Vowel Harmony in Bantu

on phonology, typology and grounding

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Introduction

- This talk considers progressive vowel height harmony in five-vowel Bantu languages
- I explore issues relating to its phonetic grounding and offer perspectives on synchronic formal analyses
- I use two types of quantitative and experimental data
  - Vowel-pair frequencies in the lexicon
  - Formant data from an acoustic production study
- Today I focus mainly on two particular pairs of interest, [e.i] and [o.u]
  - 🕮 For more, see Nichols (2021: ch. 4)

Introduction

- A vowel-pair frequency study finds that [e.i] and [o.u] are generally under-represented in an area of the lexicon usually thought to be unaffected by harmony
- But that the dispreference for [o.u] seems to be stronger, mirroring the typological tendency, perhaps suggesting that the grounding of its avoidance is stronger
- However, a production study examining V-to-V coarticulation – often touted as the origin of vowel harmony – finds potential evidence of the opposite
- Which may suggest a role for perceptual factors in the origin of height harmony
- I also present a close consideration of lexical-statistical data in one language, Lozi, finding that height harmony may not necessarily operate in the way we might suppose

1. Background information

Vowel harmony

- In a nutshell, vowel harmony is the phonological restriction that vowels within a certain domain must agree with respect to one or more features

  🇹🇷 [deniz], *[daniz], *[denɯz] ‘sea’ [altɯn], *[eltɯn], *[altin] ‘gold’

- The effects of harmony are typically observable not only in static restrictions in the lexicon but also in phonological alternations

  🇹🇷 [deniz-i], *[deniz-ɯ] ‘sea-ACC’; [altɯn-ɯ], *[altɯn-i] ‘gold-ACC’

- However, exceptions are very common in vowel harmony systems

  🇹🇷 [elʲma] ‘apple’; [tʃek-ijor] ‘pull-IMPF’

- Though intervening consonants do not usually affect harmony, they sometimes do

  🇹🇷 [kol-u] ‘arm-ACC’; [rolʲ-y] ‘role-ACC’

Bantu languages

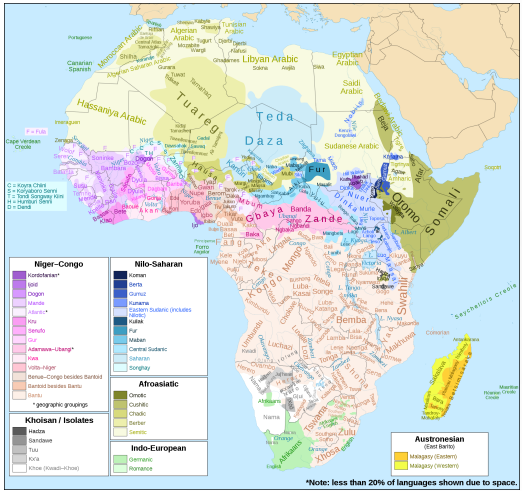


Figure 1: Linguistic map of Africa

- The Bantu languages are sub-family of the Niger–Congo phylum, which comprises some 1,500 languages (Heine & Nurse 2000)
- There are around 500 ± 50 Bantu languages, according to taxonomic preference (Hammarström 2019; Marten 2020)

Bantu languages

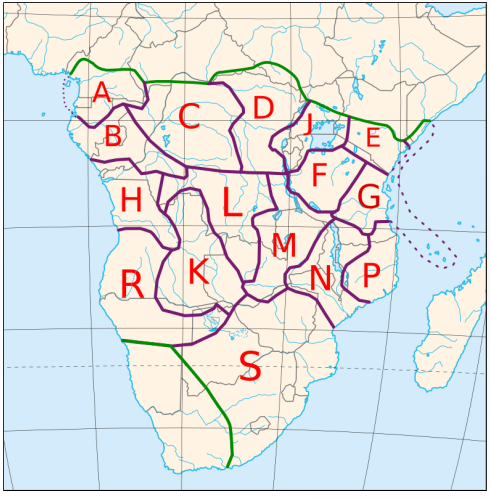


Figure 2: Guthrie zones of the Bantu languages

- Spoken across a vast contiguous area of sub-Saharan Africa (Bostoen & Van de Velde 2019)
- Grouped into 16 lettered geographic zones
- Each language is also given a number (and sometimes a following letter)
  - S.42 for Zulu
  - L.31a for Tshiluba
- First proposed by Guthrie (1967–71)
  - See also Maho (2009)

Bantu languages

- Most Bantu languages have a phonemic inventory of either five or seven vowels (Maddieson & Sands 2019)
  - ❺ /i, u, e~ɛ, o~ɔ, a/
  - ❼ /i, u, e, o, ɛ, ɔ, a/, /i, u, ɪ, ʊ, ɛ, ɔ, a/ or /i u e o ɛ ɔ a/
  - ☞ This talk concerns only those languages with a **five-vowel** system
- Almost all have phonemic tone (Kisseberth & Odden 2003; Marlo & Odden 2019)
- Many show contrastive vowel length (Maddieson & Sands 2019)
- However, neither of these interfere with the application vowel harmony

Bantu languages

- Bantu morphology makes heavy use of both prefixes and suffixes (Nurse & Devos 2019; Schadeberg & Bostoen 2019; Van de Velde 2019)
- Underived nouns are most often composed of a stem and noun class prefix
  - E.g. Swahili ***m-toto*** '1-child' = 'child', ***wa-toto*** '2-child' = 'children'
- Nouns are commonly derived by suffixation
  - E.g. Swahili ***nen-o*** 'say-DRV' = 'word', ***m-pish-i*** '1-cook-DRV' = 'cook'
- Compounds are also to be found
  - E.g. Swahili ***mw-ana*** + ***ch-ama*** '1-child + 7-party' = 'party member', ***ki-pima*** + ***joto*** '7-measure + heat' = 'thermometer'

Bantu languages

- In Bantu languages, verbs typically take more affixes than the noun
- Prefixes are used to encode argument agreement, negation, tense/aspect/mood
- Suffixes mark valency changes and other derivations – “verbal extensions”
- A “final inflectional vowel” – part of the exponence of tense/aspect/mood – is also required (in most Bantu languages)

(1) Ha-wa-ta-tu-**fung**-ul-i-a m-lango. (Swahili)
NEG-SM3PL-FUT-OM1PL-**shut**-REV-APPL-FV 3-door
‘They will not open the door for us.’

