

DURATION OF VOWELS BEFORE HOMORGANIC NASAL-OBSTRUENT SEQUENCES IN TUMBUKA

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ABSTRACT

The Bantu language Tumbuka, spoken in Malawi and Zambia, has the vowel phonemes /i, e, a, o, u/ but no phonemic contrast in vowel length. In the present study we measured the duration of vowels before homorganic nasal-obstruent sequences (NC) and compared them to the duration of vowels before single obstruents for four speakers of Tumbuka. With this data, we tested whether there is acoustic support for the existence of a phonological process of pre-NC lengthening, as reported for many other Bantu languages. Our results provide no support for such an interpretation in Tumbuka: pre-NC vowels were only 10 ms longer than pre-obstruent vowels, and though this difference was statistically significant, it is below the just noticeable difference for duration of 25 ms and therefore most likely not perceivable. We conclude that the observed pre-NC lengthening in Tumbuka is a purely co-articulatory, phonetic process.

Keywords: vowel duration, Tumbuka, NC sequences, compensatory lengthening, Bantu.

1. INTRODUCTION

Homorganic sequences of a nasal and an obstruent (henceforth: NC) are common in Bantu languages and can occur morpheme-internally or across morpheme boundaries, due to place assimilation. See the examples from Tumbuka in (1a) and (1b)

respectively, the latter with a place-assimilated nasal noun class (9/10) prefix.

- (1a) ku-dʒump^ha ‘to walk’
 (1b) m-p^hindi ‘gourd’
 n-dege ‘bird, plane’
 ŋ-goma ‘maize’

A process of pre-NC vowel lengthening is very common in Bantu (see [22] for an overview), though it does not seem to occur in all Bantu languages. Downing & Mtenje [6], for instance, describe Chichewa as not having pre-NC lengthening, and this observation is supported by acoustic measurements discussed in Hubbard [10, p.155].

In Bantu languages with a phonemic vowel length contrast, the contrast typically neutralizes before NC sequences. The outcome of this neutralization, however, varies widely. Table 1 gives an overview of experimental studies on vowel duration in several Bantu languages and is an update of a list compiled by Hubbard [11]. The languages in Table 1 are ordered according to their outcome: Languages with a VNC/V ratio (almost) identical to the long-short vowel ratio (V:/V) have complete lengthening to [CV:NCV] and are given at the top of the table. On the other end of the continuum are languages with a VNC/V ratio of 1 and thus no lengthening at all ([CVNVCV]), as in CiTonga. In-between are languages where the VNC/V ratio is larger than 1, but not identical to the V:/V ratio, indicating partial lengthening to [CV·NCV].

Table 1: Summary of previous experimental studies on the duration of short, long and pre-NC vowels in Bantu languages, ordered from complete lengthening [CV:NCV] at the top to no lengthening [CVNVCV] at the bottom.

Language	V (ms)	V: (ms)	VNC (ms)	V:/V ratio	VNC/V ratio	Source
CiYao	61	132	130	2.2	2.1	[11]
Lusaamia	65	194	187	3.0	2.9	[19]
Kinyarwanda	96	169	158	1.8	1.6	[21]
Luganda	73	237	191	3.2	2.6	[11, 9, 28]
Runyambo	110	215	168	2.0	1.5	[11]
Sukuma	129	280	200	2.2	1.5	[11, 18]
Bemba	122	245	164	2.0	1.3	[8]
CiTonga	100	241	101	2.4	1.0	[11]

Outside the Bantu language family, pre-NC lengthening also occurs, though far less frequently, e.g. in Johore Malay [23], Noni (a Bantoid language spoken in Cameroon [12]), and Southern-Cushitic Iraqw [20] (all three discussed in [5]). An experimental study on pre-NC lengthening in the Austronesian languages Tamambo, Erromangan, Vanuatu and Pamona is provided by Riehl [25].

