 2016), see also section 4.

[3] The Bantu northwestern area includes Cameroon, Gabon, the Republic of the Congo, and parts of the DRC.

[4] Synchronically, sequences of LH and HL are always realized on two successive vowels belonging to different syllables. R and F occur only in closed syllables and they historically result from the loss of a word-final vowel whose tone was maintained and realized on the immediately preceding vowel, e.g., BLR 3749 *kúmà 'python' > Ngwi

shown by the following minimal pairs and triplets elicited in isolation. Attested contrastive tone patterns are illustrated for mono- (1), di- (2), and trisyllabic words (3).

(1)

H	**F**
ŋkúm 'chief(s)'	*ŋkûm* 'python(s)'
R	**F**
wŭm 'theft'	*wûm* 'husband'
R	**H**
kăβ 'share'	*káβ* 'tell'
L	**F**
wìɲ 'arrow'	*wîɲ* 'handle'

(2)

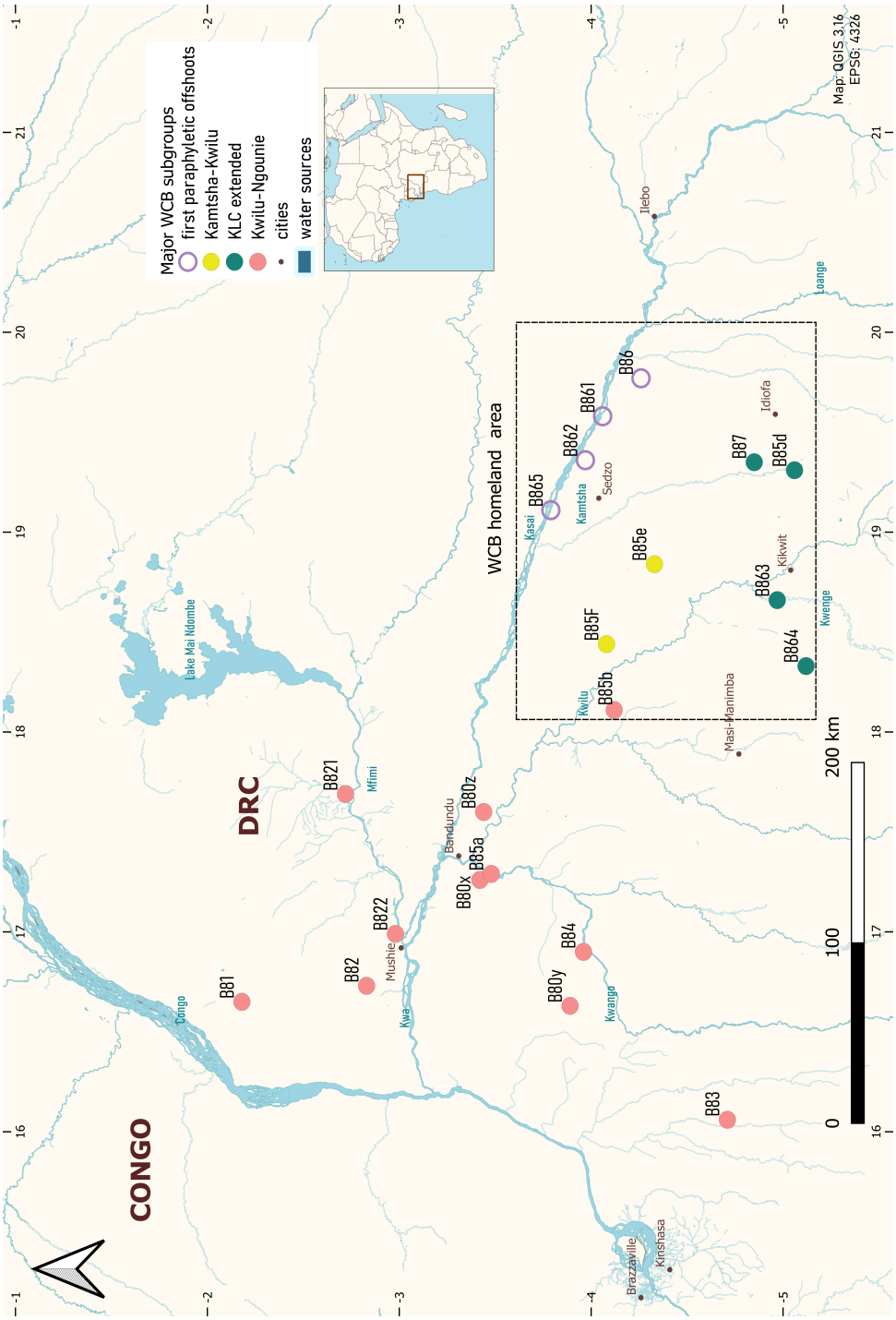
HH	**LH**
kámá 'bite, sting'	*kàmá* 'steal'
LL	**LF**
ìtsùʁ 'chicken coop'	*ìtsûʁ* 'banana bunches'
LF	**LR**
ìkɔ̂m 'broom'	*ìkɔ̆m* '*Myrianthus arboreus* (fruit)'
LL	
ìkɔ̀m 'flaws'	
LH	**LF**
ìtsɤ́ʁ 'orphans'	*ìtsɤ̂ʁ* 'story, proverb'
LH	**LR**
òkúr 'fufu'	*òkŭr* 'cob'
LH	**HL**
vìí 'bones'	*víî* 'problems'

(3)

LLH	**LHL**	
àvɛ̀ár 'wives'	*àvɛ́àr* 'people'	
LLH	**HHH**	
kɛ̀àrá 'give back'	*kɛ́árá* 'crawl'	
LHH	**LLH**	
èsúú 'safou fruit'[5]	*èsúù* 'earth worm, bait'	
LLH	**LHL**	**LHH**
èkùó 'sunset'	*èkúò* 'tribes'	*èkúó* 'umbilical cords'

ŋkûm. Unlike level tones, contour tones involve phonetic lengthening of the host vowel. Ngwi does not have phonemic vowel length.

[5] The scientific name of the *safou* tree, a.k.a the African plum, is *Dacryodes edulis*.



Map 1: Approximate location of Ngwi B861 and other B80 languages

The main tone process at the NP level in Ngwi is rightward H tone spreading. Both H tones and R tones can trigger it within the limits of the noun phrase as shown in (4)–(6).

(4) /ŋkúm è ìkɔ̀lɔ̀ŋɔ̀/→ [ŋkúm Ø íkɔ́lɔ́ŋɔ́] 'praying mantis' (lit: chief of the spider)[6]

(5) /ètɛ̀ám ènɛ́/→ [ètɛ̀ám énɛ́] 'this antelope (sp.)'[7]

(6) /mbwɔ̌m ìpə̀/→ [mbwɔ̌m ípə́] 'two noses'

If the last constituent of a NP has a F (or a HL) tone or R (or LH) tone, the spreading H tone cannot change this contour tone pattern into H or HH, as shown in (7)–(11).

(7) /ŋkúm èmə̂ʁ/→ [ŋkúm émə̂ʁ] 'one chief'

(8) /ìsǎŋ ì dzûʁ/ → [ìsǎŋ í dzûʁ] 'trousers' (lit: clothes of upstream)

(9) /kyɛ́ŋ è kúù/ → [kyɛ́n é kúù] 'ankle ring' (lit: bracelet of leg)

(10) /òkɔ̌r ò vân/ → [òkɔ̌r ó vân] 'toothbrush' (lit: rope of teeth)

(11) /ndzɛ̀ám è bùú/ → [ndzɛ̀ám é bùú] 'parent' (lit: god of the earth)

The following are possible syllable shapes in Ngwi: CVC, VC, CV, and V. Due to the diachronic loss of final vowels (Pacchiarotti & Bostoen 2021), CVC is by far the most common. For the purposes of the present paper, however, VC and V are particularly relevant (see the historical discussion in sections 4.3.2 and 4.3.3). VC occurs only word-finally in di- or trisyllabic words. /ɛ/ and /a/ (in this order) are the only two vowels which can appear in CV.VC sequences, as shown in (12). Note that we treat a sequence of a nasal and a consonant as a prenasalized consonant, i.e., as a single consonantal unit.

---

[6] (4) and (8)–(11) are instances of connective constructions where a head noun is modified by another noun usually introduced by a relator called connective, associative or genitive (Van de Velde 2013, 217). In Ngwi, the connective element triggered by the head noun is realized phonetically only if the following noun starts in a consonant.

[7] In the examples here and elsewhere, 'n.' stands for noun, 'v.' for verb, and 'sp.' for species.

(12) (V.)CV.VC

ò.mpɛ́.àm 'man, male'	*è.fɛ́.àŋ* 'tobacco pipes'
ò.ŋkɛ́.àr 'woman'	*à.pɛ́.àʁ* 'coffins'
ò.yɛ̀.áŋ 'lie (n.)'	*è.kɛ̀.ám* 'partridge'
ndzɛ̀.ám 'god(s)'	*kɛ́.àŋ* 'fry (v.)'
mbɛ̀.áŋ 'virgin forest'	*wɛ̀.ár* 'wife'
è.tɛ́.ám 'antelope (sp.)'	*ò.vɛ̀.àm* 'whip (n.)'

V can occur word-initially, medially, or finally after a CV shape, as shown in (13) and (14). In $CV_x.V_y$ words, there are restrictions on the quality of V_x and V_y. If $V_x = V_y$ these two vowels can only be /ɔ/, /u/, or /i/, as shown in (13).

(13) $CV_x.V_y$ $[V_x=V_y]$

à.kì.í 'eggs'[8]	*è.wì.í* 'anthill'
lí.ì 'stream'	*tì.í* 'excrements'
à.tí.ì 'ears'	*ò.bí.ì* 'tuber, ear'
mpɔ́.ɔ̀ 'fetus'	*ndzɔ́.ɔ̀* 'elephant(s)'
è.wú.ù 'white hair'	*è.bù.ú* 'pimple'
è.kú.ù 'leg'	*à.yú.ù* 'hair'

If $V_x \neq V_y$ then V_x must be /u/ or /i/ while V_y can be /i/, /u/, /ɔ/, /ɛ/ or /a/, as in (14). Noun stems with the shape CV.V are considerably more frequent than CV.

(14) $CV_x.V_y$ $[V_x \neq V_y]$

ndʒú.à 'snake(s)'	*mvú.á* 'dog'
ŋkú.ó 'snail, cowry'	*ò.dzú.ò* 'root'
è.ʃù.é 'penis'	*ì.tʃú.é* 'puff adder'
ndzì.à 'hunger'	*mì.á* 'mother'
è.ndí.é 'white men'	*ì.kí.é* 'tobacco, cigarette'
ví.ù 'mushroom(s)'	*ì.dʒí.ù* 'grass, weeds'
à.sú.ì 'saliva'	*fù.í* 'plant (v.)'

Sequences such as /u.a/, /u.o/, /u.e/, /i.a/, and /i.e/ as in (14) coexist in Ngwi with diphthongs, which are found in closed syllables whose last consonant is most commonly a nasal, as shown in (15) — see section 4.3 for further discussion.

[8] /i/ in word-final position, especially in CV.V word shapes, is realized with more constriction than one usually sees in a vowel and may sound almost like a fricative, e.g. /à.kì.í/ 'egg' [à.kĭj].

(15) *ntʃwŏŋ* ‘leech(es)’
àlwêm ‘sperm’
lyâm ‘prepare’
dʒwâʁ ‘swim’
ʃyêm ‘blow (nose)’

Besides the fact that they are tone-bearing units, evidence to treat the vowel sequences in (13) and (14) as sequences of two vowels belonging to two different syllables — rather than analyzing instances such as those in (13) as one long vowel and those in (14) as diphthongs — comes from vowel deletion processes. In Ngwi, sequences of two vowels across morpheme boundaries are reduced to one in fast speech. As shown in (16), where the apostrophe indicates vowel deletion, it is the last vowel of the first linear word which gets deleted.

(16) /ò.mvá òné/ > [ò.mv’ óné] ‘this poor person’
/ntsə̀ ìné/ > [nts’ íné] ‘these fish’
/à.wì àné/ > [à.w’ àné] ‘these stones’

However, in CV.V words, irrespective of whether [V_x=V_y] or [V_x≠V_y], only one of the two vowels in a sequence is deleted, as shown in (17). If the sequence of two vowels in CV.V words had belonged to the same syllable (e.g. CV: or CGV, where G stands for a glide), one would expect the same outcome observed in (16).

