Phonetic and Phonological Effects of Depressor Consonants in Malawian CiTonga

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Abstract

In this paper we show that certain consonants have the effect of depressing the tone on adjacent vowels in Malawian CiTonga, a Bantu language spoken mainly in Nkhata Bay. We argue that some of these effects are phonological, changing High vowels to Low. In other cases the effect is not categorical, but gradient, as certain consonants have a greater lowering effect than others on the tone of the adjacent vowel. For these cases we propose the effect is phonetic overall. Still, we demonstrate that in these latter cases where the lowering effect is most pronounced, there are near-neutralization effects, which in some cases can lead to neutralization and homophony in the judgment of native speakers. We make some general typological observations, comparing the set of depressor consonants in CiTonga to other Bantu languages.

Keywords: Citonga, Bantu, depressor consonants, neutralization, tone

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1 Introduction

CiTonga is a Bantu language spoken mainly in Nkhata Bay, a lakeshore district in northern Malawi. It is classified by Guthrie (1967-71) as belonging to Zone N, Group 10 (N15). Other languages in Zone N include Tumbuka and Chichewa. Previous literature on CiTonga tone includes Mtenje (1994), Mtenje (2006), Bickmore and Mkochi (2018, 2019), and Mkochi and Bickmore (2021). Building on these tonal analyses, in this paper we show that certain consonants have the effect of depressing the tone on adjacent vowels.[1] We will argue that some of these effects are phonological, changing high-toned vowels to low. In other cases, the effect is not categorical, but gradient, as certain consonants have a greater lowering effect than others on the tone of the adjacent vowel. For these cases we propose that the overall effect is phonetic. However, we demonstrate that in these latter cases where the lowering effect is most pronounced, there are near-neutralization effects, which in some cases can lead to neutralization and homophony in the judgment of native speakers. Finally, we make some general typological observations, comparing the set of depressor consonants in CiTonga to those in other Bantu languages.

The paper is organized as follows. Section 2 outlines the language's sound inventories, and the tonal systems and rules. In Section 3 we present blocking of doubling as evidence for depressor consonants. Phonetic effects of depressor consonants are discussed in Section 4. Section 5 summarizes the paper.

2 CiTonga basics

The vowel and consonant inventories of CiTonga are shown in (1) and (2).

(1) Vowel inventory

i u
e o
a

(2) Consonant inventory

		Bilabial	Lab. dental	Alveolar	Palatal	Velar	Glottal	Lab. velar
Stop		b p p^h		d t t^h	ɟ c c^h	g k k^h		
	Pre-nas	mb mp^h		nd nt^h	ɲɟ $ɲc^h$	ŋg $ŋk^h$		
Fricative			v f	z s			h	
Nasal		m		n	ɲ	ŋ		
Lateral				l				
Approx			ʋ		j	ɰ		w

[1] All data presented in this paper come from the first author, a native speaker of CiTonga, who was a visiting Fulbright scholar at the University at Albany in New York for approximately nine months. While much of the data in Section 2, establishing the most basic facts about the verbal tonology, is drawn from Bickmore and Mkochi (2018, 2019), the data presented in the main body of the paper (Section 3) is newly presented for the first time.

CiTonga has lost the Proto-Bantu vowel length contrast. We propose that all underlying vowels are short, and posit a regular process that lengthens the penultimate vowel of the last word in a phonological phrase.

(3)	a.	[mùlììmì]$_\phi$	‘farmer’
	b.	[mùlìmì yùúwà]$_\phi$	‘that farmer’
	c.	[mùlììmì]$_\phi$ [wàngùt^{h}éèlà]$_\phi$	‘the farmer arrived’

Tone is contrastive for both verbal and nominal roots, as seen in the isolation forms below.

(4)	a.	dììk-à	‘spill’	g.	cì-lèèzò	‘chin’
	b.	dìík-à	‘cover oneself’	h.	cì-mìítè	‘tree’
	c.	t^{h}èèl-à	‘arrive’	i.	mà-lííŋì	‘rings’
	d.	t^{h}èél-à	‘give up’			
	e.	vììmb-à	‘cover’			
	f.	vìímb-à	‘be constipated’			

The tone bearing unit (TBU) is the mora. The surface tone contrasts on syllables are shown below, where only Cáá is unattested.