The present study investigates whether the Bantu language Tumbuka has pre-NC lengthening and if it does, whether the process is categorical (similar to what has been reported for CiYao) or partial (similar to Runyambo or Bemba). For this purpose, an acoustic analysis of vowel duration in pre-NC sequences and before single obstruents was performed. In contrast to the Bantu languages that were investigated previously, summarized in Table 1, Tumbuka has no phonemic vowel length contrast. The present study therefore contributes to completing the typological picture of Bantu pre-NC vowel duration by including a language without phonemic vowel length contrasts.

As noted by Vogel & Spinu [28], data on pre-NC vowel length in Bantu languages is usually restricted to recordings of a single speaker or two, who have often lived abroad for a considerable number of years. The present experimental study of Tumbuka is based on data from four speakers who were recorded on location in Malawi, thus reducing the risk of misrepresenting the language.

Pre-NC lengthening in Bantu languages has been used in the literature as argument that on the surface the following NC sequence is a complex single consonant rather than a consonant cluster (e.g. [3, 11, 13]). This argument hinges on the assumption that both the nasal and the following obstruent project a mora and that the mora of the nasal re-associates exclusively with the preceding vowel in the surface form to cause compensatory lengthening of the vowel [14], see Downing [5] for an overview of the discussion and an alternative proposal. The present study follows Downing in the assumption that no conclusion on the phonological status of the NC sequence can be drawn on the basis of the duration of the preceding vowel.

2. TUMBUKA

Tumbuka or Citumbuka is a Bantu language spoken mainly in the northern region of Malawi but also in the eastern part of Zambia. It belongs to the Narrow Bantu group (Guthrie's zone N.21, [7]), and is spoken by at least 2.5 million speakers [2]. Previous linguistic descriptions are restricted to work by Christian missionaries in the late 19th and early 20th

centuries and two more recent dissertations, one focussing on its morphology [27], the other on its morpho-syntactic structure [2]. Little is still known about its phonetics and phonology. Tumbuka, in contrast to many other Bantu languages, has only short vowels, namely /i, e, a, o, u/. And unlike most Bantu languages, it has no systematic tone contrast. Rather, High tones predictably occur on the phrase penultimate, lengthened, syllable [27].

In terms of syllable structure, Vail [27] describes Tumbuka as having only open syllables, and interprets NC sequences as sequences of two phonemes, both associated with the syllable onset.

3. EXPERIMENTAL STUDY OF VOWEL DURATION

3.1. Participants and recordings

Participants were four adult native speakers of Tumbuka from northern Malawi, all multilingual.

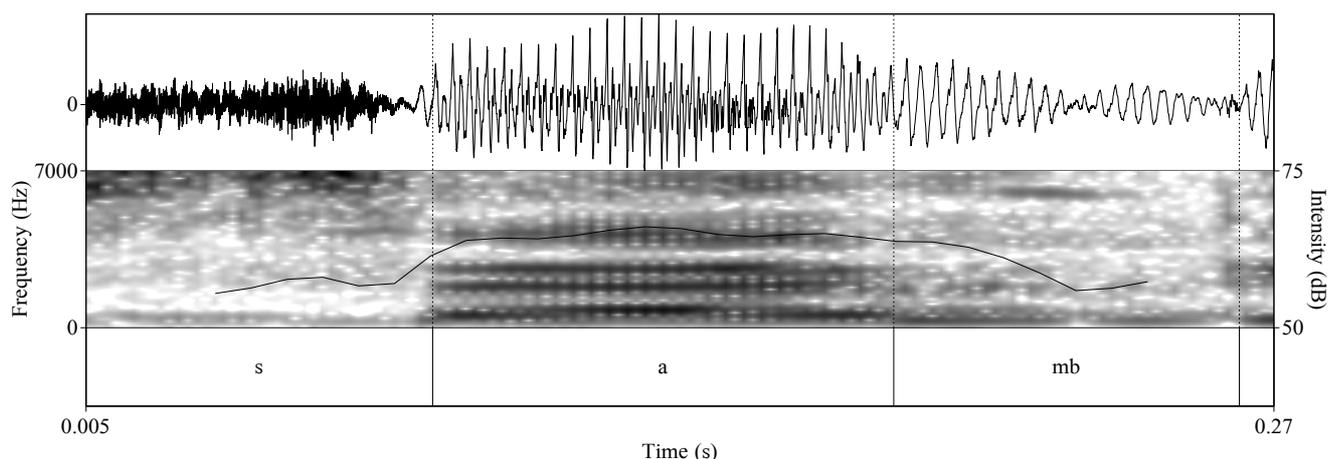
The recordings were made by the third author during a fieldwork trip in Mzuzu and Zomba, Malawi, in 2013, and were conducted in relatively quiet rooms, though some background noise could not be avoided. Recordings were made directly onto a MacBookPro laptop, using a SoundProjects LSM microphone (with a sampling frequency of 44.1 kHz).