(17) a. /èwìí èné/ → [è.wì’ éné] ‘this anthill’
**[è.w’ éné] (intended meaning: ‘this anthill’)
b. /ndzɔ́ɔ̀ ìné/ → [ndzɔ́’ ìné] ‘these elephants’
**[ndz’ìné] (intended meaning: ‘these elephants’)
c. /òkúá òné/ → [ò.kú’ óné] ‘this salt’
**[ò.k’ óné] (intended meaning: ‘this salt’)
d. /òndíé òné/→ [ò.ndí’ óné] ‘this white man’
**[ò.nd’ óné] (intended meaning: ‘this white man’)

In CV.V words, a H tone on the last vowel can propagate rightward even if its hosting element is deleted in vowel elision processes preventing sequences of three vowels in a row across morpheme boundaries. Similarly, deleted L-toned vowels leave a floating L tone which prevents H tone spreading. In (17)a, c, and d, the last H-toned vowel of the first linear noun gets deleted but its floating H tone is realized on the underlyingly L-toned agreement prefix of the following demonstrative. By contrast in (17)b, there is no H tone propagation because the last vowel in *ndzɔ́ɔ̀* ‘elephant’ is

L-toned. The preceding H tone on /ɔ́/ cannot spread because of the floating L tone left by the deleted /ɔ̀/. With this background in mind, we now turn to the synchronic vowel system.

3 The vowel system of Ngwi

The seven vowel phonemes of the eastern variety of Ngwi are shown in Table 1.[9] Ngwi does not have phonemic vowel length.

	front	central	back
high	i		u
mid-high			ɤ
mid		ə	
mid-low	ɛ		ɔ
low		a	

Table 1: Ngwi vowel phonemes

(Near) minimal pairs and triplets, proving the phonemic status of the segments in Table 1, are shown in (18).

(18) /ə/ *ŋkâm* 'monkey(s)' /ə/ *èlâm* 'tongue'[10]
/u/ *ŋkûm* 'python(s)' /i/ *èlîm* 'glues'

/ə/ *ndâβ* 'bell(s)' /ə/ *ìsáʁ* 'horn, elephant tusk'
/ɔ/ *ndɔ̂β* 'fish hook(s)' /ɤ/ *ìtsɤ́ʁ* 'orphans'

[9] According to Kumpel Wossey (2001), western Ngwi has a 7-vowel system that is different from the one we report for eastern Ngwi in Table 1: /i/, /e/, /ɛ/, /a/, /ɔ/, /o/, /u/. It is an inventory more typical of the 'Bantu languages of the forest' in that it lacks /ɤ/ and /ə/ but has /e/ and /o/ (cf. Grégoire 2003).

[10] In the absence of a conditioning environment, the open-mid front and back vowels of Ngwi are realized as [ɛ] and [ɔ] respectively. However, the o- prefixes of CL1 (< PB *mù-), CL3 (< PB *mù-) and CL11 (< PB *dù-) are always realized as [o] and the e- prefixes of CL4 (< PB *mì-) and CL7e (< PB *kì-) always as [e], as in *è-lâm* 'tongue' in (18). In 7-vowel Bantu languages such as Mongo C61 (de Rop 1958), [e] and [o] usually arise diachronically from the lowering of PB *ɪ and *ʊ respectively. However, anywhere else in the Ngwi lexicon, PB *ɪ and *ʊ merged with PB *i and *u respectively, yielding /i/ and /u/ (see discussion in section 4.1). In principle, [e] and [o] can be shown to contrast with vowels other than /ɛ/ and /ɔ/ in word initial position, e.g. *è-tûn* 'CL7-enemy' vs. *ì-tûn* 'CL8-enemy', *ò-ʃúŋ* 'CL3-tree' vs. *è-ʃúŋ* 'CL4-tree'. Nevertheless, we refrain from giving [e] and [o] phonemic/allophonic status, because their distribution is morphologically heavily restricted. They can occur only as realizations of noun class prefixes and agreement morphemes of nouns belonging to classes 1, 3, 11, 4, and 7e. For this reason, we consider them as sub-phonemic (Garrett 2015, 239; Honeybone & Salmons 2015).

/ə/ *ètə́* 'fetish, medicine'
/ɛ/ *ètɛ́* 'heads'
/a/ *ètá* 'bows'

/u/ *ìtûn* 'doorway'
/ɔ/ *ìtɔ̂n* 'spot, speckle'

/u/ *ìpûʁ* 'hole, obstacle'
/ɤ/ *ìpɤ̂ʁ* 'livers'

An exploratory analysis of the acoustic vowel space of the Ngwi speaker Frédéric Mbeam-Oyuu Empenge Itobola (plotted for inverted values of F1 and F2) is provided in Figure 1.[11]

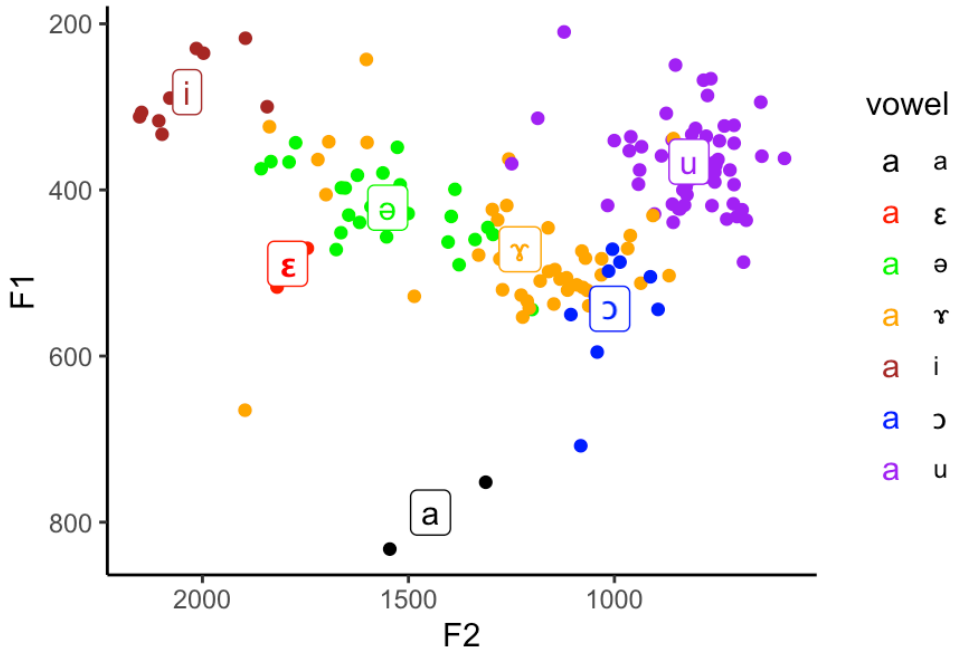


Figure 1: Acoustic vowel space of Ngwi

The interior vowels, /ə/ and /ɤ/, are worthy of consideration. As can be seen in Figure 1, the values for /ə/ are spread over a vast, central portion of the space. In terms of height, the /ə/ area is clearly above the mid-low and below the high portion of the vowel space. This is in line with what one might expect from under-specification theory where "schwa is a vowel that lacks a well-defined target, and so assimilates strongly to surrounding segments, resulting in substantial variation in the vowel quality of schwa" (Flemming 2009). On the other hand, available values for /ɤ/ are much more widely dispersed than anticipated, with an F2 range stretching from near to /u/ to near to /i/. These values seem to

[11] A higher resolution version of this Figure can be found here:
https://osf.io/9x3v7/?view_only=88d0a95d1a714e8da1bd7c6e77e22359

center around a set of coordinates which is closer to that of /ʌ/ than to that of a prototypical mid-high unrounded vowel. For instance, Koffi (2018) reports the following cross-linguistic average values: for /ʌ/ — F1 565 Hz, F2 1258 Hz; for /ɤ/ — F1 414 Hz, F2 1248 Hz. These facts might be interpreted in different ways: (i) the relatively high F1 levels for [ɤ] tokens might be due to a maximization effect of the acoustic distance from /u/; (ii) such wide-ranging F2 values might indicate that /ɤ/ is actually treated as a non-peripheral vowel in Ngwi. This, in turn, would make it perceptually less salient than its peripheral counterparts /u/ and /ɔ/ (see Polka & Bohn 2003), and allow for greater dispersion at the acoustic level. While we hold that, auditorily, this vowel is indeed better described as /ɤ/ than /ʌ/, we still largely lack the data to further assess the situation.

Root-internally, /i/ and /u/ trigger progressive vowel heightening in the open-mid vowels /ɛ/ and /ɔ/ which are then realized as [e] and [o] respectively, as in (19). However, as shown in (20), the singular CL5 *ì-* noun class prefix and plural CL8 *ì-* noun class prefix never trigger such progressive vowel heightening across morpheme boundaries. There are no *ù-* noun class prefixes in Ngwi.

(19) /lìɛ̀/ → [lìè] 'cry (v.)'
/ntʃúɛ̀/ → [ntʃúè] 'electric fish'
/dzùɔ́/ → [dzùó] 'civet cat(s)'
/lɔ̀tʃúù/ → [lòtʃúù] 'yesterday'

(20) /ì-kɔ́r/ → [ìkɔ́r] 'frog, toad'
/ì-tɔ̂r/ → [ìtɔ̂r] 'wells'

In the next section, we discuss the major historical sound changes which shaped the Ngwi vowel system as we observe it today by focusing on the phonologization of /ə/ and /ɤ/ (see Table 1) and the emergence of /ɛ.a/ and /i.a/ sequences as in (13) and (14).

4 Historical developments

In order to trace the historical developments undergone by the present-day vocalic system of Ngwi, we used a top-down approach and relied on the nearly 10.000 protoforms available in the Bantu Lexical Reconstructions (BLR) 2/3 database (Coupez et al. 1998; Bastin et al. 2002; Bostoen & Bastin 2016). Some of these protoforms go back to PB while others are reconstructable only to lower nodes in the Bantu family tree. In all examples in the following subsections, we give the form and meaning of the protoforms along with their index number as found in the BLR database, e.g., BLR 1265 *dùmbù 'mouth'. Protoforms without an index number are not officially included in the BLR 2/3 database but are tentatively proposed

based on comparative WCB data collected during the ERC-funded projects KongoKing (http://www.kongoking.org/) and BantuFirst (https://www.bantufirst.ugent.be/) led by the last author of this paper. For greater clarity, we segment the noun class prefix from the noun root in the Ngwi reflexes of nominal reconstructions, e.g. *ò-dzûm* 'mouth'. The symbol Ø- preceding a noun root means that the noun takes a zero noun class prefix, e.g., *Ø-mvûy* 'pig(s)'. Whenever possible, we use as examples Ngwi reflexes of protoforms with a widespread distribution in the Bantu domain and a high reliability score (see Bostoen & Bastin 2016 for details). Finally, we specify the meaning of a Ngwi reflex only when it differs from the one(s) posited for the corresponding protoform.

4.1 The 7 > 5 vowel merger

The reconstructed PB vowel system is given in Table 2 (Bastin et al. 2002). Although Bastin et al. (2002) represent *ɛ and *ɔ with the graphemes <*e> and <*o>, we adopt here the more phonetically transparent notation *ɛ and *ɔ for greater clarity.

	front	central	back
high	*i *ɪ		*ʊ *u
mid-high			
mid			
mid-low	*ɛ		*ɔ
low		*a	

Table 2: The PB vowel system

Two restructurings of this system are particularly common in Bantu languages: 5-vowel systems whereby *i and *ɪ merged into /i/ and *u and *ʊ merged into /u/ or 7-vowel systems where PB *ɪ and *ʊ lowered to /e/ and /o/ (Schadeberg 1995; Bostoen 2019; Hyman 2019). These restructurings are illustrated in Table 3 and Table 4 respectively.

	front	central	Back
high	i ← *ɪ		*ʊ → u
mid-high			
mid			
mid-low	ɛ		ɔ
low		a	

Table 3: Typical Bantu 5-vowel system

	front	central	back
high	i		u
mid-high	e		o
mid			
mid-low	ɛ		ɔ
low		a	

Table 4: Typical Bantu 7-vowel system (especially in languages of the Congo rainforest; elsewhere 7-vowel languages tend to maintain the PB system)

Ngwi displays a synchronic 7-vowel system which is only partially the result of one of the aforementioned restructurings. At an earlier stage, like numerous WCB languages belonging to the Kikongo Language Cluster (Bostoen & Goes 2019), Ngwi underwent the 7 > 5 vowel merger illustrated in Table 3. Evidence for this merger is provided in (21)–(27). As shown in (21) and (22), PB *u and *ʊ yielded /u/.