Vowel harmony in Bantu

- Vowel harmony is extremely common among Bantu languages
  - Clements (1991), Hyman (1999: §2, 2003), Odden (2015: §1), Kula (in press)
- In the family, we find two main types of vowel harmony:
  - **Height** harmony
  - **Tongue root** harmony
- In five-vowel languages, and in this talk, it is the **first** of these that is of interest

Height harmony in Bantu

- Height harmony is most often characterised as being **confined to verbs**, causing alternations only in verbal extensions
- By far the commonest variety is the so-called canonical pattern (after Hyman 1999: 238)
  - Found in e.g. Kinyarwanda (D.61), Luganda (E.15), Shona (S.11), Swahili (G.42)
- This has been the focus of most work on height harmony in Bantu
  - Katamba (1984), Mtenje (1985), Moto (1989), Clements (1991), Hyman (1991), Scullen (1992), Mutaka (1995), Steriade (1995), Harris (1994, 1997), Marten (1996, 1997), Beckman (1997), Downing (2010), Downing & Mtenje (2017)

Canonical height harmony in Bantu

- Canonical height harmony is progressive (= perseverative = left-to-right)
- It is also asymmetric w.r.t. rounding (and/or backness) and, at least descriptively, can be split into **front** and **back** height harmony

(2) a. Canonical front height harmony: i → e / _ {e o}

b. Canonical back height harmony: u → o / _ o

- This is common synchronically and diachronically robust (Hyman 1999: 238, 245)
- Note also that, mid vowels do not occur outside the initial syllable of verb roots or in verbal extensions unless except as a result of harmony
- Typologically, another asymmetry is also found: certain languages show **only back height harmony** but none exhibit **front height harmony only** (Hyman 1999: 245)

Canonical height harmony in Swahili

(3) Unsuffixed:

a. -zib-a
'to stop up'

b. -fung-a
'to shut'

c. -teg-a
'to set a trap'

d. -chom-a
'to stab'

e. -pang-a
'to arrange'

(4) Applicative suffix:

a. -zib-i-a
'to stop up for'

b. -fung-i-a
'to shut for'

c. -t**e**g-**e**-a
'to set a trap for'

d. -ch**o**m-**e**-a
'to stab for'

e. -pang-i-a
'to arrange for'

(5) Reversive suffix:

a. -zib-u-a
'to unblock'

b. -fung-u-a
'to open'

c. -teg-u-a
'to disassemble a trap'

d. -ch**o**m-**o**-a
'to pull out'

e. -pang-u-a
'to disarrange'

(Kirkeby 2000; Awde 2002; Ngonyani & Ngowa 2016)

2. Vowel-pair frequencies in the lexicon

The lexicon, naturalness and phonotactics

- The lexicon of a particular language is likely to contain gaps regarding those structures that are combinatorily possible given, for example, its segment inventory
- Similarly, certain combinations may be relatively over- or under-represented
- Some of these may be **accidental** whereas other may be **phonotactic** in nature (e.g. Becker et al. 2011; Gorman 2013; Wilson & Gallagher 2018)

The lexicon, naturalness and phonotactics

- There is evidence that phonetically unnatural or complex patterns are able to be learnt (e.g. Pycha et al. 2003; Seidl & Buckley 2005; Peperkamp & Dupoux 2007; Skoruppa & Peperkamp 2011; Moreton & Pater 2012a,b; Windsor & Stewart 2017)
- But only weakly – putatively phonetically natural or simple patterns, however, are seemingly comparatively easier to acquire (e.g. Wilson 2006; Moreton 2008; Hayes et al. 2009; Becker et al. 2011; Hayes & White 2013; Moore-Cantwell 2016)
- There is also some evidence that categorical alternations may be echoed by gradient preferences in the lexicon (e.g. Martin 2007, 2011)
- And that the learning of alternations is facilitated by static generalisations (e.g. Chong 2017, 2021; see also Tesar & Prince 2003; Hayes 2004; Jarosz 2006)

This study

- Recall that, in five-vowel languages, height harmony is most often characterised as being **confined to verbs** and alternations are only seen in verbal extensions
  - Beckman (1997: 38): 'The distributional generalisations which apply to height features in Shona verbs apparently do not hold of Shona nouns'
- Are those pairs that are banned in verbs **under-represented** in nouns?
- Given that height harmony in verbs is commonly asymmetric in some way, do we find any asymmetries in nouns?
- Here, I examine vowel-pair frequencies **in the nouns** of six languages, focusing on four pairs of particular interest: **[e.e]**–**[e.i]** and **[o.o]**–**[o.u]**

Methodology

- Data from the Comparative Bantu Online Dictionary:
  - 💻 http://www.cbold.ish-lyon.cnrs.fr/
  - ☹ Though this seems to have since gone offline
- Each file was hand-corrected for machine-readability and then processed in R
  - Raw counts for all 25 possible vowel pairs obtained
  - Observed and expected frequencies calculated
  - From which corresponding observed–expected ratios were derived
    - ☞ <1 under-represented; ≈ 1 as expected; >1 over-represented
- Individual entries (already) tagged for part of speech.

The sample

Language (code)	Harmony system	Data source	№ of entries
Chewa (M.31b)	Canonical	Mtenje (2001)	24,076
Kalanga (S.16)	Canonical	Mathangwane (1994)	8,505
Yao (P.21)	Canonical	Ngunga (2001)	25,954
Pende (L.11)	Quasi-canonical	Gusimana (1972)	38,385
Lozi (K.21)	Back height harmony only	Jalla (1982)	49,981
Makhuwa (P.31)	Back height harmony only	Kisseberth (1996)	29,802

Table 1: The six-language sample

The sample

Canonical *Chewa, Kalanga, Yao*			
i.i	i.e	i.u	i.o
u.i	u.e	u.u	u.o
e.i	e.e	e.u	e.o
o.i	o.e	o.u	o.o
a.i	a.e	a.u	a.o

Quasi-Canonical *Pende*			
i.i	i.e	i.u	i.o
u.i	u.e	u.u	u.o
e.i	e.e	e.u	e.o
o.i	o.e	o.u	o.o
a.i	a.e	a.u	a.o