3.2. Stimuli

The participants read 108 sentences of varying complexity at least twice, see the examples in (2) (the relevant vowels in underscore). The target vowels analysed in the present study were all in unstressed and pretonic position and were followed by a homorganic NC sequence. The C in these sequences was restricted to the plosives /b, d, g, p^h, t^h, k^h/ and the affricates /dʒ, tʃ/ (though not equally distributed), while the fricatives /v, z, h/ that also occur in this position in Tumbuka were not included. The stimuli set had a total of 41 target items. In the 34 control items, the vowel was also in unstressed and pretonic position, but was followed by a single obstruent from the class /b, d, dʒ, g, p, t, tʃ, k, p^h, t^h, tʃ^h, k^h, β, v, z, ʎ, f, s, h/. Fricatives had to be included in the control items (though not present in the target items) to attain a sufficiently large set of controls.

- (2a) ŋk^huzunura ‘m-p^hindi zinandi’ sono
 “I am saying ‘PL-gourd many’ now.”
- (2b) wakap^hata mⁱnt^havi ya k^huni ili
 “They pruned the branches of this tree.”

Figure 1: Example of determining vowel onset and offset in sequence /musambizgi/ “the teacher”



The set of 75 items was repeated at least twice, by four speakers, which yielded 618 tokens in total. Of these, 27 tokens had to be discarded because they showed too much background noise or a considerable amount of vowel nasalization, which made it impossible to determine the segment boundary between vowel and following nasal.

The onset and offset of the vowel tokens was determined and annotated in Praat [1] on the basis of changes in formant movements and amplitude in the spectrogram, and a change in wave patterns and amplitude in the sound wave, see Figure 1 for an example.

The vowel stimuli were furthermore categorized in two groups (which were not equally distributed in the stimuli set): high (/i/ and /u/) versus non-high (/a/, /e/ and /o/), as high vowels are generally shorter than non-high ones [17, 26].

3.3. Statistical analysis

The statistical analysis was carried out with a linear mixed-effects model in the program R [24]. The statistical model features the dependent variable duration and the predictor type, i.e. target vowels appearing before an NC cluster (NC) or control vowels (C) appearing before an obstruent, and height, i.e. whether the vowel is high (H) or non-high (L).

Additionally, two random variables were taken into consideration: speaker and word. The model also accounts for type and height, and the interaction between them, as random slopes per speaker. Contrasts were set accordingly ($H = +0.5$, $L = -0.5$; $NC = -0.5$ and $C = +0.5$). The complete model is given below:

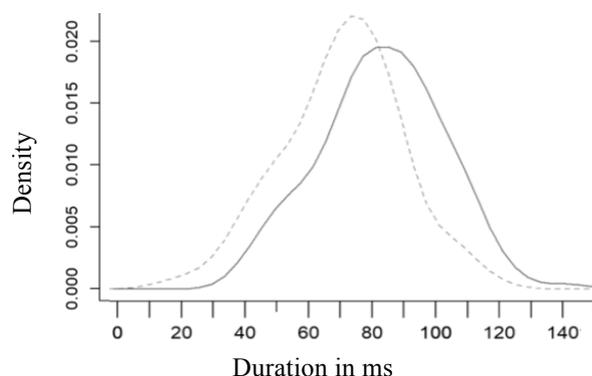
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duration ~ type * height + (type *
height | speaker) + (1 | word)
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3.4. Results