(21) PB *u	BLR 1265	*dùmbù ‘mouth’ > *ò-dzûm*
	BLR 2112	*kúm ‘come from’ > *kûm* ‘arrive’
	BLR 3131	*túng ‘tie up’ > *tûŋ*
	BLR 368	*búdà ‘rain, year’ > *Ø-mvúyè*
	BLR 1536	*gùdú ‘pig’ > *Ø-mvûy*
	BLR 2108	*kúdù ‘land turtle’ > *Ø-mfûr*
	BLR 2118	*kúmú ‘chief’ > *Ø-ŋkúm*
	BLR 2125	*kùnd ‘bury’ > *ò-pfŭŋ* ‘burial’[12]
	BLR 761	*cúgù ‘day’> *è-ʃúù*
	BLR 3778	*cùnì ‘meat, flesh’> *ò-sûŋ* ‘muscle’
	BLR 5395	*gútù ‘calabash’ > *è-pfûy*
	BLR 360	*bùá ‘nine’ > *ì-wùá*

[12] The deverbative noun of which *òpfŭŋ* ‘burial’ is a reflex must have ended in a high vowel, i.e. either *kùnd-ú or *kùnd-í, as these are the only contexts in which the alveolar nasal — also when followed by a consonant as in *nd — gets palatalized. See, for instance, its near-homonym *ìpfŭŋ* ‘stomach’, which is a reflex of BLR 1545 *kùndú ‘stomach’.

(22) PB *ʊ	BLR 1509	*gùndà 'forest' > *ò-kûn*
	BLR 303	*búdì 'goat' > *Ø-mbûr*
	BLR 316	*búgà 'path' > *Ø-mbûʁ*
	BLR 1179	*dúk 'vomit' > *lúà*
	BLR 2642	*púkù 'mouse' > *Ø-mfúù*
	BLR 4152	*túmɛ̀ 'messenger' > *Ø-ntûm*
	BLR 2041	*kún 'plant, sow'> *kûn*
	BLR 2042	*kúnì 'firewood' > *è-kûŋ*
	BLR 1490	*gòdù 'leg' > *è-kúù*
	BLR 1223	*dúngú 'pepper' > *è-lúŋ*
	BLR 2664	*pútá 'wound' > *Ø-mpúr*
	BLR 1628	*jòndɔ̀ 'hammer'> *Ø-ndʒûn*
	BLR 1621	*jùgú 'groundnut' > *è-yŭʁ*

Similarly, PB *i and *ɪ yielded /i/ in Ngwi, as shown in (23) and (24).

(23) PB *i	BLR 1046	*dím 'be extinguished, get lost' > *dzîm*
	BLR 3356	*jímì 'pregnancy' > *dʒ-îm*
	BLR 9667	*jini 'pubes' > *dʒ-ĭŋ* 'vagina'
	BLR 1854	*kítà 'oil' > *v-îr*
	BLR 237	*bìmɔ̀ 'abdomen' > *è-bím* 'chest'
	BLR 1845	*kíngɔ́ 'neck' > *Ø-ŋkíŋ*
	BLR 2585	*pììpí 'darkness' > *Ø-mpîb*
	BLR 2572	*pìn 'press with fingers'> *è-pîŋ* 'finger'

(24) PB *ɪ	BLR 2506	*pìcí 'bone' > *w-ìí*
	BLR 1378	*gìdí 'egg' > *ì-kìí*
	BLR 1801	*kímb 'wander about' >*kîm* 'run away'
	BLR 940	*dì 'be' > *lì*
	BLR 959	*dìd 'cry' > *lìè*
	BLR 1592	*jíbò 'house' > *dʒ-îb*
	BLR 3364	*jímbɔ̀ 'song, dance' > *Ø-lîm*
	BLR 985	*dìmbɔ̀ 'birdglue' > *ò-lîm*
	BLR 249	*bíndɔ̀ 'dirt' > *Ø-mbîn*
	BLR 3431	*jíjì 'stream' > *Ø-líì*
	BLR 579	*cíndí 'squirrel' > *è-fín*
	BLR 6207	*jíjab 'know' > *ʒíà*

As seen in (25)–(27), respectively, PB *ɔ, *ɛ, and *a were retained in Ngwi.

(25) PB *o	BLR 261	*bɔ́mà 'python' > Ø-*mbɔ̂m* 'boa'
	BLR 1429	*gɔ̀mà 'drum' > Ø-*ŋɔ̂m*
	BLR 1088	*dɔ́b 'fish (v.)' >*lɔ̂b*
	BLR 1127	*dɔ̀ng 'speak, teach'> *lɔ̂ŋ* 'teach, advise'
	BLR 1106	*dɔ̀gɔ̀ 'witchcraft' > *ì-lɔ̂ʁ*
	BLR 1927	*kɔ́mbɔ́ 'broom' > *ì-kɔ̂m*
	BLR 1147	*dɔ́ɔ́tì 'dream' > Ø-*ndɔ̂y*
	BLR 1607	*jɔ̀gù 'elephant' > Ø-*ndzɔ́ɔ̀*
	BLR 664	*cɔ́nì 'shame'> è-*ntsɔ̂ɲ*
	BLR 6515	*cɔ́mí 'eldest child' > Ø-*ntsɔ̂m*
(26) PB *e	BLR 900	*dɛ̀gɛ̀ 'weaver bird' > *è-lɛ̂ʁ*
	BLR 919	*dɛ́mb 'be tired' > *lɛ̌m*
	BLR 897	*dɛ̀dù 'beard' > *è-lɛ̂y*
	BLR 2166	*mɛ́ɛ́mɛ́ 'sheep' > *ì-mɛ́mɛ́*
	BLR 1583	*jɛ́njɛ́ 'cricket' > Ø-*ndʒɛ́n*
	BLR 2255	*nɛ́nɛ̀ 'big' > *nɛ̂n*
	BLR 508	*cɛ̀d 'be slippery' > *sɛ̂r*
	BLR 3295	*jɛ́n 'see' > *yɛ̂n*
	BLR 2469	*pɛ̀ɛp 'blow (wind)' > *fɛ́bɛ́*
(27) PB *a	BLR 3252	*játɔ̀ 'canoe' > *w-âr*
	BLR 1	*bá 'palm oil nut'> *è-bá*
	BLR 61	*bàgú 'stumbling block'> *ì-bǎʁ* 'stump'
	BLR 3180	*nyàmà 'animal' > Ø-*ɲâm*
	BLR 812	*dàgá 'promise' > *è-lǎʁ*
	BLR 2410	*pàpá 'wing' > *ì-pǎβ*
	BLR 1695	*kámá 'hundred' > Ø-*ŋkám*
	BLR 1274	*gàb 'divide, give away' > *kǎb*
	BLR 2744	*támà 'cheek' > *ì-tâm*
	BLR 1739	*kájí 'leaf' > è-*káy*
	BLR 9605	*pákù 'honey' > Ø-*mpâʁ*
	BLR 394	*càbʊk 'cross river' > *sǎβ*
	BLR 496	*cátù 'three' > *ì-sâr*
	BLR 9207	*táà 'bow' > *ò-tá*

4.2 The phonologization of [ə] and [ɤ]

After the 7 > 5 vowel merger had taken place, /i/ as the merged reflex of PB *i and *ɪ developed two allophones in V_1 position in a *$C_1V_1C_2V_2$ template, namely the interior vowels [ə] and [ɤ]. The conditioning environments which historically triggered [ə] and [ɤ] as allophones of /i/ in V_1 are given in (28) and (29) respectively. In this section, unless otherwise specified, the asterisk next to a segment not preceded by the label BLR refers to a form presumably present in an earlier stage of Ngwi.

(28) Proto-Ngwi *i in C_1 > [ə]/__ C_2 *ɛ, *a, *ɔ

BLR 3464	*jínà 'name' > *dz-ân*
BLR 1798	*kímà 'monkey' > *Ø-ŋkâm*
BLR 6108	*cìkà 'girl, woman' > *ò-sâʁ* 'young girl'
BLR 2139	*mà 'thing' > *Ø-vâm*[13]
BLR 957	*dìbɔ̀ 'bell' > *Ø-ndăb*
BLR 3472	*jínɔ̀ 'tooth' > *dz-ân*
BLR 574	*cígɛ́ 'horn' > *ì-sáʁ*
BLR 1828	*kígɛ̀ 'eyelash' > *è-kâʁ*
BLR 971	*dímɛ̀ 'tongue' > *è-lâm*
BLR 2936	*tɪndɛ 'wax' > *tsăn* 'earwax, pus'
BLR 2898	*tín 'cut' + suffix > *ì-tsân* 'stalk' (e.g. of sugar cane)[14]
BLR 6024	*bít 'lie down' + suffix > *vâr* 'sleep'

(29) Proto-Ngwi *i in C_1 > [ɤ]/__ C_2 *u

BLR 193	*bìdú 'cola nut' > *ì-bɤ̌r*
BLR 6196	*tígúɛ́ 'young orphan' > *è-tsɤ́ʁ* 'orphan'
BLR 8151	*pɛ̀kúá 'raphia fiber' > *ì-pɤ̌ʁ* 'raphia palm'[15]
BLR 2569	*pígù 'kidney' > *ì-pɤ̂ʁ* 'liver'
BLR 6113	*cíkù 'hiccup' > *à-sísɤ̂ʁ*

This gave rise to the system in Table 5.

	front	central	back
high	/i/		/u/
mid-high			[ɤ]
mid		[ə]	
mid-low	/ɛ/		/ɔ/
low		/a/	

Table 5: The emergence of /ə/ and /ɤ/ in Ngwi

[13] This protoform possibly had a noun prefix with an /i/ which was reanalyzed in Ngwi as part of the simple noun stem.

[14] We hypothesize that the deverbative nouns 'stalk' and 'sleep' were derived from their respective verb roots through the PB deverbative noun suffixes *-ɔ̀ or *-ɛ̀ (cf. Schadeberg & Bostoen 2019, 189–190, which they write as *-ò and *-è respectively).

[15] This protoform has a low reliability score in BLR 2/3 (Coupez et al. 1998, Bastin et al. 2002) and is attested only in zone C languages. Since several zone C languages underwent the restructuring of the inherited PB system illustrated in Table 4, where PB *ɪ merged with PB *ɛ, it is entirely possible that current BLR 8151 should actually be reconstructed as *pìkúá.

As happens with other WCB varieties spoken along the Lower Kasai in the DRC, Ngwi underwent final vowel loss (Pacchiarotti & Bostoen 2021). Once this diachronic sound change took place, the conditioning environment which originally triggered [ə] and [ɤ] as allophones of /i/ was lost and phonemic split arose. Roots starting out with an identical V_1 but a different V_2 end up with a different V_1 and without a V_2, e.g., BLR 3356 *jímì 'pregnacy' > *dʒ-îm*, but BLR 3472 *jínò 'tooth' > *dz-ən*.[16] Loss of a conditioning environment is one of the most well-known sources for the creation of phonemic splits (Hock 1991, 56; Labov 1994, 332). See Bostoen & Koni Muluwa (2011, 2014) for other cases of phonologization of root-internal vowel allophones due to the loss of a conditioning final vowel in several WCB languages spoken in the Lower Kasai region.

The assimilation processes in (28) and (29) did not target all suitable lexical items. While evidence for (29) is scanty, there is evidence that several lexical items escaped the change in (28), as shown in (30). To show that this irregularity is not attributable to a conditioning environment, in (30), each lexical item which was not targeted by the assimilation in (28) is followed by a formally similar or identical item which was targeted by this innovation.