Back only *Lozi, Makhuwa*			
i.i	i.e	i.u	i.o
u.i	u.e	u.u	u.o
e.i	e.e	e.u	e.o
o.i	o.e	o.u	o.o
a.i	a.e	a.u	a.o

Table 2: Harmonic and non-harmonic vowel pairs in each harmony system of the sample

Results

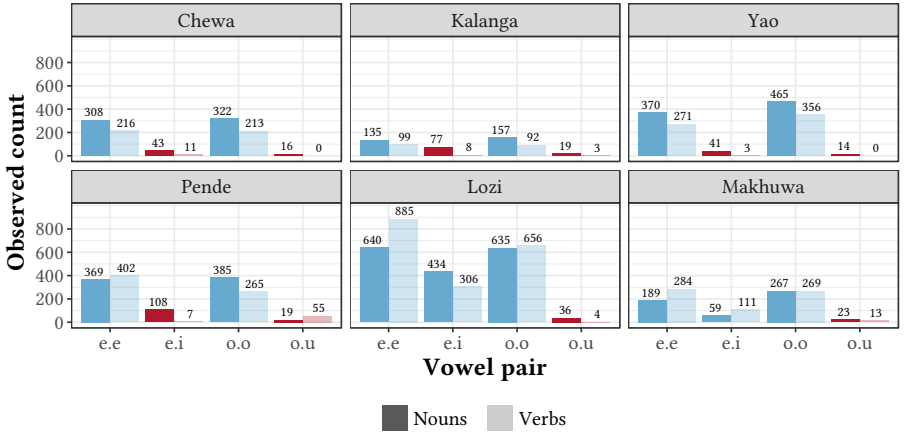


Figure 3: Raw counts in nouns and verbs (**harmonic** v. **non-harmonic**)

Results

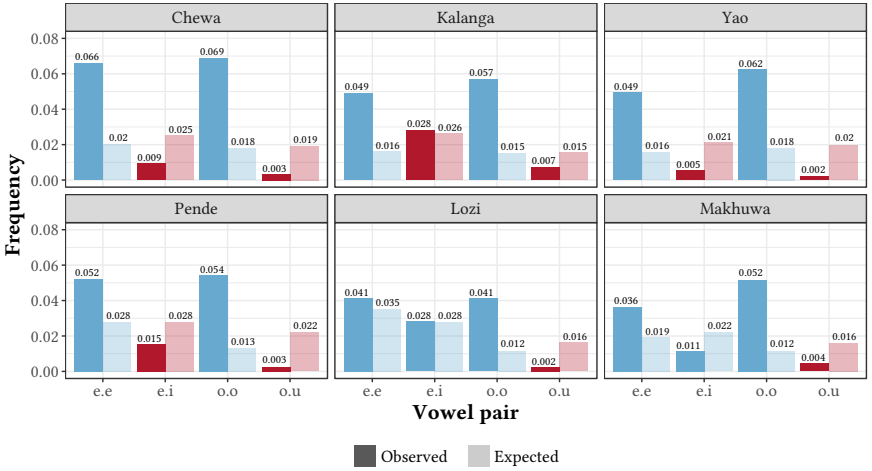


Figure 4: Observed and expected frequencies in nouns and verbs (**harmonic** v. **non-harmonic**)

Results

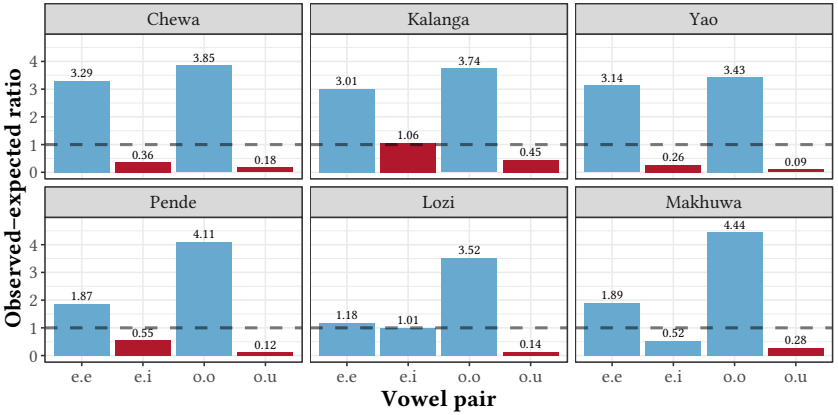


Figure 5: Observed–expected ratios in nouns (**harmonic** v. **non-harmonic**; dashed line = 1)

Results

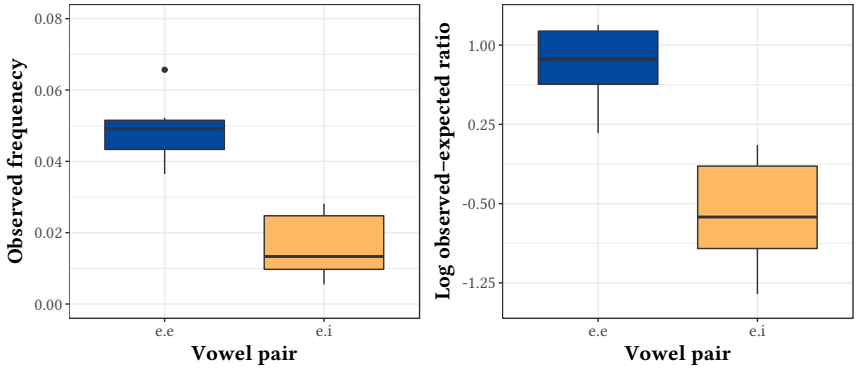


Figure 6: Observed frequencies (left) and log observed–expected ratios (right) in nouns for [e.i]–[e.e]