(5)	a.	Short-Low	*Cà*
	b.	Short-High	*Cá*
	c.	Long-Low	*Càà*
	d.	Long-Falling	*Cáà*
	e.	Long-Rising	*Càá*
	f.	Long-High	**Cáá*

We assume an underspecified phonological tonal contrast of H vs. Ø, where L is introduced at the very end of the phonology onto toneless TBUs. Bickmore and Mkochi (2018, 2019) examine the entirety of the language’s tonology, and propose a number of phonological rules in a derivational account. In the interests of space, we summarize here only those processes which are critical for evaluating the influence of consonants on tone.

The first tonological process is tone doubling, whereby a tone is spread onto the following TBU. This can be seen in the Class 1a/2a forms below.

(6)	a.	[kàpààlà]	‘sp. fish (SG)’	/kapala/
	b.	[á-kápààlà]	‘sp. fish (PL)’	/á-kapala/
	c.	[ɲàlùùbwè]	‘leopard’	/ɲalubwe/
	d.	[á-ɲálùùbwè]	‘leopards’	/á-ɲalubwe/

While the singular forms in (6a, c) are marked by a Ø prefix, their corresponding plurals take /á-/. As can be seen, the H tone of the prefix is realized not only on the underlying TBU which sponsors it, but on the following TBU as well. We formalize this below.

(7) Tone doubling

μ μ
H

Let us now turn to verbs, where we can examine how tone doubling interacts with other processes. As noted above, CiTonga has preserved the Proto-Bantu binary tone contrast in verb roots (3). We illustrate this contrast below in (9) and (10) with infinitival forms (as they appear in non-phrase-final position), whose structure is given in (8).

(8) Structure of the infinitive: Infinitive *ku* + [$_{\text{stem}}$ Root + Extension(s) + Final Vowel *a*]

Extensions are suffixes which modify the semantics of the verb, often affecting its valency. Those illustrated below are the causative /-is/, the reciprocal /-an/, and the applicative /-il/.

(9) Infinitives with a toneless root

a.	kù-lím-á	'to cultivate'
b.	kù-lím-ís-à	'to cause to cultivate'
c.	kù-lím-ís-àn-à	'to cause each other to cultivate'
d.	kù-lím-íl-ìs-àn-à	'to cause to cultivate for each other'

In each case a high tone appears on the initial vowel of the root, as well as on the following TBU.

(10) Infinitives with a high root

a.	kù-nàm-á	'to lie'
b.	kù-nám-ís-á	'to cause to lie'
c.	kù-nám-ís-àn-á	'to cause each other to lie'
d.	kù-nám-íl-ìs-àn-á	'to cause to lie for each other'

As can be seen, each form in (10) is tonally distinct from its counterpart in (9). To account for these differences, we adopt the analysis in Mkochi and Bickmore (2021), which we now summarize. The verbs in (9) have a single underlying high tone, which links to the TBU of the root and then undergoes doubling. The forms in (10), by contrast, have two underlying high tones – one which links to the stem-initial TBU and the other which links to the stem-final TBU. This may be most clearly seen in (10c-d), where two tones are evident on the surface, the first of which undergoes tone doubling. (We take up the issue of the surface low tone on the root in (10a) below).

We propose that the root in (10) contributes a high tone to the verb, whereas the root in (9) is toneless. To account for the single high in (9) and the second high in (10), we propose that every verb form in CiTonga contains a melodic high (also referred to in the literature as a grammatical or suffixal high). Every language has a set of inflectional features (TAM, polarity, clause type, etc.). When some constellation of these inflectional features results in not only the addition of tones to a form, but a specification of how those tones must dock onto the form's TBUs, these are "melodic tones," also known as "grammatical" or "suffixal" tones (Odden and Bickmore 2014, forthcoming). In CiTonga, a single melodic high (MH) is added to every verb form – both infinitive and conjugated finite forms. Two tone docking principles are operative.

The first docks a floating H onto the stem-initial TBU. The second docks any remaining floating H onto the stem-final TBU.[2] This is illustrated below.