(30)	BLR 1973	*kídà 'tail' > *ò-yîr*
but	BLR	*pıda 'family, clan' > *Ø-mpây* 'uncle'
	BLR 1592	*díbɔ̀ 'house' > *Ø-dʒîb* 'house for birds'
but	BLR 957	*dìbɔ̀ 'bell' > *Ø-ndâb*
	BLR 3364	*jímbɔ̀ 'song, dance' > *Ø-lîm* 'song'
but	BLR 3472	*jínɔ̀ 'tooth' > *dz-ân*
	BLR 985	*dìmbɔ̀ 'birdlime' > *ò-lîm*
but	BLR 2936	*tìndɛ̀ 'wax' > *Ø-tsân* 'earwax, pus'
	BLR 3354	*jímad 'stand, stop' > *yímá* 'be standing'
but	BLR 2895	*tímà 'heart' > *ò-tâm*
	BLR 1854	*kítà 'oil' > *v-îr*
but	BLR 6024	*bít 'lie down' > *vâr*
	BLR 237	*bìmɔ̀ 'abdomen' > *è-bím* 'chest'
but	BLR 1798	*kímà 'monkey' > *Ø-ŋkâm*

All lexical items in (30) had the right environment for the change *i > [ə] to take place. In all instances, V_1 *i is followed by V_2 *ɔ, *a or *ɛ which cause centralization of *i to [ə] as shown in (28). Nevertheless, some V_1 *i

[16] 'Pregnancy' and 'tooth' in Ngwi both belong to class 5. Class 5 nouns starting in a vowel take *dʒ-* as a noun class prefix. This prefix is depalatalized to [dz] when the noun root starts with /ə/.

were retained instead of undergoing assimilation.[17] Additionally, there is evidence that the shift *i > [ə] was irregularly extended to words which did not have the right conditioning environment for this change to occur, as can be seen in (31). Word-finality cannot be considered as a triggering factor here. The very few Ngwi CV roots we have observed so far end in any vowel except /ɤ/.

(31) BLR 2881 *tí 'tree, stick' > *è-tá* 'medicine, fetish'
BLR 751 *cúí 'fish' > *Ø-ntsá*
BLR 285 *bùè 'stone' > *ì-và* 'big stone'

Finally, there is evidence that partially nativized borrowings (easily detectable by the presence of a final vowel), did not undergo the shift *i > [ə], e.g. *è-tʃìmà* 'whirlwind' < BLR 5882 *tìmbà 'whirlpool'. This kind of irregularity in sound change is pervasive in WCB (and probably Bantu more generally) and is observed with other diachronic sound changes (see Pacchiarotti & Bostoen forthcoming for possible explanations). Even if lexical borrowing can salvage the sound change regularity hypothesis in some cases, many 'exceptions' cannot be accounted for by borrowing.

We conclude this section with some further phonological considerations with respect to the assimilation processes in (28) and (29). The phonological conditioning in (28) and (29) arose once the 7 > 5 vowel merger had left the language with a vowel space clearly split into two relevant natural classes, i.e. [–high] (/a/, /ɔ/, /ɛ/) and [+high] (/i/, /u/). As we will see in sections 4.3.2 and 4.4, [–high] appears to be a salient class for the phonology of Ngwi. This process is in line with what we know from the study of phonetic biases on phonological learnability: more complex phonological patterns, with either an arbitrary distribution of features or a more complicated architecture thereof, are harder to acquire for (adult) language learners (Pycha et al. 2003; Peperkamp et al. 2006; for an overview of the relevant literature within models of Artificial Grammar Learning see Finley 2012). In this sense, a system with two high vowels opposed to three non-high vowels (either mid-low or low, i.e. not mid-high) is more economical than the system in Table 2 from which contemporary Ngwi originated, where the organization of features into significant natural classes is more problematic.[18] Of course, a simple formal architecture of

[17] When a conditioning environment disappears, speakers have two options: (a) retain the assimilation and phonologize the allophone or (b) give up the assimilation which is no longer required phonetically. It seems as if in Ngwi speakers chose (a) for some lexical items such as those in (28), and (b) for some others, such as those in (30).

[18] The 'problematic' aspect lies in the presence of near-high counterparts to /i/ and /u/, namely /ɪ/ and /ʊ/, a class of non-high vowels that would not appear to pattern with the other non-high vowels of the system. However, it is worth mentioning that the

phonological features does not necessarily stem from phonetic groundedness; see Greenwood (2016, 31). However, the closer a vowel is to the lower end of the space, the more salient its definition as [–high] is (Ladefoged 1971; Boersma 1997), making the [–high] class at this stage of the evolution of Ngwi both formally simple and phonetically grounded. This [–high] class triggered the distant regressive assimilation phenomenon illustrated by the change in (28), which can be reformulated with features as in (32).

(32) $C_1V_1[_{+high,\ +front}]C_2V_2 > C_1V_1[_{-high,\ -front,\ -back}]C_2V_2/\_\_\ V_2[_{-high}]$

The change in (32) raises at least two different questions: (i) why did V_1 lose [+high]?; (ii) why did V_1 not become [+low] (or [+mid-low])?[19] The first point can be resolved as follows: [+high] harmonized with a [–high] class thus becoming [–high] in its own turn. The second question is probably harder to answer satisfactorily, and entails a deeper understanding of the problems posed by (i): *a priori*, one might have expected that the centralization of /i/ would result in /ɜ/ or /ɐ/ (i.e. somewhere lower in the vowel space and more in line with the low F1 values of /a/, /ɔ/ and /ɛ/). However, 'schwa', i.e. the mid-central vowel commonly transcribed as [ə] in the IPA, is arguably an underspecified vowel subject to reduction phenomena in phonological processes, i.e. to assimilation to its segmental context, which makes it highly context-sensitive in terms of phonetic realization (see Flemming 2009, 1). Incidentally, this could also explain the considerable dispersion observable for [ə] tokens in the Ngwi vowel space in Figure 1. As such, the underspecified mid-central vowel [ə] is the ideal output of any centralization process where backness is undefined. Additionally, lower central vowels are cross-linguistically much rarer, a fact which might be due to their relatively high position in proposed vowel

---

emergence of lower vowels in the grammar is generally predicted to have an earlier ('easier' or 'more natural') onset in traditional Dispersion Theory models (Liljencrants & Lindblom 1972, Vaux & Samuels 2015, 576).

[19] A possible third question would be: why did V_1 lose both its [+front] and [+back] specifications? In an earlier version of this paper we proposed to address the issue as follows: since the [–high] class described above is unspecified for backness, the most reasonable solution was for /i/ to converge towards the center (centralization). However, as was pointed out to us by Pavel Iosad (p.c.), this stipulation would require that one subscribe to the notion that schwa is actually necessarily [–front] and [–back], which is only one of the possible ways to characterize its under-specification for backness. The fact that /i/ converged towards the center can therefore be explained as an effect of its target being either unspecified for backness ([0backness]?) or explicitly specified as [–front], [–back]. We will leave this point for future consideration, as either hypothesis does not substantially affect the argument at hand.

sonority scales (Gordon et al. 2012, 221). In this sense, the phonetic output of the centralization phenomenon in (32) is unsurprising.

As for the change in (29), it can be reformulated as in (33).

(33) $C_1V_1[_{+high,\ +front}]C_2V_2 > C_1V_1[_{-high,\ -front,\ +back}]C_2V_2/\_\_\ V_2[_{+high}]$

The assimilation to [+back] in (33) is problematic because it entails an apparently odd change in height, whereby a high vowel assimilated to another high vowel by becoming mid-high. A seemingly more expectable output might have been either /u/ or, since /i/ is unrounded, /ɯ/. However, from a Dispersion Theory perspective (Liljencrants & Lindblom 1972; Lindblom 1986), vowels tend to disperse across the vowel space to enhance perceptibility. In this sense, a system with three back vowels (a high one, a mid-high one, and a mid-low one) is definitely better balanced than one with two back high vowels and a mid-low one. In fact, /ɤ/ is expected to be part of the optimal 7-vowel system proposed by Lindblom (1990). Since high vowels are cross-linguistically less likely to trigger round harmony (Finley 2012), /ɤ/ (as opposed to, say, /o/) should not be taken as a surprising outcome. Alternatively, as suggested to us by Pavel Iosad (p.c.), one could posit that since there is no contrast between [ɤ] and [ɯ], [ɤ] is phonologically [+high].

4.3 The emergence of /ɛ.a/ and /i.a/ vowel sequences

In the following subsections we provide evidence for the claim that most /ɛ.a/ sequences found in CV.VC words (section 4.3.2) and /i.a/ sequences found in CV.V words (section 4.3.3) originate in the fission of an erstwhile palatal on-glide diphthong *ya* (phonetically [ja]), itself originating in a long /aː/, into a sequence of two vowels belonging to two successive syllables. We refer to this process as the syllabification or fission of [ja] into /ɛ.a/ and /i.a/ sequences. The long vowel at the origin of the *ya* diphthong arose diachronically from several distinct phonological environments. Due to the immediate relevance of diphthongs for the emergence of /ɛ.a/ and /i.a/ sequences, we first discuss them briefly in section 4.3.1.

4.3.1 The crucial role of diphthongization

As discussed in detail in Koni Muluwa & Bostoen (2012), on-glide diphthongs in Lower Kasai languages such as Ngwi have their origin in the automatic vowel lengthening that commonly happens in Bantu before a nasal consonant cluster (NC) (cf. Hyman 2019). It is well known that vowel length is an ideal phonetic environment for the emergence of diphthongs, not only in Bantu but also in other language families both within and outside of Africa (see Koni Muluwa & Bostoen 2012, 370 for a list of

relevant references). The most common diphthongs in Ngwi, /wɔ/ and /yɛ/ arose from the automatically lengthened PB mid vowels *ɔ and *ɛ. Consider the data in (34)–(35).

(34) BLR 2986 *tɔ́ndɔ̀ 'roof' > *ò-twɔ̂n*
BLR 265 *bɔ̀mbɔ́ 'nose' > *Ø-mbwɔ̌m*
BLR 117 *dɔ̀ndà 'pain, wound, abscess' > *Ø-lwɔ̂n* 'birth pain'
BLR 3001 *tɔ̀ngɔ̀ 'sleep' > *Ø-lwɔ̌ŋ*
BLR 6806 *pɔ́ngɔ̀ 'fat' > *Ø-mpwɔ̂ŋ* 'marrow'
BLR 6731 *kɔ́ndɛ̀ 'bean' > *è-kwɔ̂n*
BLR 1446 *gɔ̀ndɛ́ 'crocodile' > *Ø-ŋkwɔ̌n*
BLR 1445/1447 *gɔ̀ndɛ̀ ~ *gɔ̀ndɔ̀ 'moon' > *Ø-ŋgwɔ̂n*
BLR 1128 *dɔ̀ngà 'river, valley, channel' > *Ø-ndwɔ̌ŋ* 'marsh'
BLR 1434 *gɔ̀mbɛ̀ 'cattle' > *Ø-ŋgwɔ́m*
BLR 665 *cɔ̀ng 'show (v.)' > *ʃwɔ̌ŋ*
BLR 655 *cɔ̀mb 'borrow, lend' > *tʃwɔ̌m*

(35) BLR 2846 *tɛ́nd 'groan, grunt' > *ì-tyɛ̂n* 'gossip'[20]
BLR 2853 *tɛ́ndɛ́ 'thorn' > *ì-tyɛ́n*
BLR 1362 *gɛ̀nd 'walk, travel, go (away)' > *kyɛ̌n*
BLR 7535 *bɛ́mbɛ́dɛ́ 'mosquito' > *è-byɛ́mɛ́*
BLR 2458 *pɛ́njù 'cockroach' > *ì-pyɛ́ɲ*

All the protoforms in (34) contain a NC in C_2 position which is reduced to a nasal (N) in Ngwi, just like in other Lower Kasai languages. The vowel preceding this historical NC tends to be automatically lengthened in Bantu languages, as was probably also the case in PB (Meeussen 1979, 2). Diphthongs such as /wɔ/ and /yɛ/ arose from lengthened *ɔː and *ɛː respectively through the following chain of changes, where G stands for glide: CVNCV > CV:N > CGVN (see Rottland 1977, 382; Hyman 2003, 50; Koni Muluwa & Bostoen 2012). This sound change is quite pervasive in Ngwi, but in this case too several suitable targets escaped it, e.g. BLR 1927 *kɔ́mbɔ́ 'broom' > *ì-kɔ̂m*, BLR 919 *dɛ́mb 'be tired' > *lɛ̌m*, BLR 1583 *jɛ́njɛ́ 'cricket' > *Ø-ndʒɛ́n*. Finally, by analogy with the diphthongization of protoforms containing a NC in C_2 position which was simplified to N, several protoforms with a historical N in C_2 position underwent the same change, e.g. BLR 6506 *tɔ́m 'chew, drink' > *twɔ̂m* 'chew', BLR 1359 *gɛ̀nì 'stranger, visitor' > *ò-ŋgìŋgyɛ̀n*. However, this analogical change was irregular as it did not apply systematically to all suitable lexical items, e.g. BLR 1429 *gɔ̀mà 'drum' > *Ø-ŋɔ̂m*, BLR 2255 *nɛ́nɛ̀ 'big' > *nɛ̂n*.