Results

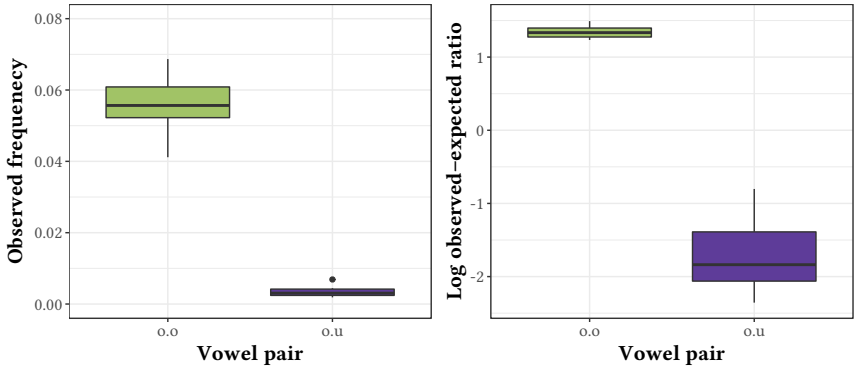


Figure 7: Observed frequencies (left) and log observed–expected ratios (right) in nouns for [o.o]–[o.u]

Results

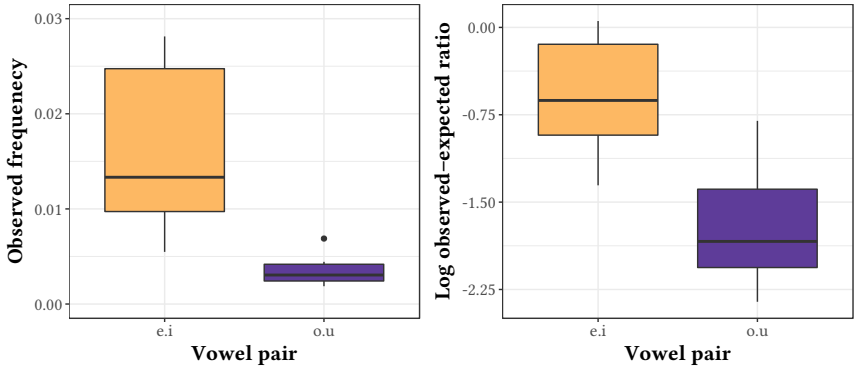


Figure 8: Observed frequencies (left) and log observed–expected ratios (right) in nouns for [e.i]–[o.u]

Discussion: Front vowels

- The results do not show a universal correlation of the presence/absence of front height harmony in verbs on the levels of [e.i] in nouns
- [e.i] is under-represented in nouns in Chewa, Yao and Pende but also in Makhuwa
- [e.i] is not under-represented in nouns in Lozi but neither is this case in Kalanga
- Nevertheless, in Kalanga, [e.e] is much more frequent in nouns than [e.i]

Discussion: Back vowels

- What is found, however, is that [o.u] is under-represented across all languages
- This could perhaps be interpreted as a gradient counterpart in nouns to the categorical rule in verbs
- Cf. the following observations by Martin (2011):
  - In English, geminates – which are prohibited tautomorphemically – are relatively under-represented in heteromorphemic items
  - In Navajo, where sibilants within roots must agree for anteriority, compounds containing sibilants disagreeing in anteriority are found less frequently than expected

Discussion: Induction or phonetic pressure?

- Martin (2011) argues that such lexical biases arise as a compromise brought about by the competition between certain phonotactic preferences and semantic preferences
- Archangeli et al. (2012a,b) suggest that patterns such as that seen in Chewa could be argued to be predictable simply on **inductive** grounds
  - '[Universal Grammar] predicts an absence of an extension while [Emergent Grammar] predicts extension due to the attractor effect'
- However, as Martin (2011: 757) acknowledges, such distributions 'could both result from the **same phonetic pressure**' (cf. "rule scattering", on which more later)
- That is, rather than one part of the lexicon exerting an influence over another, both share a common cause

Discussion: Induction or phonetic pressure?

- Recall that Makhuwa lacks front height harmony but nevertheless displays a marked difference between [e.e] and [e.i] in nouns
- This therefore cannot be due to the influence of the effect of harmony in verbs
- Moreover, it is potentially problematic for such accounts that [o.u] is much more under-represented than expected in nouns than [e.i] as, in four of the six sample languages, both occur in extremely low levels in verbs
- As [e.i] and [o.u] behave similarly in verbs in languages with both front and back height harmony, a difference in their behaviours in nouns is unexpected
- This is also further reflected in a more widely cross-Bantu context – no Bantu languages possess front but not back height harmony (Hyman 1999: 245)

Discussion: Induction or phonetic pressure?

- It may be then that [e.i] and [o.u] are under-represented due to their avoidance being phonetically motivated or well grounded because of differences in height
- And that there is some sort of stronger bias against [o.u] than [e.i]

Summary

- I looked at the frequencies of [e.e]–[e.i] and [o.o]–[o.u] in **nouns** and the relationship with alternations seen in **verbs** due to height harmony
- Those pairs agreeing in height are generally over-represented in nouns and those disagreeing in height are generally under-represented
- The overall difference in representation of [o.o] compared with [o.u] was **greater** than the difference between [e.e] and [e.i]
- Back rounded [o.u] is without exception **less frequent** than front unrounded [e.i] in the current sample
- Perhaps suggesting that, although there is pressure to avoid **both** [e.i] and [o.u], this pressure is greater regarding [o.u] than [e.i]

3. A closer look at Lozi

Introduction

- Having taken a look at a broad sample, here I now zoom in on Lozi
- What might a closer examination of a single language tell us?
- Again, I discuss vowel pairs, using the same methodology as the previous section
- After closer inspection, I propose that Lozi actually works slightly differently than we might have assumed
- Namely that the language shows a prohibition against [o.u] – and only [o.u] – that is blind to lexical category

Lozi

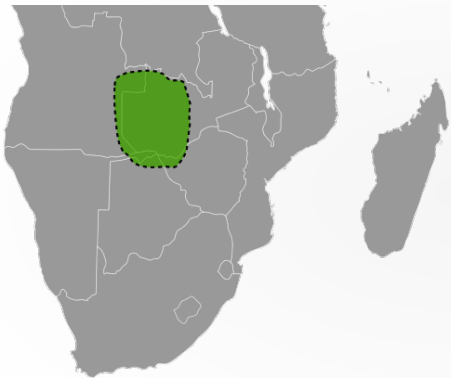


Figure 9: Lozi-speaking area within southern Africa

- Lozi is a Bantu language spoken by c. 750,000 speakers mainly in Zambia (Eberhard et al. 2023)
- It is descended from Sotho (S.33) (Gowlett 2003)
  - But has also been heavily influenced by Luyana (K.31)
  - As well as, to a lesser extent, Tswana (S.31)
  - See Gowlett (1989) for more on Lozi's history

