

Two types of Swahili NC sequences

Acoustic and aerodynamic evidence

Selina William Wayimba^{*,†}, Aaron Braver^{*,†}, and Will Bennett[†]



© University of Dar es Salaam
* Rhodes University
† Texas Tech University
aaronbraver.com/bantu11

Introduction

- Two analyses of NCs sequences
- We show that Swahili has two distinct types of NC sequences—one which behaves like unary tautosyllabic segments and another that behaves like heterosyllabic sequence
- Phonetic distinctions:
 - Component duration and overall duration
 - Impressionistic sense of articulatory integration
- The added wrinkle: some /m+b/ clusters are realized as [mb], even though Swahili lacks a b-b contrast otherwise

Wayimba, Braver, and Bennett

Bantu 11

1

A preview of Swahili's two NC sequences

Root	Class 1/3: /m-/ "Syllabic"	Class 9: /N-/ "Prenasalized"
<-baya> /baja/ 'bad'	[mbaja] 'bad one' (= 'bad guy')	[nbaja] 'bad one' (= 'bad thing')
<-bovu> /bovu/ 'poor, spoiled'	[mbovu] 'rotten, spoiled one'	[nbovu] 'rotten, spoiled one/thing'
<-bichi> /bitfi/ 'fresh, raw'	[mbitfi] 'fresh, wet, raw one'	[nbitfi] 'fresh, wet, raw one/thing'

Wayimba, Braver, and Bennett

Bantu 11

2

Not a Swahili-specific situation

- Nyanga (Mwita, 2008:63):
 - m + bale [m.ba.le] 'brother' (3σ)
 - n + bale [mba.le] 'plate' (2σ)
- Ciyao (Hyman & Ngunga, 1997:135, 140-141)
 - 1sg.obj pfx -N-: ku-N-peleka → kuu.**be**.le.ka 'to send me' (4σ)
 - 2/3sg.obj pfx (syllabic) -N-: ku-N-peleka → ku.**m**.pe.le.ka 'to send you/him' (5σ)
 - Cl1 pfx (syllabic) N-: N-bulusi → **m**.bu.lu.si 'foreigner' (4σ)
 - Cl3 3 pfx (syllabic) N-: N-bale → **m**.ba.le 'raphia palm' (3σ)
- Zulu (Doke 1926:66-68)
 - um-phetho 'hem' (cl.3, *umu-) [mpʰ]
 - izim-paphe 'feathers' (cl.10, /iziN-/) [mpʰ]

Wayimba, Braver, and Bennett

Bantu 11

3

Structure and duration of NC clusters

- Herbert (1986) argues prenasalized consonants are similar in duration to plain/simplex consonants, e.g., Fijian (Maddieson & Ladefoged, 1993:271):

/mb/	/nd/	/t/	/k/
132 ms	131 ms	125 ms	116 ms

- Hubbard (1995) argues that prenasalized consonants are *not* similar in duration to plain/simplex consonants in Runyambo, Sukuma, and Luganda (252):

	N in VNV	N in VNC	C in VCV	Total NC
Runyambo	84 ms	96 ms	65 ms	120 ms
Sukuma	73 ms	119 ms	37 ms	144 ms
Luganda	62 ms	85 ms		109 ms

Wayimba, Braver, and Bennett

Bantu 11

4

Structure and duration of NC clusters

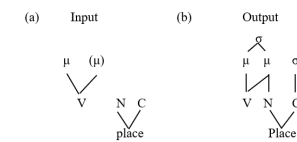
- Maddieson & Ladefoged (1993) claim two distinct, contrasting, types in Fula and Sinhala i.e single vs geminate nasal+ stops

- o Sinhala:

Singleton:	/la'da/	'blind'	[^h d = 100 msec]
Geminate:	/lannda/	'thicket'	[^h nd = 295 msec]

- Downing (2005) argues NCs are sequences at both the underlying and surface levels

Figure 1.2: Downing's VNC Representations



Wayimba, Braver, and Bennett

Bantu 11

5

The crux of the puzzle

- /N+b/ and /m+b/ are both possible sequences that can be assembled with real morphology
- So... are they the same?
 - o Phonetically?
 - o Phonologically?