(11) Derivations of (9d) and (10d)

```
a.   ku-[lim-il-is-an-a      ku-[nam-il-is-an-a      UR

          H                       H        H

b.   ku-[lim-il-is-an-a      ku-[nam-il-is-an-a      Docking to stem-initial μ
          |                       |
          H                       H       H

c.   ku-[lim-il-is-an-a      ku-[nam-il-is-an-a      Docking to stem-final μ
          |                       |           |
          H                       H           H

d.   ku-[lim-il-is-an-a      ku-[nam-il-is-an-a      Tone doubling
          | / /                   | / /       |
          H                       H           H

e.   [kù-lím-íl-ìs-àn-à]     [kù-nám-íl-ìs-àn-á]     PR (non-phrase-final)
```

When the verb form is phrase-final, the process of penultimate lengthening (illustrated in (3) above) will apply. As high tones are not allowed in phrase-final position, any such high will shift to the preceding mora, as formalized below.

(12) Phrase-final left shift

```
μ    μ ]ϕ
 \   +
   H
```

These two phrase-level processes are illustrated below, where the derivations in (11) are continued.

```
(13) a.   ku-[lim-il-is-aan-a     ku-[nam-il-is-aan-a     Penultimate lengthening
               | /                     | /          |
               H                       H            H

     b.                           ku-[nam-il-is-aan-a     Phrase-final left shift
                                       | /      |
                                       H        H
```

[2] We follow Mkochi and Bickmore (2021), in assuming that the root H, just like the melodic H and all the other high tones contributed by the reflexive pronoun and verb extensions and clitics, is underlyingly floating.

c. [kù-lím-íl-ìs-ààn-à] [kù-nám-íl-ìs-áán-à] PR (phrase-final)

With regard to the effects of penultimate lengthening and phrase-final left shift on verbs with differing stem lengths and the ways in which these two rules interact with other tonal processes, the reader is referred to Bickmore and Mkochi (2018), where this is explored in depth. The effects of depressor consonants, which are the focus of this paper, are most clearly exemplified within the non-phrase-final forms of verbs and therefore those are the ones developed here. Unless otherwise noted, all the verb forms presented below are given in their non-phrase-final realization.

The only form not yet accounted for is (10a). When two adjacent Hs are found within the stem, the first one is deleted. This is formalized below in (14) as Reverse Meeussen's Rule and illustrated in (15).

(14) Reverse Meeussen's Rule

```
   μ   μ
   |   |
ø ←H   H          Domain of application: Stem
```

(15)
```
a.    ku-[nam-a           UR

           H   H

b.    ku-nam-a      Stem-initial and Stem-final docking
          |   |
          H   H

c.    ku-nam-a      Reverse Meeussen's Rule
          |   |
      ø ←H   H

d.    n/a           Tone doubling

e.    [kù-nàm-á]    PR
```

Two additional tone rules can be illustrated within finite verb forms. Below we examine simple past forms, which have the structure: Subject Marker – Past /ngu/ – Root – Extensions – Final Vowel /a/. These exhibit the same stem tone patterns as the infinitives in (9) and (10).[3]

(16) Simple past: toneless root

a. tì-ŋgù-[lím-á 'we cultivated
b. tì-ŋgù-[lím-ís-à 'we caused to cultivate'
c. tì-ŋgù-[lím-ís-àn-à 'we caused each other to cultivate'

[3] Note that there is no OCP-driven deletion in (10b) because tone doubling follows the Reverse Meeussen's Rule.

(17) Simple past: H root

a.	tì-ŋgù-[nàm-á	'we lied'
b.	tì-ŋgù-[nám-ís-á	'we caused to lie'
c.	tì-ŋgù-[nám-ís-àn-á	'we caused each other to lie'

In CiTonga it is possible to add an itive ('go and verb') sense to some TAMs by adding the H-toned prefix /cí-/. Some past itive forms are given below.