Non-high vowels were found to be longer than high vowels, by 24 ms (95% confidence interval = $-34 \dots -14$ ms, t -value = -5.36). Furthermore, the analysis showed that vowels before NC sequences were longer than vowels before plosives, namely by 10 ms (95% confidence interval = $-18 \dots -2$ ms, t -value = -2.67). The interaction between type and vowel height was not significant (effect size = 0.6 ms, 95% confidence interval = $-15 \dots +14$ ms, t -value = -0.09).

Figure 1 displays the distribution of the vowels. The average duration of vowels before NC sequence was 83 ms, and that of vowels before obstruents 71 ms, resulting in a VNC/V ratio of 1.17.

Figure 2: The distribution of vowels before NC sequences (solid line) and before single obstruents (dotted line).



As can be seen from Figure 2, there is a huge overlap in the distribution of the vowels in the two contexts.

4. DISCUSSION AND CONCLUSION

Our study showed that in Tumbuka, vowels before NC sequences are longer than vowels before single obstruents. Though statistically significant, the difference between the vowels in the two contexts was only 10 ms. This value is below the *Just Noticeable Difference* (JND) for duration of 25 ms or its logarithmic adjustment as a change in duration of 20% [15], and therefore not expected to be perceivable, though future perceptual studies will have to show whether this is indeed the case.

From these results we conclude that there is a very small effect of pre-NC lengthening in Tumbuka, and that this lengthening process is partial (not categorical) and thus purely phonetic.

The cause of the phonetic vowel lengthening before NC sequences that we observed here is most likely a coarticulatory effect, since the lowering of the velum, which is required for a following nasal, is slower than the raising of the lower lips or the tongue (especially the tongue tip) that is required for a following obstruent. We do not expect this coarticulatory effect to emerge in phonologically long vowels, since their longer duration provides more time for a change in the position of the velum and makes them less sensitive to a slight gestural delay. These expectations are supported by a study by Vogel & Spinu [28] on Luganda, which measured vowel duration before nasal and non-nasal consonants. In this study, phonologically short vowels before nasals had a mean duration of 98 ms and before non-nasals one of 90 ms, while long vowels before nasals and before non-nasals were almost identical in duration (with 172 ms and 173 ms, respectively).

Compared to other Bantu languages, the VNC/V ratio of 1.17 that we found for Tumbuka places it at the lower end of the language continuum in Table 1, and thus together with CiTonga in the group of languages that exhibit almost no pre-NC lengthening. We can think of two reasons for this. First, previous phonetic studies on pre-NC vowel duration in Bantu (summarized in Table 1) all have investigated languages with a phonological contrast in vowel length. A possible hypothesis is thus that considerable lengthening occurs only in languages that have a phonemic vowel length contrast (as already suggested by de Chene & Anderson [4]). Future duration studies on (Bantu) languages without phonemic length contrasts are needed to show whether this hypothesis holds.

Second, the present study only measured unstressed vowels while most previous studies looked at stressed vowels. It could therefore be

argued that pre-NC lengthening is restricted to stressed position. This, however, is contradicted by the findings in the study by Marlo & Brown on Lusaamia [19], in which pre-NC vowels had a similar duration to phonologically long vowels both in stressed and in unstressed position (though all vowels were significantly shorter in unstressed position, as expected [16]).

The difference in duration between the two vowel heights that we found in Tumbuka, with non-high vowels being longer than high vowels, is not surprising and in line with previous findings reported for other languages (e.g. [17, 21, 26]).

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