[20] In many WCB languages, reflexes of this protoform mean 'talk, chat'.

4.3.2 /ɛ.a/ sequences in CV.VC words

Synchronic /ɛ.a/ sequences in contemporary Ngwi occur only in word-medial position in a synchronic CV.VC structure. In the light of the discussion in section 4.3.1, it seems highly plausible that the /ɛ.a/ sequences in (36) arose from a chain of changes such as the following: CaNCV > Ca:N > CyaN > Cɛ.aN, as in *gàngà> *òŋgà:ŋ* > *òŋgyàŋ* > *òŋgɛ̀áŋ*.

(36) BLR 1332 *gàngà 'medicine man' > *ò-ŋgɛ̀áŋ* 'doctor'
BLR 1706 *kàndá 'letter' > *ò-ŋkɛ̀án*
BLR 1321 *gàndá 'clan' > *ò-ŋkɛ̀án* 'grandchild'
BLR 844 *dàmbá 'cloth' > *è-lɛ̀ám*
BLR 2400 *pángà 'cave' > *ò-pɛ́àŋ* 'parcel of land, fence'
BLR 97 *bánjá 'dwelling place, courtyard, etc.' > *Ø-mbɛ̀áŋ* 'battle, war'
BLR 8407 *pàmbí 'antelope bushbuck' > *Ø-mpɛ̀ám*
BLR 3196 *jàmbɛ́ 'god'> *Ø-ndzɛ̀ám*
BLR 8741 *tàngí 'bedstead' > *Ø-ntɛ̀áŋ*
BLR 2394 *pànjí 'side of body' > *è-pɛ̀áŋ*
BLR 1719 *káng 'fry, roast' > *kɛ́àŋ*
BLR 8650 *dàng 'like, desire' > *lɛ̀áŋ* 'want, love, desire'
BLR 9390 *cánk 'be happy' > *ò-sɛ́àŋ* 'joy'

Koni Muluwa & Bostoen (2012, 368) report the [–high] vowel *a becoming [ya] in several other Lower Kasai languages besides Ngwi. Possibly, the breaking of a long /a:/ vowel into a diphthong might have been triggered by the fact that other [–high] vowels such as /ɔ/ and /ɛ/ show a strong tendency to diphthongize in Ngwi (see section 4.3.1). At the same time, the crystallization of [ya] into two vowel nuclei did not act as an attractor, i.e., diphthongs created out of mid-vowels ɛ and ɔ in section 4.3.1 did not become sequences of two vowel nuclei.[21]

At some point, this on-glide /ya/ diphthong was syllabified in Ngwi and two vowel nuclei were created, i.e., ja> e̯a > ɛ.a. This change is schematically represented in terms of syllable-internal restructuring in

[21] Pavel Iosad (p.c.) has suggested to us that since [a:] goes a step further compared to /ɔ/ and /ɛ/ in the fission of the erstwhile diphthong, a reasonable progression of sound change is one where lengthening > diphthongization > fission happens with /a/ before spreading to the mid vowels. This hypothetical pathway, phonetically grounded in the inherent length of /a/ compared to /ɛ/ and /ɔ/, predicts that if a language has diphthongs involving mid vowels /ɛ/ and /ɔ/, it also has diphthongs involving low vowels such as /a/. According to the survey in Koni Muluwa and Bostoen (2012, 370), this prediction is only partially borne out: a few Lower Kasai languages such as Ntsambaan B85F, Nsong B85d, and Mbuun B87 apparently only have diphthongs from mid-vowels [ɛ] and [ɔ]. Detailed data collection might (dis)prove this fact.

Figure 2, where σ = syllable, O = Onset, N = Nucleus and C = Coda. The syllabification process out of an original palatal on-glide *ya* diphthong is illustrated for the simple noun stem *ŋgɛ̀án* 'medicine man' devoid of its synchronic noun class prefix, see (36). The syllable-internal structure of phonological diphthongs reflects their general understanding in the relevant literature as complex vowel units where both vowel elements are part of the syllable nucleus (Ladefoged 1993).

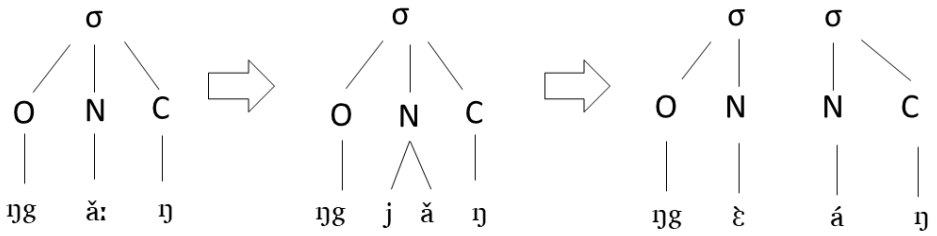


Figure 2: creation of /ɛ.a/ sequences in Ngwi

On the other hand, the /ɛ.a/ sequences in (37) did not arise from protoforms containing a NC in C_2 position.

(37) BLR 8255 *jáná 'palm wine' > *v-ɛ̀án* 'wine'
BLR 8211 *pámì 'man, male'> *ò-mpɛ́àm*
BLR 6434 *nàìnàì 'eight' > *ì-nɛ̀àní*
BLR 1674 *kádí 'woman, wife' > *ò-ŋkɛ́ɛ̀r* 'woman, female'[22]
BLR 3158 *jàdí 'girl at puberty, woman' > Ø-*wɛ̀ár* 'wife'
BLR 9467 *mat 'run' > *mɛ̀ɛ̀rá* 'trample on'
BLR 2433 *pɛ̀gà 'shoulder' > *ì-pɛ́ɛ̀ʁ*

The first three entries in (37) are reflexes of protoforms with a simple nasal in C_2 position. These are readily explained by analogical extension: the same process described above for original *NC which were simplified to N was extended to historical *N in C_2 position such as *pámì 'man, male' (see section 4.3.1 for analogical extension happening with *wɔ* and *yɛ* diphthongs). Cases where no simple nasal is present in (37) might be accounted for in a different way. Protoforms such as *kádí 'woman, wife' and *jàdí 'girl at puberty, woman' have a front vowel in *V_2 position. BLR 9467 *mat 'run' might also have been followed by a verbal derivational suffix with a front vowel, such as the applicative *-ɪd. In other Lower Kasai languages, the reflexes of protoforms with *a in *V_1 and a front vowel in *V_2 often have a palatal-glide diphthong /ya/ in V_1, e.g., BLR 1674 *kádí >

[22] Both *ò-ŋkɛ́ɛ̀r* 'woman, female' and Ø-*wɛ̀ár* 'wife' are irregular reflexes because *d in C_2 did not become zero as expected (see section 4.3.1).

B85bT *mu-kyáy*, B85e *ɔ̃-kyáy*, B86 *mù-kyáy*, B862 *ŋkyál* (Koni Muluwa & Bostoen 2012, 376–377). In these cases, /ya/ diphthongization can be considered as an instance of umlaut or anticipatory assimilation to the palatal segment *i that used to be present in the protoform *kádí (Schürr 1970, 3 cited in Koni Muluwa & Bostoen 2012). In other varieties, V_1 *a undergoes umlaut, whereby *a > ɛ under the influence of a V_2 front vowel, e.g., BLR 1674 *kádí >B85d *mɔ̀-kɛts*, B85F *bà-kés*, B87W *ò-kéts*. Yet in others, the open-mid vowel *ɛ* resulting from umlaut further diphthongizes to *yɛ*, e.g., BLR 1667 *kádì 'bitter, fierce' > B85bV *kyɛ́y* (see Bostoen & Koni Muluwa 2014 for a typology of umlaut in these languages). Thus, the /ya/ diphthong which gave rise to /ɛ.a/ sequences in *ò-ŋkéàr* and *Ø-wèár* might have been triggered by the presence of a historical front vowel. However, this development cannot account for protoforms which have *a in *V_2 position and a front vowel in *V_1 such as *pègà 'shoulder'. In fact, *ì-péàʁ* as a reflex of BLR 2433 *pègà remains unexplained. Even if one were to posit that *ì-péàʁ* arose out of a vowel that was lengthened as a compensatory strategy for the loss of the final vowel of forms such as *pègà 'shoulder', e.g. *pègà > °*pèɛ̀ʁ*, *ɛ:* in Ngwi diphthongizes into *yɛ*, not *ya*.

4.3.3 /i.a/ sequences in CV.V words

The /i.a/ sequences occur in Ngwi only in word/syllable-final position. Phonetically, they are realized as [ɪ.a] or [e.a], but when they participate in vowel deletion processes, /a/ gets deleted and the remaining vowel surfaces as [i], as illustrated in (38).

(38) /èsíà/ → [èsíà] ~ [èséà] 'feather'
/èsíà ènɛ́/ → [èsí' ènɛ́] 'this feather'

Diachronically, unlike /ɛ.a/ sequences, all /i.a/ sequences arose due to the loss of a C_2 consonant in a $C_1V_1C_2V_2$ template. The combinations of vowels involved in the creation of /i.a/ sequences in this historical template are varied.

Some /i.a/ sequences in Ngwi are simply the result of the coming together of a historical V_1 *ɪ and V_2 *a due to the loss of *d in C_2 position, as in (39). Note that the loss of an intervocalic consonant in Ngwi did not trigger loss of syllable boundaries and the coalescence of a two-vowel sequence into one long vowel (see de Chene 2014, 26–27 for examples of languages where vowel length was created in such contexts).

(39) *V_1=ɪ; *V_2=a

BLR 183	*bídá 'call, announcement' > Ø-*mbíà* 'greeting'
BLR 5884	*jíjà 'fire' > Ø-*ʧîá*
BLR 6207	*jíjab 'know' > *ò-ʒíà*

Recall that whenever a C_2 was not lost but preserved, PB *ɪ or *i in V_1 followed by a PB non-high vowel such as *a in V_2 gave rise to an allophonic [ə] in V_1 position, see (28). The fact that the /i.a/ sequences in (39) did not further develop into /ə.a/ suggests that regressive assimilation occurred only when the triggering segment and its target were not adjacent .

A few other synchronic /i.a/ sequences seem to have arisen diachronically from the coming together of a historical V_1 *a and V_2 *i due to the loss of *d in C_2 position, as in (40).

(40) *V_1=a; *V_2=ɪ

BLR 3161	*jàdí 'village' > *w-ìá*
BLR 412	*cádí 'work (n.)' > *ò-ʧíà*
BLR 404	*cád 'work (v.)' > *ʧíà* 'weed, clear ground'[23]

To account for the reflexes in (40), one needs to posit metathesis, whereby CaCi > Cai > Cia or CaCi > CiCa > Cia. Metathesis could have been triggered by analogy with the /i.a/ sequences historically originating in V_1 *ɪ and V_2 *a as in (39) or the more numerous from V_1 *a and V_2 *a in (41).

(41) *V_1=a; *V_2=a

BLR 1662	*kádà 'embers, charcoal' >*ì-kíà*
BLR 1294	*gádà 'finger nail' >*è-kíà* 'nail, claw, fish scale'
BLR 1555	*jàdà 'hunger' > Ø-*ndzìà*
BLR 406	*cádá 'feather' > *è-síà*
BLR 1557	*jàdà 'rubbish heap' > Ø-*ʤìà*
BLR 2140	*máá 'mother' > Ø-*mìá*[24]
BLR 2806	*tàátá 'father' > Ø-*tìá*

At first glance, the /i.a/ sequences in (41) look like the outcome of distant regressive dissimilation. When two low vowels were found in

[23] The infinitive form *ʧíà* is included in (40) because we assume that it is historically derived from BLR 404 *cád 'work' plus a semantically compatible derivational suffix with a front vowel such as PB applicative *-ɪd.