(18) Simple past itive: toneless root

a.	tì-ŋgù-cí-[lím-à	'we went and cultivated'
b.	tì-ŋgù-cí-[lím-ìs-à	'we went and caused to cultivate'
c.	tì-ŋgù-cí-[lím-ìs-àn-à	'we went and caused each other to cultivate'

(19) Simple past itive: H root

a.	tì-ŋgù-cí-[nám-á	'we went and lied'
b.	tì-ŋgù-cí-[nám-ìs-á	'we went and caused to lie'
c.	tì-ŋgù-cí-[nám-ìs-àn-á	'we went and caused each other to lie'

The resulting tone patterns in these itive forms can be straightforwardly accounted for by positing a rule which deletes the second of two Hs found over a stem boundary. (The reader will recall from the discussion just above that when two adjacent Hs are found within the stem, the left one is deleted (14).) This is formalized as Meeussen's Rule in (20) and illustrated in (21).

(20) Meeussen's Rule

```
μ [St μ
|     |
H     H → ø
```

(21) Derivations of (18c) and (19c)

```
a.  ti-ŋgu-ci-lim-is-an-a       ti-ŋgu-ci-nam-is-an-a      UR
           |                           |
           H       H                   H   H    H

b.  ti-ŋgu-ci-lim-is-an-a       ti-ŋgu-ci-nam-is-an-a      Stem-initial and
            |  |                       |   |        |      stem-final docking
            H  H                       H   H        H

c.  ti-ŋgu-ci-lim-is-an-a       ti-ŋgu-ci-nam-is-an-a      Meeussen's Rule
           |  |                        |   |        |
           H  H → ø                    H   H → ø    H
```

```
d.   ti-ŋgu-ci-lim-is-an-a        ti-ŋgu-ci-nam-is-an-a       Tone doubling
              |/                            |/         |
              H                             H          H

e.   [tì-ŋgù-cí-lím-ìs-àn-à]      [tì-ŋgù-cí-[nám-ìs-àn-á]    PR
```

The motivation for the final tone rule to be presented here can be seen in past itive forms with a (toneless) object marker.

(22) Past itive forms with a toneless object marker

a. tì-ŋgù-cí-ʋá-lìm-íl-ìs-àn-à ‘we went and caused them to cultivate for each other’
b. tì-ŋgù-cí-ʋá-nàm-íl-ìs-àn-á ‘we went and caused them to lie for each other’

The rules motivated thus far are exemplified in the derivations below.

```
(23) a.  ti-ŋgu-ci-ʋa-lim-il-is-an-a     ti-ŋgu-ci-ʋa-nam-il-is-an-a     UR
               |                               |
               H          H                    H    H     H

     b.  ti-ŋgu-ci-ʋa-lim-il-is-an-a     ti-ŋgu-ci-ʋa-nam-il-is-an-a     Stem-initial and
                |    |                         |    |          |      stem-final docking
                H    H                         H    H          H

     c.  ti-ŋgu-ci-ʋa-lim-il-is-an-a     ti-ŋgu-ci- ʋa-nam-il-is-an-a    Tone doubling
               |/   |/                         |/    |/          |
               H    H                          H     H           H
```

To account for the fact that the roots (/lim/ and /nám/) both surface as low, we propose a third process (in addition to Reverse Meeussen’s Rule (14) and Meeussen’s Rule (20)) to repair an OCP violation:

(24) Delinking[4]

```
μ   μ  μ   μ
 \ /   X /
  H    H
```

[4] With regard to this process, we note that it fails to apply if the second double-linked H is itself followed by a H. This configuration obtains in trisyllabic stems with a H root, preceded by a H-Ø sequence (as is the case in the past itive forms being considered here). For example, in a form such as /ti-ŋgu-cí-ʋa-nám-is-á/ ‘we went and caused them to lie’, doubling creates *ti-ŋgu-cí-ʋá-nám-ís-á*. Delinking simply does not apply in such cases. Instead, as detailed in Bickmore and Mkochi (2018), the form surfaces as *ti-ŋgù-cí-ʋá-ꜜnám-ís-á*, where the OCP violation across the stem is phonetically realized as a downstep.

(25) Derivation of (23a,b) continued

```
a.  ti-ŋgu-ci-ʋa-lim-il-is-an-a        b.  ti-ŋgu-ci-ʋa-nam-il-is-an-a    Delinking
            |/        |                            |/         |      |
            H         H                            H          H      H
```

In each case, tone doubling applies once to the H linked to the TAM prefix /cí-/ and once to the stem-initial H, after which delinking (24) applies, which has the effect of repairing the newly created OCP violation. With the basic tone rules of the language now described and exemplified, we turn to the effects of depressor consonants.