Wayimba, Braver, and Bennett

Bantu 11

6

Punchline: no, they are not the same

Wapendwa naomba msaada wenu. Nafanya ka syllable count task, kwahiyu naomba ukipata muda naomba unisaidie kujibu. Maneno kama mbichi, mbaya, mbovu yapo na silabi ngapi?

Select one or more

☐ 1 0

☐ 2 1

☐ 3 4

☐ Yaweza kuwa 1 au 2 0

☐ Yaweza muwa 2 au tatu 15

09:48 ✓

Dear all, I would like to ask for your help. I am working on a syllable-counting task, so if you have a moment, could you help me out? How many syllables do words like mbichi, mbovu, and mbaya have?

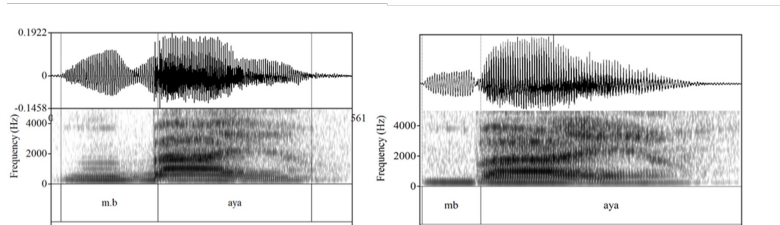
o 1	0
o 2	1
o 3	4
o It can be 1 or 2	0
o It can be 2 or three	15

Wayimba, Braver, and Bennett

Bantu 11

7

Punchline: no, they are not the same



Results

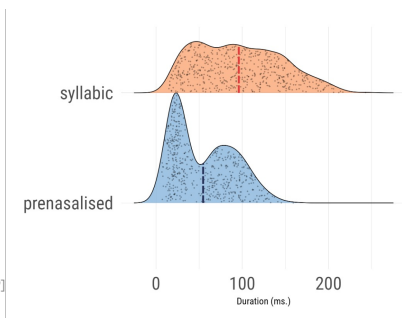
Methods

- 3 participants (1 female, 2 male)
- WhatsApp poll
- Word-list reading:
 - 'prenasalized' mb (cl. 9): 144 tokens
 - 'syllabic' m.b (cl. 1/3): 122 tokens
 - Zoom H4n Handy recorder, Nady HM-10 (head-mounted) microphone.
- Durations measured in Praat

Overall duration: Syllabic vs. prenasalized

- Syllabic: 96.08 ms
- Prenasalized: 54.71 ms

Linear mixed effects model:
 total_dur ~ type + (1 | speaker) + (1 | token_id)
 type [syllabic]:
 $\beta = 83.75, t(547) = 35.41, p < 0.001, 95\% \text{ CI: } [79.10, 88.39]$

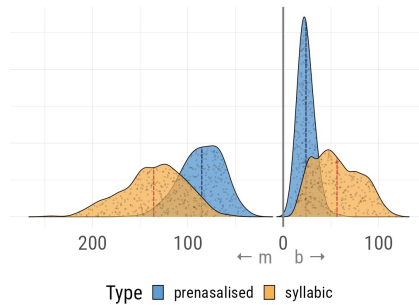


[m] and [b] durations: Syllabic vs. prenasalized

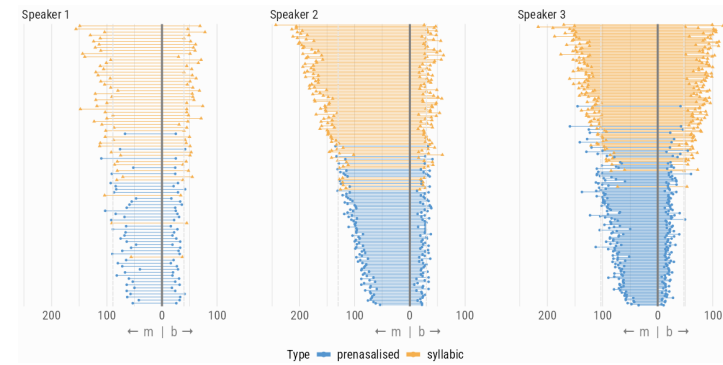
	m	b	ratio
prenasalized	85.34 ms	23.86 ms	3.58
syllabic	135.77 ms	56.59 ms	2.40
ratio	0.63	0.42	

m_dur ~ type + (1 | speaker) + (1 | token_id)
 type [syllabic]:
 $\beta = 49.99$, $t(547) = 24.70$, $p < 0.001$, 95% CI = [46.01, 53.96]

b_dur ~ type + (1 | speaker) + (1 | token_id)
 type [syllabic]:
 $\beta = 33.55$, $t(545) = 25.00$, $p < 0.001$, 95% CI: [30.91, 36.18]