[24] BLR 2140 *máá exists alongside BLR 2146 *mààmá. On the other hand, there is no **tàà reconstruction alongside *tàátá for 'father'. Nevertheless, it is possible that *tìá* 'father' in Ngwi was formed by analogy to *mìá* 'mother' which could in turn be diachronically derived from a shortening of BLR 2146 *mààmá.

adjacent syllables, the first low vowel became [–low], schematically: CaCa > CiCa > Cia or CaCa > Caa >Cia. Apparently, this sound shift is widely attested in Oceanic languages, where aCa > eCa/əCa or more rarely iCa (Blevins 2009), as well as Kera (Chadic) (Pearce 2007) and some Russian dialects (Botma et al. 2015).[25]

However, considering the explanation for the emergence of /ɛ.a/ sequences set forth in section 4.3.2, there is at least one more way to account for the reflexes in (41). In their comparative study of diphthongization in WCB languages belonging to Guthrie's B70 and B80 referential groups, Koni Muluwa & Bostoen (2012) report instances where diphthongs cannot be explained by conditioning factors such as umlaut phenomena or compensatory lengthening due to the loss of a segment. These cases are illustrated with data from West and East Yans B85a and B85b respectively and Mpur B85e in (42). Note that these unexplained diphthongs occur in reflexes of protoforms with *a in both $*V_1$ and $*V_2$ position, just like those in (41).

(42) $*V_1$=a;$*V_2$=a

BLR 1294	*gádà 'nail' > B85e *ŋ́ŋyâl*
BLR 812	*dàgá 'promise' > B85b *lyàḱ*
BLR 425	*càká 'sorghum' > B85b *syàḱ*
BLR 1684	*kákà 'anteater' > B85b *kyàḱ*
BLR 1820	*dáká 'tongue, language' > B85a *ndeak*

Factoring in the data in (42), one could posit that the Ngwi /i.a/ sequences in (41) arose out of a palatal on-glide *ya* diphthong just like the /ɛ.a/ sequences in CV.VC words. Unlike what happened with /ɛ.a/ sequences, where *ya* originated in a long [aː] vowel created due to automatic lengthening before a NC, in the case of the /i.a/ sequences in (41), the *ya* diphthong originated in a long [aː] vowel created due to the loss of C_2, e.g., BLR 1662 *kádà > *káà* > *kyâ* > *kíà*. As it happened with /ɛ.a/ sequences, the *ya* diphthong was resyllabified as a sequence of two full vowels. Under this account /ɛ.a/ and /i.a/ sequences would have the same origin: the fission of a /ya/ diphthong out of a long [aː] vowel. The resulting heterosyllabic vowel sequence is realized as /ɛ.a/ in word medial position and as /ɪ.a/ or /e.a/ in word final position.

Another advantage of this unified account is that it can provide an explanation for the apparently unexplainable cases of diphthongization in (42). Palatal on-glide diphthongs in other Lower Kasai varieties such as Mpur B85e and East Yans B85b can be explained by positing that a long

[25] We thank Pavel Iosad (p.c.) for pointing us to the existence of this phenomenon in languages other than Oceanic.

/aː/ was created as a compensatory strategy for the loss of the final vowel. This long /aː/ then broke into a *ya* diphthong, e.g., CVCV > CVC > CVːC > CGVC, or BLR 812 *dàgá> Yans B85b *lăk* > *làák* >*lyàḱ*. What is more, the development /ya/ > /ɛa/ might be attested even in dialectal varieties of presumably the same language, compare the East Yans B85b forms in (42) displaying /ya/ with West Yans B85a *ndeak* < BLR 820 *dáká, where presumably <ea> does not represent a diphthong but a series of two vowels. Similarly, in the eastern variety of Ding B86, when the applicative suffix *-il* combines with CVC verb roots where V is /a/, the result is [ɛa], e.g., */lâm-il/* 'prepare-APPL' > [lɛam] (fieldwork data collected by the first author in consultation with Donatien Musimar Aleben). One could posit that the /i/ of applicative *-il* causes anticipatory assimilation of V_1 a to *ya* which then undergoes syllabification.

In Table 6, we present a possible seriation of changes to account for the /i.a/ outcome in Lower Kasai languages like Ngwi B861 and the /ya/ outcome in Lower Kasai languages like Mpur B85e, out of protoforms with a $C_1V_1C_2V_2$ shape where C_2 is not a N or a NC and V_1 and V_2 were both *a. The chronology of C_2 loss and final vowel loss is based on Pacchiarotti & Bostoen (2021).

BLR 1294 *gádà 'nail'	**Ngwi B861**	**Mpur B85e**
loss of C_2	káà	—
final vowel loss	—	ŋál̀
compensatory lengthening	—	ŋáàl
diphthongization	kyâ	ŋyâl
syllabification	kía	—

Table 6: Possible chronology for i.a and ya outcomes in Lower Kasai languages

In an experimental study on the heterosyllabic vs. diphthongal realizations of inherited *iV Late Latin sequences in five Romance languages, Chitoran & Hualde (2007, 55, 59) find that the general evolutionary tendency for heterosyllabic [iV] sequences to be shortened to diphthongs is inhibited when vowel sequences are found in word-initial (stressed) syllables, because they have a greater duration than vowel sequences found in non-initial (unstressed) syllables. Considering these experimental findings, the creation of heterosyllabic /i.a/ sequences in Ngwi might have been favored by the fact that a historical disyllabic word became, at some point in earlier stages of Ngwi, a monosyllabic CVː

stressed word. Tone might also have played a role in the syllabification process.

4.4 Other V.V sequences

In this section we briefly discuss the historical development of word final V.V sequences other than /i.a/. Unlike /i.a/ sequences discussed in section 4.3.3, the V.V sequences discussed here arose from three different protosyllable shapes, namely: *CVCV, *CVV, and *CV.

Those which arose from *CVCV structures can be subdivided roughly into three groups depending on the quality of historical *V_1 and *V_2. If *V_1 and *V_2 were both [–high], that is *ɔ, *ɛ, or *a, the long vowel created by the loss of the intervocalic consonant broke into a diphthong which then syllabified into a sequence of two vowels, e.g., *jɔ̀bɔ́ > *dzɔ̀ɔ́* > *dzwɔ̌* > *dzùó*. Some examples of this sound change are given in (43). As suggested in section 4.2, this sound change provides further evidence for [–high] as a natural phonetic class in Ngwi.

(43) *$CV_{[-high]}$ $CV_{[-high]}$ > *$CV_{[+high]}.V_{[-high]}$

BLR 6882	*jɔ̀bó ‘civet cat’ > *Ø-dzùó*[26]
BLR 1891	*kɔ́dɔ̀ ‘grandparent, female ancestor’ > *ò-kúò* ‘tribe, ethnicity’
BLR 7003	*kɔ́dɔ́ ‘snail, cowry’ > *Ø-ŋkúó*
BLR 2594	*pɔ́dɔ̀ ‘calmness’ > *Ø-púó* ‘be silent’
BLR 260	*bɔ́kɔ̀ ‘arm’ > *è-wúò*
BLR 893	*ndɛ́dɛ́ ‘white man’ > *ò-ndíé*
BLR 7809	*gɛ̀dɛ́ ‘downstream’ > *Ø-ŋgìé*
BLR 3536	*jɔ́kà ‘snake’ > *Ø-ndʒúà*
BLR 647	*cɔ̀ká ‘axe’ > *ì-ʃúà*

Another possibility to account for the reflexes in (43) would be to posit that the two historical [–high] vowels dissimilated and historical *V_1 became [+high], e.g. *jɔ̀bó > *dzòó* > *dzùó* or *jɔ̀bó > *dzùbó* > *dzùó*. However, positing a long vowel which develops into a diphthong that then undergoes syllabification is more appealing, as this is essentially the same

[26] Note that while intervocalic loss of PB *d, *c, and *j is a mostly regular sound change in Ngwi, the loss of an intervocalic PB *b occurred only very sporadically. Similarly, while the loss of the merged Proto-WCB reflex *k of PB velar stops *k and *g in C_2 is very common throughout WCB (Pacchiarotti & Bostoen 2020), the loss of Proto-WCB *k in C_2 in Ngwi occurs in a very limited number of words (the most common reflex of Proto-WCB *k in C_2 is /ʁ/).

process at play in the creation of other V.V sequences (see sections 4.3.2 and 4.3.3).

When *V_1 and *V_2 were both [+high], they were retained as such as can be seen in (44). Sporadically, total assimilation occurred (cf. *túkì 'insult' > *ì-tíì*).

(44) *$CV_{[+high]}CV_{[+high]}$ > $CV_{[+high]}.V_{[+high]}$

BLR 4570	*bòdó 'swart, pimple' > *è-bùú*
BLR 1490	*gòdò 'leg' > *è-kúù*
BLR 1168	*dòdò 'bitterness' > *ò-lúù*
BLR 2642	*pókò 'mouse' > *Ø-mfúù*
BLR 761	*cúgù 'day' > *è-ʃúù*
BLR 2506	*pìcí 'bone' > *w-ìí*
BLR 1378	*gìdí 'egg' > *ì-kìí*
BLR 5755	*bídì 'leaf' > *ò-bíì* 'tuber, ear (e.g. of corn)'
BLR	*bìdí 'heat' > *Ø-mbìí*
BLR 3431	*jíjì 'stream' > *Ø-líì*
BLR 6040	*tìtì 'excrement' > *Ø-tìí*
BLR 5638	*jìbù 'mushroom' > *vìù*
BLR 2073	*kúpí 'short' > *kùì*
BLR 5339	*túkì 'insult' > *ì-tíì*

When either *V_1 or *V_2 was [+high], the [–high] historical vowel was fully assimilated to the [+high] vowel regardless of its phonotactic position as shown in (45). This assimilation process corroborates [+high] as a natural phonetic class as opposed to [–high] in Ngwi.

(45) *$CV_{[+high]}$ $CV_{[–high]}$ ~ *$CV_{[–high]}CV_{[+high]}$ > $CV_{[+high]}.V_{[+high]}$

BLR 230	*bícà 'back, rear' > *Ø-mbíì*
BLR 1607	*jɔ̀gù 'elephant' > *Ø-ndzúù*[27]
BLR 2677	*púdɔ̀ 'foam' > *è-fúù*
BLR 9461	*cákú 'safou fruit' > *è-súú*

V.V sequences also arose from the reanalysis of historical *CVV shapes, where VV was likely a diphthong in PB, into a sequence of two vowel nuclei, as shown in (46). While *u/*ʊ followed by *a were retained as such, other *CVV shapes show irregularity, compare for instance *ì-tíì* < BLR 3030 *tóì and *ò-dzúù* < BLR 6463 *dìù where *V_1 fully assimilates to *V_2 with *è-wúù* < BLR 364 *búì where *V_2 fully assimilates to *V_1.

[27] This form is attested in the western variety of Ngwi. In the eastern variety, 'elephant' is *Ø-ndzɔ́ɔ̀.*

(46) *CVV > CV.V

BLR 1521	*gúá 'salt' > *ò-kúá*
BLR 282	*búà 'dog' > *Ø-mvúá*[28]
BLR 3030	*túì 'ear' > *ì-tîì*
BLR 364	*búì 'white hair' > *è-wúù*
BLR 6463	*dìù 'root, fiber' > *ò-dzúù* 'root'

There is also scanty evidence that *CV shapes developed into CV.V, possibly through a stage were V.V was a diphthong, see (47). In this case too the [–high] natural class seems to have played an important role. Crucially, the only two examples available involve *ɔ. This change possibly happened by analogy with the creation of two vowel nuclei out of diphthongs from lenghthened [–high] vowels elsewhere in the language (see section 4.3.1).

(47) *CV > CGV > CV.V

BLR 1855	*kɔ̀ 'banana' > *ì-ŋkùò*
BLR 7178	*tɔ́ 'caterpillar' > *ò-túò*

5 Conclusions

In this paper we have shown that Ngwi, a West-Coastal Bantu language spoken in the DRC, has two phonemic interior vowels /ə/ and /ɤ/ and great tolerance for heterosyllabic vowel sequences. After the restructuring of the inherited PB seven vowel system, Ngwi was left with five phonemic vowels which formed two natural classes. The [+high] class contained /i/ and /u/, while the [–high] class contained /ɛ/, /ɔ/, and /a/. The interior vowels were originally allophones of /i/ in V_1 position in a $C_1V_1C_2V_2$ template, triggered by distinct conditionings. [ə] was the allophonic realization of Proto-Ngwi *i whenever V_2 was [–high], while [ɤ] was the allophonic realization of Proto-Ngwi *i whenever V_2 was [+high, +back]. Once the diachronic sound change of final vowel loss took place, the conditioning V_2 environment was lost and the interior allophonic vowels phonologized.