Back height harmony only in Lozi

(6) Causative suffix:

a. -pim-is-a
‘to help avoid’

b. -hupul-is-a
‘to remind’

c. -lemb-is-a
‘to put to shame’

d. -long-is-a
‘to help load’

e. -tam-is-a
‘to help tie’

(7) Applicative suffix:

a. -bih-el-a
‘to report to’

b. -fuluh-el-a
‘to paddle towards’

c. -lem-el-a
‘to fell for’

d. -shombot-el-a
‘to catch for’

e. -sham-el-a
‘to urinate in’

(8) Reversive suffix:

a. -tin-ulul-a
‘to undress’

b. -lut-ulul-a
‘to unthatch’

c. -lek-ulul-a
‘to resell’

d. -n**o**t-**o**l**o**l-a
‘to unlock’

e. -pak-ulul-a
‘to unbolt’

(Jalla 1982)

Results

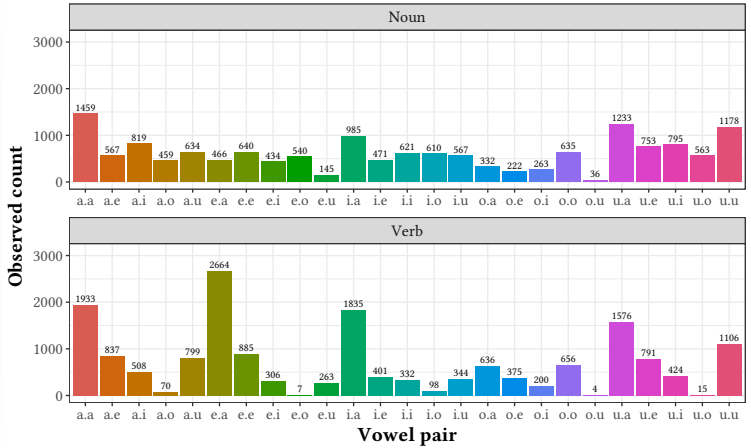


Figure 10: Raw counts for all vowel pairs (by part of speech)

Results

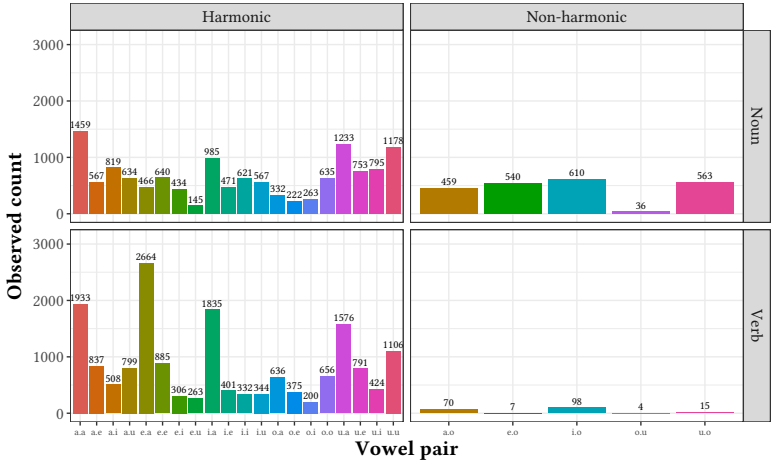


Figure 11: Raw counts for all vowel pairs (by part of speech and harmonicity)

Results

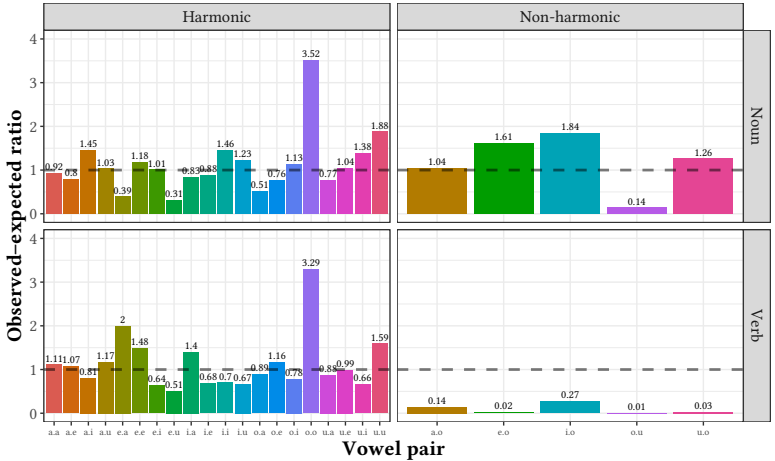


Figure 12: Observed–expected ratios for all vowel pairs (by part of speech and harmonicity)

Results

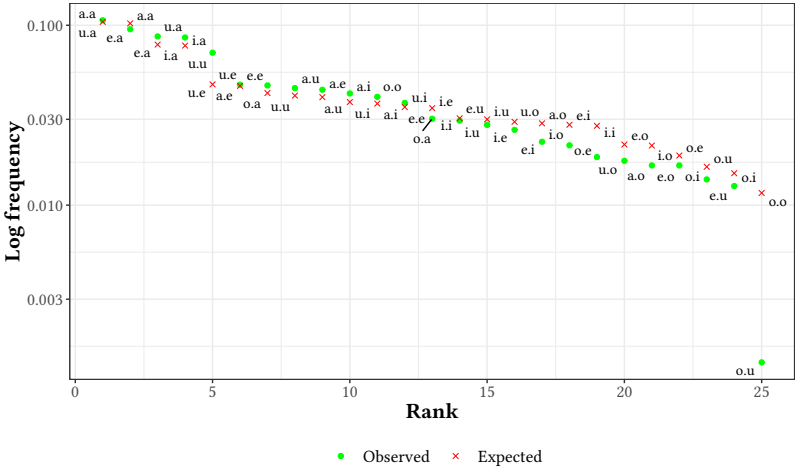


Figure 13: Observed and expected rank–frequency distributions for all vowel pairs