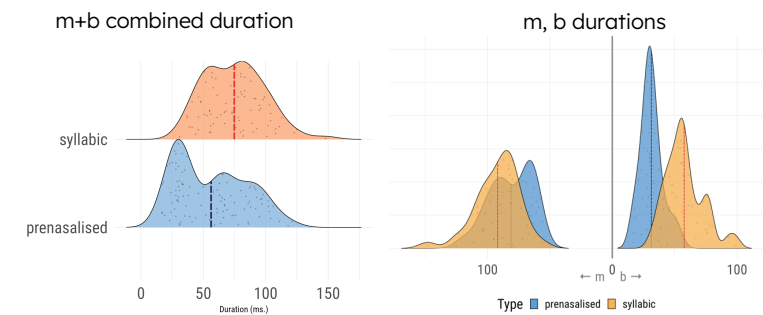
Individual tokens by speaker



Behavior in intervocalic position

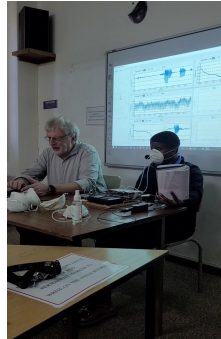
- 2 of the same participants (1 female, 1 male)
- Word-list reading:
 - 'prenasalized' mb (cl. 9): 106 tokens
 - 'syllabic' m.b (cl. 1/3): 78 tokens

Behavior in intervocalic position



Aeromask

- Apparatus to record simultaneous nasal and oral airflow together with audio (Elmerich 2024, Amelot & Demolin 2025)
- Auto-calibration for ambient pressure
- Acoustically transparent mask
- Software: work in progress



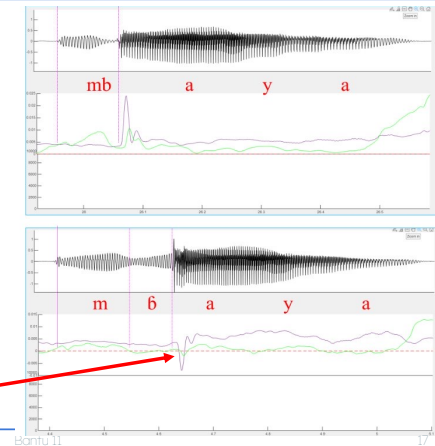
Preliminary findings

- Difference in laryngeal action

'Prenasalized m.b'

'Syllabic m.b'

Implosive [ɓ]!



Historical ramifications

- Swahili is not standardly diagnosed as having a contrast between plosive /b/ and implosive /ɓ/
- But, the 'b' in /m-b/ surfaces as implosive, and the 'b' in cl.9 /N-b/ does not
- Class 9 is known for laryngeal perturbations across southern Bantu
 - Xhosa ex: -**le**ta '(to) talk' ~ **in-ri**et'o '(a) talk'
 - Class 9 /N-/: de-aspirates stops, hardens fricatives and /l/, nasalizes clicks, and **purportedly de-implosivizes /b/ (awaiting aerodynamic confirmation)**
- Class 9 change /ɓ/→[b] is shared with Nguni/Southern Bantu

Conclusions

Prenasalised Consonants in Swahili

- Single articulatory gesture (see spectrogram)
- Tautosyllabic (our finding)
- Homorganic (Mwita, 2008:62, Hubbard, 1995:235)
 - /shamba/ 'farm'
 - /ngoma/ 'drum'
 - /ndege/ 'bird'
- Appear in environments where *clusters* are not licensed:
 - Prenasalized consonants (/^mb/ and /ⁿd/) can occur word initially
 - Clusters like /mb/ are permissible only word-finally (due to SSP)