The great majority of heterosyllabic vowel sequences in Ngwi, whether word-medial or word-final, originate in the lengthening of a [–high] vowel. This [–high] vowel broke into a diphthong which was then syllabified as a sequence of two vowel nuclei. There were two main sources for vowel lengthening depending on the historical phonotactic shape from which the synchronic vowel sequence derives. The first source is automatic vowel lengthening in front of a nasal consonant cluster in C_2 position which was reduced to a simple nasal in Ngwi, i.e., CaNCV > Ca:N > CyaN > Cɛ.aN. While the other two [–high] vowels /ɛ/ and /ɔ/ diphthong-

[28] In elicitation, this word often sounds as [mvá]. However, whenever a word starting in a vowel follows, the /u/ surfaces, e.g. /mvúá ènɛ́/ > [mvú énɛ́] 'this dog'.

ized to [yɛ] and [wɔ] respectively, only the *ya* diphthong arising from a long [aː] became a sequence of two vowel nuclei in word-medial position, namely /ɛ.a/. The second source is a long [–high] vowel (or the coalescence of two distinct [–high] short vowels) created by the loss of an intervocalic consonant in a *$CV_{[-high]}CV_{[-high]}$ historical shape, i.e., *CVCV > CVV > CGV > CV.V, where G stands for glide. This second source gave rise to /i.a/, /i.e/, /u.o/, and /u.a/ sequences. Vowel sequences of [+high] vowels such as /i.i/, /u.u/, /i.u/, and /u.i/ may also originate from the loss of an intervocalic consonant in a *CVCV shape but do not involve any intermediate diphthongization step. Finally, word/syllable final V.V sequences in CV.V words where $V_{[+high]}.V_{[-high]}$ may also originate in *CVV shapes where VV was presumably a diphthong which was reanalyzed as two vowel nuclei. Thus, diphthongization originating in long vowels has been the major driving force in the creation of vowel sequences in Ngwi. While in some language families *iV sequences evolved into diphthongs (see, e.g., Chitoran & Hualde 2007), the diachronic phonological account proposed here offers evidence for the exact opposite development in Ngwi, i.e., /ɛ.a/ and /i.a/ sequences originating in diphtongs.

We conclude with a few region-specific observations which might be of interest for future diachronic phonological and phonetic research in the area. Diphthongs originating from vowel breaking are rare in Bantu languages but extremely common in all Lower Kasai languages spoken in the WCB homeland (Koni Muluwa & Bostoen 2012), see Map 1. Diphthongization appears to be a strong areal feature in the WCB homeland and the fission of diphthongs into heterosyllabic vowel sequences might have parallels in other languages. In fact, this feature makes a good candidate for substrate interference. In support of this speculation, Motingea Mangulu (2010, 156) observes that in Bantu languages such as Ntomba C35a, spoken north of the WCB homeland in the Mai Ndombe Province, on-glide diphthongs such as [wV] undergo what he calls 'revocalization' (*revocalisation* in the original French text), whereby the labiovelar glide becomes a full vowel, e.g. *mbwé* 'gray hair' is often realized as *mbùé*. Motingea Mangulu (2010) suggests that the phonetic realizations involving a glide should be considered as a recent development. Apparently, surrounding Pygmy groups speaking a variety of Mongo C61 display the same phenomenon (Hulstaert 1948) as the one observed in Ntomba C35a (and in Ngwi B861 as described in this paper). Note that the chronology proposed by Motingea Mangulu (2010), i.e., two heterosyllabic vowel sequences becoming a diphthong, is the opposite of what we propose in section 4.3.3, i.e., a diphthong crystallizing in two consecutive vowel nuclei. Without being able to say more at present, just like final vowel loss (Pacchiarotti & Bostoen 2021, 458), diphthongization occurs in languages belonging to distinct WCB phylogenetic subgroups (see Figure 3), is entirely absent in the remainder

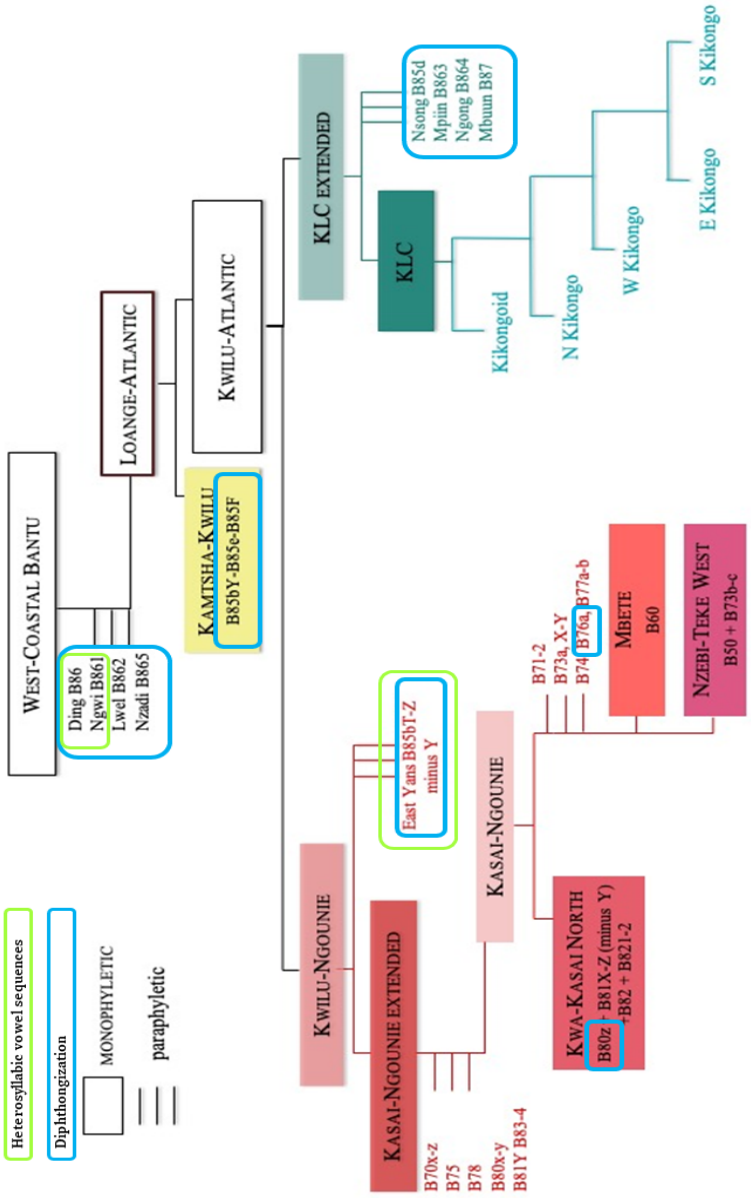


Figure 3: Distribution of diphthongization and suspected cases of heterosyllabic vowel sequences in WCB branches

of the branch, and is geographically restricted to the homeland area (see Map 1). Similarly, the fission of an erstwhile diphthong into a sequence of two vowel nuclei occurs in Ngwi B861 and very likely in Ding B86 (see section 4.3.2) and Yans B85 varieties based on evidence found in Rottland (1977) — see Figure 3. The suspected existence of fission in Ding B86 and Yans B85 should of course be corroborated by targeted research.

As such, diphthongization and fission make good candidates for substrate interference, i.e., the exposure to a shared external source through language contact is a plausible explanation for the geographic distribution of these features.

Another areal feature which could be the result of ancestral interactions with non-Bantu speaking populations is the presence of interior vowels. As briefly discussed in section 1, these appear to be quite common (and in complementary distribution with –ATR harmony) in the Macro-Sudan Belt. Within Bantu, they are particularly common in the northwestern area where languages from zones A and B are spoken and rainforest hunter-gatherer groups are still present, but not elsewhere. For instance, besides Ngwi and other WCB varieties belonging to Guthrie's referential zone B (see section 1), they are attested in Nen A44 (Mous 2003), Kpaʔ A53 (Guarisma 1969), and Makaa A83 (Heath 2003). Outside of Bantu zone A, they are also present in Bantoid languages such as Isu (Roland Kiessling p.c.). Whatever the case might be, fine-grained, both low-level phonetic and historically informed phonological research are pivotal for understanding the linguistic landscape of prehistoric central Africa and the phonological systems of poorly described languages found in the southern outskirts of the Congo rainforest.

Comments invited

PiHPh relies on post-publication review of the papers that it publishes. If you have any comments on this piece, please add them to its comments site. You are encouraged to consult this site after reading the paper, as there may be comments from other readers there, and replies from the author. This paper's site is here:

https://10.2218/pihph.6.2021.6693

Acknowledgements

We would like to thank Pavel Iosad for his insightful and stimulating comments on an earlier version of this paper. The research for this article was mainly funded by the Consolidator's Grant n° 724275 of the European Research Council (ERC) under the European Union's Horizon 2020

research and innovation program granted to the last author. The first and second authors also acknowledge the support of the FWO (Fonds Wetenschappelijk Onderzoek Vlaanderen) for the postdoctoral fellowship n° 12ZV721N and the PhD fellowship n°11D7221N respectively.

Author contact details

Sara Pacchiarotti, Lorenzo Maselli and Koen Bostoen
UGent Centre for Bantu Studies (BantUGent)
Department of Languages and Cultures
Blandijnberg 2
9000 Ghent
Belgium.

sara.pacchiarotti@ugent.be
lorenzo.maselli@ugent.be
koen.bostoen@ugent.be

References

Bastin, Yvonne, André Coupez, Evariste Mumba & Thilo C. Schadeberg. (eds.). 2002. *Bantu Lexical Reconstructions 3.* Tervuren: Royal Museum for Central Africa, online database: linguistics.africamuseum.be/BLR3.html (last accessed November 28, 2017).

Blevins, Juliette. 2009. Low vowel dissimilation outside of Oceanic: The case of Alamblak. *Oceanic Linguistics* 48(2). 477–483.

Boersma, Peter. 1997. Inventories in functional phonology. *Proceedings (Instituut voor Fonetische Wetenschappen, Universiteit van Amsterdam)* 21. 59–90.

Boone, Olga. 1973. *Carte ethnique de la République du Zaïre. Quart sud-ouest*. Tervuren: Musée royal de l'Afrique centrale.

Bostoen, Koen. 2019. Reconstructing Proto-Bantu. In Van de Velde, Mark, Bostoen, Koen, Nurse, Derek & Philippson, Gérard (eds.), *The Bantu Languages,* second edition, 308334. Oxford: Routledge.

Bostoen, Koen & Yvonne Bastin. 2016. Bantu lexical reconstruction. *Oxford Handbooks Online*. Oxford: Oxford University Press.

Bostoen, Koen & Heidi Goes. 2019. Was Proto-Kikongo a 5 or 7 vowel language? Bantu spirantization and vowel merger in the Kikongo Language Cluster. *Linguistique et langues africaines* 5. 2568.

Bostoen, Koen & Joseph Koni Muluwa. 2011. Vowel split in Hungan (Bantu H42, Kwilu, DRC): A contact-induced language-internal change. *Journal of Historical Linguistics* 1(2). 247268.

Bostoen, Koen & Joseph Koni Muluwa. 2014. Umlaut in the Bantu B70/80 languages of the Kwilu (DRC). *Transactions of the Philological Society* 112(2). 209–230.

Botma, Bert, Pavel Iosad & Hidetoshi Shiraishi. 2015. Phonetic (non-) explanation in historical phonology: Duration, harmony, and dissimilation. Paper presented at *The second Edinburgh Symposium on Historical Phonology* held at the University of Edinburgh.

Bwantsa Kafungu, Pierre S. 1966. *Esquisse phonologique et morphologique de la langue ngwii*. Mémoire, Université de Lovanium et Université de Kinshasa.

Bwantsa Kafungu, Ofonobon Olocy Aatom. 1979. *Les formes nominales et verbales du ngwî de la Kamtsha-Loange (Bandundu/Zaïre)*. Thèse de doctorat, Université Nationale du Zaïre, Institut Superieur Pédagogique Kinshasa/Gombe.

Chitoran, Ioana & José Ignacio Hualde. 2007. From hiatus to diphthong: the evolution of vowel sequences in Romance. *Phonology* 24. 37–75.

Clements, Nick & Annie Rialland. 2008. Africa as a phonological area. In Heine, Bernd & Nurse, Derek (eds.), *A linguistic geography of Africa,* 36–85. Cambridge/New York: Cambridge University Press.