3 Evidence of depressor consonants: Blocking of doubling

Within Bantu, a number of languages exhibit depressor consonants (DCs). In some cases, these effects are claimed to be phonological – as they are categorical and can neutralize the underlying tonal contrast (from H to L). In Nambya, H-toned V's are lowered to low by a preceding DC (Downing and Gick 2005). In Ikalanga, DCs block rightward tone spreading (Hyman and Mathangwane 1998). In Xhosa, high tone shift is generally to the antepenult, but if that syllable has a DC, then shift is to the penult (Rycroft 1980). In other cases, the effect is gradient, and non-neutralizing, as in neighbouring Chichewa (Trithart 1976; Cibelli 2015).

CiTonga exhibits both phonological and phonetic effects of depressor consonants. We begin with the phonological effects. As was illustrated in (9), (16), and (18), in verbs with toneless roots, the melodic high which docks onto the stem-initial (root) vowel subsequently undergoes tone doubling (TD). In the simple past itive forms in (18), after Meeussen's Rule applies, the H on /cí-/ doubles onto the root-initial TBU.

The forms below show that tone doubling applies across a sonorant, a voiceless obstruent, and a prenasalized voiced obstruent. In each case below the root is toneless. The melodic high docks onto the stem-initial mora and then doubles onto the final vowel.

(26) Tone doubling applies across a sonorant:[5]

a.	kù-púm-á	'to beat'
b.	kù-nén-á	'to deride'
c.	kù-píɲ-á	'to reduce in size'
d.	kù-nól-á	'to sharpen by grinding'
e.	kù-ʋéʋ-á	'to thatch'
f.	kù-líj-á	'to cry out'
g.	kù-néɰ-á	'to draw water'
h.	kù-nów-á	'to be sweet'

[5] The only sonorant not illustrated in the infinitive forms here is the velar nasal /ŋ/, as it is never root-final. The fact that it permits TD across it can be seen in forms such as tì-ngù-cí-ŋól-à 'we went and denied with grimace', where the H on the prefix /cí-/ doubles onto the first mora of the stem.

(27) Tone doubling applies across a voiceless obstruent

a. kù-táp-á ‘to take from’
b. kù-mbát-á ‘to stick on’
c. kù-cúc-á ‘to drip continuously’
d. kù-múk-á ‘to answer’
e. kù-séf-á ‘to sift’
f. kù-lás-á ‘to stab’

(28) Tone doubling applies across a prenasalized voiced obstruent

a. kù-témb-á ‘to curse’
b. kù-ndónd-á ‘to go in line’
c. kù-péɲɟ-á ‘to look for’
d. kù-náŋg-á ‘to destroy’

As seen below, when a glide follows one of the above consonants, tone doubling still applies.

(29) a. kù-kómw-á ‘to be in great pain’
b. kù-púkw-á ‘to desire greatly’
c. kù-tófj-á ‘to press with fingers’
d. kù-tóndw-á ‘to be puzzled’

It turns out, however, that tone doubling is completely blocked if the consonant immediately following the H is either a voiced obstruent or an aspirate (both plain and prenasalized aspirates). In the infinitival forms below (in stark contrast to those above in (26)–(29)), we see that the melodic high which docks onto the stem-initial TBU is blocked from doubling onto the following TBU if the second C of the stem is either a voiced obstruent (30) or an aspirate (31).

(30) Tone doubling blocked by voiced obstruents

a. kù-fúz-à ‘to be full’
b. kù-ʋéɟ-à ‘to fish (with line and hook)’
c. kù-cóv-à ‘to gamble’

(31) Tone doubling blocked by aspirates

a. kù-wót^h-à ‘to warm oneself’
b. kù-kúnc^{h}ij-à ‘to nod in assent’
c. kù-lík^h-à ‘to cut down tree
d. kù-pémp^h-à ‘to beg
e. kù-kúnt^h-à ‘to pluck’
f. kù-tíŋk^h-à ‘to hate’

To further exemplify the blocking, in the simple past itive forms below, we see that the high tone on the itive prefix /cí-/ (cf. (18)) fails to double onto the following TBU if the stem begins with either a voiced obstruent or an aspirate.