Surface representations of ^mb and m.b

Figure 1:3 Surface representation of ^mb and m.b

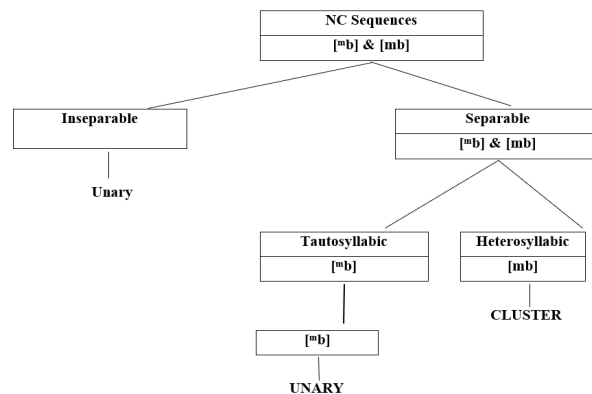
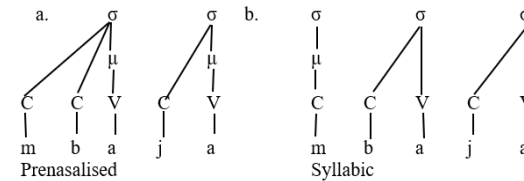


Figure 1:1 A three-step Swahili phonological NC Sequences

Asanteni sana!

Thank you to:

Dider Demolin, participants,
audiences of LabPhon 20 and SAMWOP 13



aaronbraver.com/bantu11

References

- Amelot, A., & Demolin, D. (2025, April). The new AeroMask and the phonetics of prenasalized consonants in Mbugu. In 17e Congrès Français d'Acoustique.
- Downing, L. J. (2005). On the ambiguous segmental status of nasals in homorganic NC sequences. In M. van Oostendorp & J. van de Weijer (Eds), *The Internal Organization of Phonological Segments* (pp. 183–216). De Gruyter Mouton. <https://doi.org/10.1515/9783110890402.183>
- Elmerich, A. (2024). Évaluation multiparamétrique de la nasalité: conception et utilisation d'un masque aérodynamique appliquée à une population témoin et pathologique: l'AeroMask (Doctoral dissertation, Université de la Sorbonne nouvelle-Paris III).
- Herbert, R. K. (1986). Definition and phonological status of prenasalization. In *Language Universals, Markedness Theory, and Natural Phonetic Processes* (pp. 6–53). De Gruyter Mouton. <https://doi.org/10.1515/9783110865936.6>
- Hubbard, K. (1995). Prenasalised consonants' and syllable timing: Evidence from Runyambo and Luganda. *Phonology*, 12(2), 235–256. <https://doi.org/10.1017/S0952675700002487>
- Hyman, L. M., & Ngunga, A. (1997). Two kinds of moraic nasal in Ciyao. *Studies in African Linguistics*, 26(2).
- Maddieson, I., & Ladefoged, P. (1993). Phonetics of Partially Nasal Consonant. In *Nasals, Nasalization, and the Velum* (pp. 251–301). Academic Press. <https://doi.org/10.1016/B978-0-12-360380-7.50014-4>
- Mwita, C. (2008). *Prenasals and IPA*. UCLA Working Papers in Linguistics.

Model tables

total_dur ~ type + (1 | speaker) + (1 | token_id)

term	estimate	std.error	statistic	df	p.value	conf.low	conf.high
(Intercept)	104.02	10.17	10.23	2.03	0.01	60.95	147.09
typesyllabic	85.75	2.37	35.41	548.05	0.00E+00	79.1	88.39

m_dur ~ type + (1 | speaker) + (1 | token_id)

term	estimate	std.error	statistic	df	p.value	conf.low	conf.high
(Intercept)	81.88	12.28	6.67	2.02	0.02	29.52	134.24
typesyllabic	49.99	2.02	24.7	533.6	0	46.01	53.96

b_dur ~ type + (1 | speaker) + (1 | token_id)

term	estimate	std.error	statistic	df	p.value	conf.low	conf.high
(Intercept)	22.07	5.73	3.85	2.08	0.06	-1.71	45.85
typesyllabic	33.55	1.34	25	546.09	0	30.91	36.18