Discussion: Analytical implications

- There is a **near-total absence** of [o.u] in both verbs and nouns
- Something which does not hold across the lexicon for [i.o, u.o, e.o, a.o]
- This suggests an active **phonotactic prohibition** against [o.u] which applies regardless of lexical category
- The reversive suffix is then underlyingly /-**u**l**u**l-/ and undergoes a phonotactic change to [-**o**l**o**l-] following /**o**/; elsewhere it surfaces faithfully as [-**u**l**u**l-]
- The remaining gaps in verbs are then synchronically **accidental** historical residue

Discussion: Exceptions are not random

- The intervening segments in exceptional instances of [o.u] are not random
  - 63% have an intervening labial

    (9) a. bub**o**f**u** ‘blindness’

    b. siy**o**p**u** ‘hut used for ritual confinements’

  - 16% have an intervening lateral

    (10) a. lub**o**l**u** ‘double chin’

    b. muh**o**l**u** ‘stomach, tripe’

  - 60% occur word-finally, a position where vowels are more prone to devoicing or deletion

Discussion: Exceptions are not random

- A modest number of exceptions are loanwords – though at a higher rate than loans in the lexicon at large

(11) From Luyana:

a.	njopu	‘damp, dewy place’
b.	malopu	‘beer’
c.	ndopu	‘elephant’
d.	sopu	‘fine grass’

(12) From English:

a.	bishopu	‘bishop’
b.	sitofu	‘stove’
c.	ingilopu	‘envelope’
d.	wolupulete	‘wall plate’

Discussion: Vowel epenthesis

- In loans such as those from English, [o.u] occurs due to vowel epenthesis
- However, in the majority of places where [o.u] might have arisen through epenthesis of [u], another vowel is added instead, especially [o]

(13)

a.	lubotolo	‘bottle’	f.	noto	‘musical note’
b.	-polofita	‘to prophesy’	g.	pondo	‘pound (sterling)’
c.	sinodo	‘synod’	h.	sitolopo	‘strap’ (Afr.)
d.	coko	‘chalk’	i.	-toloka	‘to interpret’ (Afr.)
e.	dokota	‘doctor’	j.	-potoloto	‘pencil’ (Afr.)

Discussion: Vowel epenthesis

- In order to investigate the behaviour of epenthesis further, I consulted a larger corpus of loanwords based on Kashoki (1999: 24–47)
- The prior observations from Jalla (1982) about the distribution of [o.u] are corroborated by these new data
- In 650 loanwords, there were 22 unique instances of [o.u] where [u] was epenthetic
- 13 (59.1%) have intervening labial and 7 (31.8%) have an intervening lateral
- Instances of [o.o] arising from epenthesis occur c. 1.5× as often as [o.u] (31 examples), and show a different distribution of intervening consonants to [o.u]
  - 11 velar (35.5%), 11 lateral, 5 labial (16.1%), 4 non-lateral alveolar 670 (12.9%)

Discussion: Complex nominals

- A crucial category of “exceptions” comprises complex nominals, i.e. nouns formed by either compounding or reduplication (Fortune 2001: 21)
- In certain words containing [o.u], the vowels straddle a boundary

(14) a. kutwel**o**-b**u**tuku ‘pity, compassion’

b. limbong**o**-l**u**me ‘kind of large edible fruit’

c. Miny**o**-l**u**i ‘Bulozi Prime Minister’

(15) a. kafuk**o**-f**u**ko ‘lion-ant’

b. maful**o**-f**u**lo ‘eagerness, favour, enthusiasm, zeal’

Discussion: Prefix exceptionality

- Another environment where Lozi freely allows [o.u] is between **prefix** and **root**

(16) a. B**o**-M**u**wae ‘Honourable Princess’ (Fortune 2001: 12)

b. ne-ni-ta-t**o**-k**u**ta ‘I was going to have my hair cut’ (Gowlett 1967: 249)

- This is also the case **between prefixes**

(17) a. k**o**-k**u**-mezi ‘at a wet place’ (Fortune 2001: 33)

b. aba-t**o**-l**u**-tusa ‘they are not coming to help us’ (Gowlett 1967: 272)

Discussion: A prosodic explanation?

- The examples from complex nominals are not surprising given that elements within compounds and bases and reduplicants often constitute **separate prosodic domains**
- Prefixes, however, are perhaps less amenable to a prosodic analysis
- There have been proposals in other languages for prefixes sharing prosodic-wordhood separate from that of their base
  - E.g. English (Wennerstrom 1993; Raffelsiefen 1999), Italian (Nespor & Vogel 1986), Hungarian (Nespor & Vogel 1986), Indonesian (Cohn 1989: 200ff), Korean (Kang 1992)
- However, it is not clear whether such a hypothesis is tenable in this case

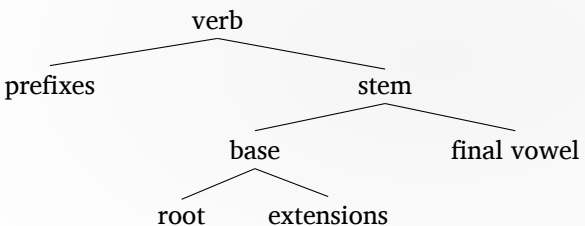
Discussion: A prosodic explanation?

- In some orthographic practices, prefixes are written as separate words, though this is probably less a reflection of speakers' intuitions and more orthographic influence from Sotho (Gowlett 1989: 147)
- And an additional potential indicator of prefixes as separate prosodic words that can be discounted is that they are unable to be coordinated
  - E.g. the prefix *bo-* cannot only show scope over the noun to which it is attached
  - ☞ *Bo-Richard ni bo-Michael* shows respect to both whereas *bo-Richard ni Michael* can only show respect to the first

Discussion: A morphological explanation?

- A typical structural representation of the Bantu verb (see e.g. Myers 1987, 1998; Hyman 1993, 2009; Downing 1998a,b, 1999; Hyman & Mtenje 1999)

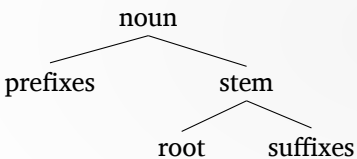
(18)



Discussion: A morphological explanation?

- The Bantu noun is generally less complex but a structure such that below is typically found (see e.g. Mugane 1997)

(19)



Discussion: A morphological explanation?