(32) Tone doubling blocked by a voiced obstruent

a.	tì-ŋgù-cí-bàl-à	'we went and bore offspring'
b.	tì-ŋgù-cí-dìk-à	'we went and spilled'
c.	tì-ŋgù-cí-ɟàm-à	'we went and danced'
d.	tì-ŋgù-cí-gàl-à	'we went and rode a horse'
e.	tì-ŋgù-cí-vìmb-à	'we went and covered'

(33) Tone doubling blocked by an aspirate

a.	tì-ŋgù-cí-hòl-à	'we went and received'
b.	tì-ŋgù-cí-p^{h}ùt-à	'we went and blew on'
c.	tì-ŋgù-cí-c^{h}ìk-à	'we went and drove'
d.	tì-ŋgù-cí-t^{h}èl-à	'we went and arrived'
e.	tì-ŋgù-cí-k^{h}àt-à	'we went and cut'

The infinitival and simple past forms below show that tone doubling is blocked even when a glide follows the DC.

(34) Tone doubling blocked by voiced obstruent + glide

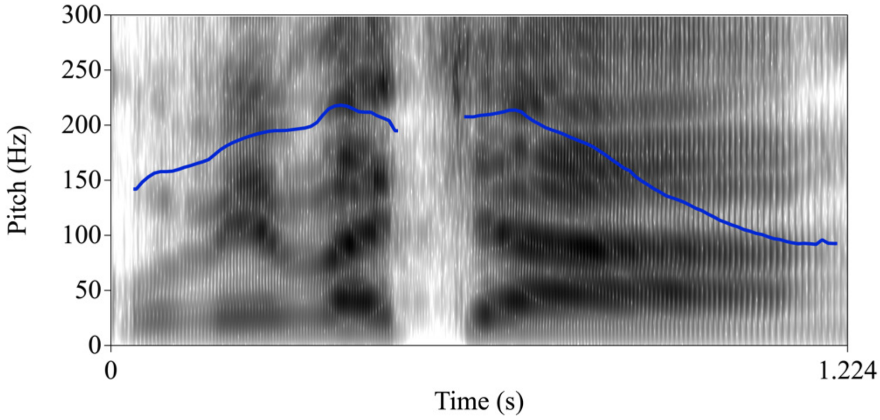
a.	tì-ŋgù-cí-bwàny-à	'we went and pushed'
b.	tì-ŋgù-cí-ɟwàt-ìk-à	'we went and put something among things quickly'
c.	tì-ŋgù-cí-gwàd-à	'we went and kneeled'
d.	kù-fúvj-à	'to deceive'
e.	tì-ŋgù-cí-zjàŋg-à	'we went and coloured'

(35) Tone doubling blocked by aspirate + glide

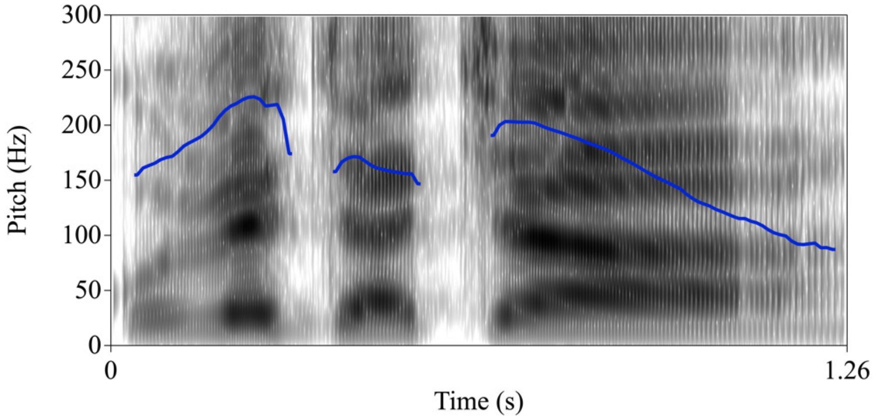
a	kù-yúnk^{h}w-à	'to sit uneasily'
b.	tì-ŋgù-cí-p^{h}wàɲ-à	'we went and broke something into pieces'
c.	tì-ŋgù-cí-t^{h}wànuk-à	'we went and opened our eyes wide'

Below, we provide pitch tracings of *kù-vév-á* 'to thatch' (26f) and *kù-véɟ-à* 'to fish (with line and hook)' (30b), in the phrasal context of preceding the negative word *cáà*.