Coupez, André, Yvonne Bastin & Evariste Mumba. (eds.). 1998. *Reconstructions lexicales bantoues 2 / Bantu lexical reconstructions 2 (electronic database).* Tervuren: Musée royal de l'Afrique centrale.

de Chene, Brent E. 2014. *The historical phonology of vowel length* London: Routledge.

de Rop, Albert Jozef. 1958. *Éléments de phonétique historique de lomongo*, Léopoldville: Université Lovanium.

Ebalantshim, Masuwan. 1980. *Esquisse grammaticale de la langue idiŋ à Káantsa*. M.A., Université Nationale du Zaïre.

Finley, Sara. 2012. Typological asymmetries in round vowel harmony: Support from artificial grammar learning. *Language and Cognitive Processes* 27(10). 1550–1562.

Flemming, Edward. 2009. The phonetics of schwa vowels. In Minkova, Donka (ed.), *Phonological weakness in English: From old to present-day English*, 78–95. Houndmills: Palgrave McMillan.

Garrett, Andrew. 2015. Sound change. In Bowern, Claire & Evans, Bethwyn (eds.), *The Routledge handbook of historical linguistics,* 227–248. London: Routledge.

Gordon, Matthew, Edita Ghushchyan, Bradley McDonnell, Daisy Rosenblum & Patricia A. Shaw. 2012. Sonority and central vowels: A cross-linguistic phonetic study. In Parker, Steve (ed.), *The sonority controversy,* 219–256. Berlin: Mouton de Gruyter.

Greenwood, Anna. 2016. *An experimental investigation of phonetic naturalness*. PhD dissertation. University of California at Santa Cruz.

Grégoire, Claire. 2003. The Bantu languages of the forest. In Nurse, Derek & Philippson, Gérard (eds.), *The Bantu languages,* 349–370. London New York: Routledge.

Guarisma, Gladys. 1969. *Etudes bafia: phonologie, classes d'accord et lexique bafia-français*. Paris: Société des Etudes Linguistiques et Anthropologiques.

Güldemann, Tom. 2008. The Macro-Sudan Belt: Towards identifying a linguistic area in Northern Sub-Saharan Africa. In Heine, Bernd & Nurse, Derek (eds.), *A linguistic geography of Africa,* 151–185. Cambridge/New York: Cambridge University Press.

Hammarström, Harald. 2019. An inventory of Bantu languages. In Van de Velde, Mark, Koen Bostoen, Derek Nurse & Gérard Philippson (eds.), *The Bantu languages*, second edition, 17–78. Oxford: Routledge.

Heath, Theresa. 2003. Makaa (A83). In Nurse, Derek & Gérard Philippson (eds.), *The Bantu languages,* 335–348. London: Routledge.

Hock, Hans Henrich. 1991. *Principles of historical linguistics*, second edition. Berlin/New York: Mouton de Gruyter.

Honeybone, Patrick & Joseph Salmons. 2015. *The Oxford handbook of historical phonology*. Oxford: Oxford University Press.

Hulstaert, Gustaaf. 1948. Le dialecte des pygmoïdes Batswa de l'Equateur. *Africa* 18(1). 21–28.

Hyman, Larry. 2003. Segmental phonology. In Nurse, Derek & Gérard Philippson (eds.), *The Bantu languages,* 42–58. London/New York: Routledge.

Hyman, Larry M. 2008. Directional asymmetries in the morphology and phonology of words, with special reference to Bantu. *Linguistics* 46(2). 309–350.

Hyman, Larry. 2019. Segmental Phonology. In Van de Velde, Mark, Bostoen, Koen, Nurse, Derek & Philippson, Gérard (eds.), *The Bantu Languages*, second edition, 128–149. Oxford: Routledge.

Hyman, Larry M., Nicholas Baier, Emily Clem, Peter Jenks, Florian Lionnet, John Merrill, Nicholas Rolle & Hannah Sande. 2019. Niger-Congo linguistic features and typology. In Wolff, Ekkehard (ed.), *The Cambridge handbook of African linguistics,* 191–245. Cambridge: Cambridge University Press.

Khang Levy, Nyi-m'shum. 1979. *Eléments de grammaire morphologique de la langue lwel*. mémoire de licence, Université Nationale du Zaïre.

King, Robert D. 1967. Functional load and sound change. *Language* 43. 831–852.

Koffi, Ettien. 2018. The acoustic vowel space of Anyi in light of the cardinal vowel system and the Dispersion Focalization Theory. In Kandybowicz, Jason, Travis Major, Harold Torrence & Philip T. Duncan (eds.), *African linguistics on the prairie: Selected papers from*

the 45th Annual Conference on African Linguistics. Berlin: Language Science Press.

Koni Muluwa, Joseph & Koen Bostoen. 2012. La diphtongaison dans les langues bantu B70–80 (Bandundu, RDC): typologie et classification historique. *Africana Linguistica* 18. 355–386.

Koni Muluwa, Joseph & Koen Bostoen. 2019. Nsong (B85d). In Van de Velde, Mark, Koen Bostoen, Derek Nurse & Gérard Philippson (eds.), *The Bantu languages*, second edition, 414–448. Oxford: Routledge.

Kumpel Wossey, Angélique 2001. *Morphologie nominale du ngwi ɛngyɛ*. Mémoire de licence, Institut Superieur Pédagogique de la Gombe.

Labov, William. 1994. *Principles of linguistic change, volume 1: Internal factors*, Oxford: Wiley-Blackwell.

Ladefoged, Peter. 1971. *Preliminaries to linguistic phonetics*. Chicago: University of Chicago Press.

Ladefoged, Peter. 1993. *A course in phonetics,* third edition. London: Harcourt Brace Jovanovich.

Liljencrants, Johan & Bjorn Lindblom. 1972. Numerical simulation of vowel quality systems: The role of perceptual contrast. *Language* 48. 839–862.

Lindblom, Bjorn. 1986. Phonetic universals in vowel systems. In Ohala, John J. & Jeri J. Jaeger (eds.), *Experimental phonology,* 13–44. New York: Academic Press.

Lindblom, Bjorn. 1990. Explaining phonetic variation: A sketch of the H&H theory. In Hardcastle, William J. & Alain Marchal (eds.), *Speech production and speech modelling,* 403–439. Dordrecht: Kluwer Academic Publishers.

Lionnet, Florian & Larry M. Hyman. 2018. Current issues in African phonology. In Güldemann, Tom (ed.), *The languages and linguistics of Africa*. Berlin: Mouton de Gruyter.

Maalu-Bungi, Crispin, H. M. Mutombo, P. A. Mbula, André Motingea Mangulu, André Makokila, Léon Mundeke, Jean-Pierre Donzo Bunza & I. M. Nsenga. 2011. *Atlas linguistique de la République Démocratique du Congo*, version révisée. Yaoundé: Editions du Cerdotola.

Maho, Jouni Filip. 2009. NUGL online: The online version of the new updated guthrie list, a Referential Classification of the Bantu Languages. http://goto.glocalnet.net/mahopapers/nuglonline.pdf (Accessed December 13, 2010).

Meeussen, Achiel Emiel. 1979. Vowel length in Proto-Bantu. *Journal of African languages and linguistics* 1(1). 1–8.

Mfum-Ekong, Adiate. 1979. *Esquisse grammaticale yansi 'parler ntsambaan': phonologie et morphologie*. mémoire de licence, Université Nationale du Zaïre.

Motingea Mangulu, André. 2010. *Aspects des parlers minoritaires des lacs Tumba et Inongo: contribution à l'histoire de contact des langues dans le bassin central congolais*. Tokyo: Research Institute for Languages and Cultures of Asia and Africa (ILCAA), Tokyo University of Foreign Studies.

Mous, Maarten. 2003. Nen (A44). In Nurse, Derek & Gérard Philippson (eds.), *The Bantu languages,* 283–306. London; New York: Routledge.

Mula, Emy. 1977. *Esquisse de grammaire kiding munken: phonologie et morphologie (parler de Bantsiona)*. Mémoire de licence, Université Nationale du Zaïre.

Niendéka, Gene & Madidi Djedje. (1986). La culture du riz chez les Ngwi orientaux dans le Nord du Kwilu (Zaïre): une culture bloquée. *Cahiers de la Recherche Développement* 11. 42–47.

Obey, E. M. 1984. *Le ngwi et le proto bantu*. Mémoire, Université de Kinshasa.

Oh, Yoon Mi, François Pellegrino, Christophe Coupé & Egidio Marsico. 2013. Cross-language comparison of functional load for vowels, consonants, and tones. *Interspeech 2013*. 3032–3036.

Pacchiarotti, Sara & Koen Bostoen. 2020. The Proto-West-Coastal Bantu velar merger. *Africana Linguistica* 26. 139–195.

Pacchiarotti, Sara & Koen Bostoen. 2021. Final vowel loss in Lower Kasai Bantu (DRC) as a contact-induced change. *Journal of Language Contact* 14. 437–475.

Pacchiarotti, Sara & Koen Bostoen. forthcoming. Erratic velars in West-Coastal Bantu: Explaining irregular sound change in Central Africa. *Journal of Historical Linguistics*.

Pacchiarotti, Sara, Natalia Chousou-Polydouri & Koen Bostoen. 2019. Untangling the West-Coastal Bantu mess: Identification, geography and phylogeny of the Bantu B50–80 languages. *Africana Linguistica* 25. 155–229.

Paulian, Christiane. 1975. *Le kukuya, langue teke du Congo: phonologie-classes nominales*: Paris: Société des Etudes Linguistiques et Anthropologiques.

Pearce, Mary. 2007. ATR allophones or undershoot in Kera? *UCL Working Papers in Linguistics* 19. 31–43.

Peperkamp, Sharon , Katrin Skoruppa & Emmanuel Dupoux. 2006. The role of phonetic naturalness in phonological rule acquisition. In Bamman, David, Tatiana Magnitskaia & Colleen Zaller (eds.), *Proceedings of the 30th Annual Boston University conference on language development,* 464–475. Somerville, MA: Cascadilla Press.

Polka, Linda & Ocke-Schwen Bohn. 2003. Asymmetries in vowel perception. *Speech Communication* 41. 221–231.

Pycha, Anne, Pawel Nowak, Eurie Shin & Ryan Shosted. 2003. Phonological rule-learning and its implications for a theory of vowel harmony. In Garding, G. & M. Tsujimura (eds.), *Proceedings of the West Coast Conference on formal linguistics 22,* 423–435. Somerville: Cascadilla Press.

Rolle, Nicholas, Matthew Faytak & Florian Lionnet. 2017. The distribution of advanced tongue root harmony and interior vowels in the Macro-Sudan Belt. *UC Berkeley Phonetics and Phonology Lab Annual Report*. 93–107.

Rottland, Franz. 1977. Reflexes of Proto-Bantu phonemes in Yanzi (B85). *Africana Linguistica* 7. 375–396.

Schadeberg, Thilo & Koen Bostoen. 2019. Word formation. In Van de Velde, Mark, Koen Bostoen, Derek Nurse & Gérard Philippson (eds.), *The Bantu languages*, second edition, 172–203. New York: Routledge.

Schadeberg, Thilo C. 1995. Spirantization and the 7-to-5 vowel merger in Bantu. *Belgian Journal of Linguistics* 9. 71–84.

Schürr, Friedrich. 1970. *La diphtongaison romane*. Tübingen: Präzis.

Surendran, Dinoj & Partha Niyogi. 2006. Quantifying the functional load of phonemic oppositions, distinctive features, and suprasegmentals. In Nedergaard Thomsen, Ole (ed.), *Competing models of linguistic change: Evolution and beyond,* 43–58. Amsterdam/Philadelphia: John Benjamins.

Swartenbroeckx, Pierre 1948. *Dictionnaire kiyansi ou kiyei, langage des bayansi ou bayey de territoire de Banningville (district du Lac Léopold II) au Congo Belge*. Bruxelles: Royal Museum for Central Africa.

Van de Velde, Mark. 2013. The Bantu connective construction. In Carlier, Anne & Jean-Christophe Verstraete (eds.), *The genitive,* 217–252. Amsterdam: John Benjamins.

Van de Velde, Mark & Dmitry Idiatov. 2016. Stem-initial accent and C-emphasis prosody in north-western Bantu. Paper presented at the Special Workshop on Areal Features and Linguistic Reconstruction, 47th Annual Conference on African Linguistics, 23–26 March, 2016, University of California, Berkeley.

Wang, W. S.-Y. (1967). The measurement of functional load. *Phonetica* 16(1). 36–54.