- In five-vowel Bantu languages, height harmony's affects are typically limited to within the "base" in verbs, with both prefixes and final vowels being unaffected
- However, in Lozi, there is not only an [i]–[e] contrast in verbal extensions but also an almost complete absence of [o.u] in nouns
- The most parsimonious description of height harmony would thus seem to be that – *modulo* reduplication and compounding – there is a prohibition against the vowel pair [o.u] in the non-prefixal domain
- That is, in the common "stem" domains seen in the preceding structures

Summary

- Having examined Lozi more closely, I propose that the language possesses a ban on only [o.u] that applies not only within the verb base but also beyond it
- I discussed those few examples of [o.u] that are found in detail – many of these appear to be amenable to reasonable explanations
- I presented a consideration of vowel epenthesis in Lozi and its relationship with the proposed prohibition
- I also discussed the implications of these finding for any potential formal analysis

4. Production study

Introduction

- Having looked at vowel-pair frequencies in the lexicon, I now present a production study looking at F1 in V-to-V coarticulation in three Bantu languages of Zambia
  - Canonical Bemba and Nyanja and non-canonical Lozi
- The principal aim is to explore the possibility of gradient coarticulatory effects on F1 reminiscent of the categorical restrictions imposed by height harmony
- This could potentially give us clues as to the origin and phonetic grounding of the particular patterns of height harmony seen in Bantu

On phonologisation

- In his discussion of phonologisation, Hyman (1976: 408) says that 'what begins as an **intrinsic** byproduct of something, predicted by universal phonetic principles, ends up unpredictable, and hence, **extrinsic**'
- This has been argued, e.g. by Ohala (1993), to be due to **hypocorrection** or **hypercorrection**
  - E.g. undercorrection for coarticulation leading to an assimilatory pattern
  - Or overcorrection for coarticulation leading to a dissimilatory pattern

V-to-V coarticulation and vowel harmony

- It has long been observed that **coarticulation between vowels** occurs even across intervening consonants (Öhman 1966 et seq.)
- And that patterns of V-to-V coarticulation may differ from language to language (see e.g. Beddor et al. 2002)
- Ohala (1994) argues that vowel harmony arises through the **phonologisation of V-to-V coarticulation**

V-to-V coarticulation and vowel harmony

- Indeed, there has been experimental evidence of this, e.g. Przezdziecki (2005) on high vowels and tongue-root harmony in Yoruba dialects
- However, Ohala's idea is challenged by work showing that V-to-V coarticulation and the perceptual compensation for this coarticulation are highly variable between languages (Beddor et al. 2002, 2007; Beddor 2009)
- And, moreover, that the amount of compensation for coarticulation is related to the degree of coarticulation found in that language

Rule scattering

- Though phonological patterns may derive from phonetic ones, the originating phonetic pattern does not necessarily go away
- The innovation of a new phonological pattern thus often results in a phenomenon known as "**rule scattering**" (Bermúdez-Otero & Trousdale 2012: 696).
  - The coexistence in one language of two separate instances of the same (or similar) sound pattern, one phonetic and one phonological (Bermúdez-Otero 2010, 2015; Bermúdez-Otero & Trousdale 2012)
  - ☞ E.g. *pre*[ʃ]*ure* v. *pre*[s͡ʃ]*ou* in English (Zsiga 1995)

This study

- The central question of this study is whether V-to-V coarticulation in Bemba, Nyanja and Lozi shows a similar pattern to height harmony
  - ☞ In other words, do we find rule scattering?
- In addition, in the case of Lozi, which lacks front height harmony, do we see any front-height-harmony-like coarticulatory effects?
- The primary acoustic correlate of height is F1
  - Higher F1 = lower vowel height; lower F1 = higher vowel height

The sample

Canonical *Bemba, Nyanja*				Back only *Lozi*			
i.i	i.e	i.u	i.o	i.i	i.e	i.u	i.o
u.i	u.e	u.u	u.o	u.i	u.e	u.u	u.o
e.i	e.e	e.u	e.o	e.i	e.e	e.u	e.o
o.i	o.e	o.u	o.o	o.i	o.e	o.u	o.o
a.i	a.e	a.u	a.o	a.i	a.e	a.u	a.o

Table 3: Harmonic and non-harmonic vowel pairs in Bemba, Nyanja and Lozi

Participants

- The final analysis included data from a 13 participants: 8 Bemba, 2 Nyanja, 3 Lozi

Speaker	Age	Home town	Languages spoken
BF1	44	Ndola	Bemba, Nyanja, English
BF2	45	Kitwe	Bemba, English
BF3	30	Kalomo	Bemba, Tonga, Nyanja, Chewa, English
BF4	57	Lusaka	Bemba, English, Nyanja
BF5	47	Ndola	Bemba, English
BF6	39	Mpika	Bemba, English
BM1	54	Kitwe	Bemba, English, Nyanja, Tonga, Spanish
BM2	34	Ndola	Bemba, Nyanja, English
NM1	44	Lusaka	Nyanja, Nsenga, Chewa, English
NM2	38	Lusaka	Nyanja, English
LM1	44	NA	Lozi, Tonga, Nyanja, Bemba, English
LM2	54	Ndola	Lozi, Tumbuka, Nyanja, Bemba, English
LM3	30	Lusaka	Lozi, Nyanja, Tonga, Bemba, English

Table 4: Details of participants for final analysis of production study

Methodology

- The experiment consisted of an elicitation task in which speakers read two repetitions of a word-list of 150–200 items containing all possible vowel combinations
- Recording were made with a Zoom H4n Pro recorder and a Røde lavalier microphone
- The data were aligned and segmented using a customisation of the forced-aligner SPPAS with subsequent manual corrections
- Formant values and other measures (e.g. duration) were extracted using Praat
- Data analysis was carried out in R and statistical models run with `lme4`, with three sets of models being run using F1 across the middle third as the dependent variable
  1. Investigating the aggregate effect of being in a non-harmonic pair
  2. Isolating the effect of individual left-hand vowels
  3. Isolating the effect of individual right-hand vowels

Results: Bemba

- Bemba showed little overall replication of the pattern seen in the harmony system in V-t-V coarticulation, though there were some similarities
- In model ❶, [u] had a significantly higher F1 where a difference in F1 might be expected, i.e. following only [o], but this same effect was not seen in model ❷
- Model ❶ also found that [o] had a significantly lower F1 in positions where a difference in F1 might be expected but model ❷ did not find differences due to preceding vowels
- Notably, there was no statistically significant difference in [i] following [e]
- The most noteworthy result from model ❸ was a significantly lower F1 of [i] before [e]

Results: Nyanja

- Nyanja also did not show a strong at-large mirroring of harmony in coarticulation
- Model ❶ showed no relevant significant differences
- Model ❷ found that [i] had a significantly higher F1 following [e]
- However, [e] had a significantly higher rather than lower F1 following [i]
- One interesting non-significant trend was that word-final [u] had a higher F1 following [e] than other vowels, an effect in the opposite direction to harmony but towards true agreement in height
- There was no significant effect or potential trend w.r.t. the F1 of [u] after [o]
- A comparison of models ❷ and ❸ shows that the effect of the right-hand vowel was generally less than that of the left-hand vowel

Results: Lozi

- Lozi showed only a limited number of differences in F1 akin to its supposed harmony system, though there are fewer relevant pairs than for Bemba or Nyanja
- Model ❶ found that [o] had a significantly lower F1 in environments in which a difference in F1 might be expected according to harmony
- Despite Lozi lacking front height harmony, model ❷ found that [i] had a significantly higher F1 following [e] and [e] had a significantly lower F1 after [a]
- This was not found for [o], however
- There was no significant effect or visible trend regarding the F1 of [u] after [o]
- However, model ❸ found that [o] had a lower F1 before [u]
  - This actually mirrors a very minor points of variation in the lexicon w.r.t. [o.u]: *mongu* ~ *mungu* ‘promontory’, *miongu* ~ *miungu* ‘pumpkins’

Discussion: The front–back asymmetry

- The greater prevalence of back height harmony across Bantu may indicate that the ultimate causes of back height harmony are more well grounded than front height harmony
- Front height harmony being found only alongside back height harmony but not the reverse leads to the implicational hierarchy that front height harmony implies back height harmony
- Recall the hypothesis that vowel harmony has its origins in the phonetic effects of V-to-V coarticulation
- As the major acoustic correlate of height is F1, we should expect to see effects on F1 that mirror what is seen in height harmony
- If the typology of Bantu further suggests that back height harmony is more well grounded than front height harmony, we should expect to more readily be able to find (more robust) coarticulatory effects mirroring back height harmony

Discussion: The front–back asymmetry

- From the totality of the results, it appears that there is relatively little robust evidence of effects on F1 that mirror back height harmony at the very general level
- It also especially noteworthy that there is also only scant evidence for any significant effect on the F1 of [u] after [o], a crucial pair in back height harmony
- There was slightly more evidence for effects on the corresponding pair in front height harmony as [i] had a higher F1 after [e] in both Nyanja and Lozi, despite the latter lacking front height harmony
- On this basis, it does not appear then that back height harmony is more well grounded with respect to the potential role of V-to-V coarticulatory effects on F1

Discussion: The front–back asymmetry

- On the contrary, the results may xsuggest that the avoidance of [e.i] in favour of [e.e] may be more well grounded than the preference for [o.o] instead of [o.u]
  - Though [i] showed no comparable effect when following [o] rather than [e]
- This broad conclusion contradicts the implicational hierarchy based on the typology of Bantu in which front height harmony implies back height harmony
- It does, however, at least in part, accord with an artificial-language-learning experiment by Finley & Badecker (2012)
  - Participants trained on front height harmony failed to generalise to back height harmony but did generalise back height harmony front height harmony
  - Their results also suggested that participants learnt to apply back height harmony only when vowels agreed in backness
  - A second experiment also found that learners seemed to favour height harmony systems in which target and trigger have the same backness

Discussion: A role for perception?

- Of course, the phonetics (or lexical statistics) of a language need not mirror the phonology entirely
- And, as seen here, it is not necessarily the case that a pattern seen in one area will be replicated in some form or another in wholesale fashion
- If coarticulation is indeed the ultimate origin of height harmony, the phonetics of these language appear to have changed
- The results may, however, be an indication that coarticulation is not the origin of height harmony as F1 is a seemingly more stable than e.g. F2, the coarticulation of which may lead to backness harmony
- Previous work on harmony more generally has found evidence that a non-articulatory source of grounding may be found in the realm of perception

Discussion: A role for perception?

- Walker (2005, 2011) argues that metaphony in e.g. Central Veneto is driven by the propagation of height features from weak unstressed high vowels to more prominent stressed vowels so as to counteract their perceptual difficulty
- Similarly, Kaun (1995, 2004) claims that rounding harmony is way of enhancing the perceptibility of the cues for rounding by associating it with a wider span
- Such approaches posit that harmony is a means of bolstering the perceptibility of less perceptually salient properties by associating them with a position that is more prosodically prominent in some way
- Bantu height harmony could have come about to enhance the perceptibility of mid vowels which, having intermediate F1 values, require more robust cuing than peripheral vowels that are more discernible from one another

Summary

- I have presented a production experiment of V-t-V coarticulation in Bemba, Nyanja and Lozi
- Relatively little evidence was found that, at a very broad level, gradient changes in F1 mirrored the categorical alternations of vowels in height harmony
- But, contrary to the vowel-pair frequency study, there was perhaps more evidence that the avoidance of [e.i] was more well grounded than the avoidance of [o.u]
- This calls into question V-to-V coarticulation as a potential origin of height harmony, with perceptual factors being a possible alternative, as has been proposed for other types of harmony

5. Final remarks

Final remarks

- The studies I have presented speak to issues relating to the grounding of vowel height harmony in five-vowel Bantu languages, which I have already summarised
- However, they are also able to contribute to our understanding of further problems such as the role of markedness in formal accounts of harmony
- Sources of evidence such as lexical statistics may help give us clues as to which structures might be more likely to be considered marked and this can influence the choice of analysis
- The most general take-aways though from what I have presented here is that:
  - It is advantageous to not only consider a “whole-language” approach when considering the sound patterns of a language
  - We should approach the same problem using multiple sources of evidence

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- You for listening!

Abbreviations

1	first person
3	third person
ACC	accusative
APPL	applicative
DRV	derivational affix
FUT	future
FV	final inflectional vowel
IMPF	imperfective
NEG	negative
OM	object marker
PL	plural
REV	reversive
SM	subject marker

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