(36) Pitch trace of *kù-vév-á cáà* ‘not to thatch’, no DCs, H doubles onto [ʋa]



(37) Pitch trace of *kù-véɟ-à cáà* ‘not to fish’, doubling onto [ɟa] blocked



In both forms the infinitival prefix *ku-* is low, and the following root vowel is linked to a melodic high tone. In (36) the H tone doubles onto the following verb-final TBU. As can be seen, this phonological L-H-H tonal sequence begins with a low on [ku-]. The pitch begins to rise through the stem-initial sonorant onset and continues to do so through the following underlyingly high TBU, where the maximum target height is reached at the beginning of the stem-final TBU to which the high is spreading. In contrast, the L-H-L sequence in (37) is realized quite differently. The pitch begins to rise during the phonologically low-toned *ku-*, and the maximum target height is reached in the middle of the H-toned syllable, and then begins to fall at the very end of that syllable. The pitch on the following, low-toned syllable is approximately as low as it was at the beginning of the initial *ku-*. The pitch then goes up significantly at the beginning of the following *cáà* (though not as high as it did in [ʋe], exhibiting characteristics of downdrift).

The following summarizes which consonants block tone doubling and which do not. (Recall that glides following a consonant do not affect the blocking or non-blocking at all.)

(38) a. Consonants which block tone doubling
- i. Voiced obstruents: /b, d, ɟ, g, v, z/
- ii. Aspirates (plain & prenasalized): /p^h, t^h, c^h, k^h, mp^h, nt^h, $ɲc^h$, $ŋk^h$, h/

b. Consonants which do not block tone doubling
- i. Sonorants: /l, m, n, ɲ, ŋ, ʋ, j, ɰ, w/
- ii. Voiceless obstruents /p, t, c, k/
- iii. Prenasalized voiced stops /mb, nd, ɲɟ, ŋg/

In terms of defining the trigger of this process, it is not obvious that there is any one feature or group of features that unifies the group of consonants which act as depressors; i.e. it may be simple enough to describe voiced obstruents and aspirates as two individual natural classes, but that begs the question as to whether the trigger must simply be stated in disjunctive terms or whether some deeper, perhaps more abstract feature is at play. We return to this issue below.

4 Phonetic effects of depressor consonants

Having just argued that there are phonological effects of depressor consonants, as diagnosed by tone doubling, we turn to an examination of the phonetic effects of depressor consonants in CiTonga. We begin by providing methodological details on how the data was collected and analysed.

4.1 Methodology

A total of 269 forms, consisting of 161 unique verb stems, were elicited over a time frame of approximately one month. The distribution of verbs according to several factors is presented in Table 1 below.

Table 1: Distribution of forms collected for this study

Underlying tone of stem	H	84
	toneless	185
TAM	infinitive	154
	distant past	115
C_1 class	aspirate	51
	aspirate with glide	6
	prenasalized voiced stop	8
	sonorant	56
	voiced obstruent	74
	voiced obstruent with glide	23
	voiceless obstruent	47

C_2 class	aspirate	21
	aspirate with glide	2
	prenasalized voiced stop	29
	sonorant	113
	voiced obstruent	29
	voiced obstruent with glide	3
	voiceless obstruent	63
	no C_2	9

The data were recorded using Audacity with a head-mounted microphone (Audacity Team 2014). Each verb form was recorded three times in the frame of *kàmbà* ____ *kácívìì* ‘Say ____ again’, and the F0 values collected were averaged over the three recordings. Verbs were elicited in this non-phrase-final context to avoid the influence of vowel lengthening, as the penultimate vowel of a phonological phrase is lengthened and affects the output of tone. Minimal pairs of stems with an underlying H tone and toneless stems were elicited at separate times to avoid one influencing another. Verb forms for each consonant of the language in C_1 and C_2 position of the stem were elicited, except for the few instances in which a consonant was not attested in a position.

All recordings were analysed in Praat (Boersma and Weenink 2019). The boundaries for the vowels measured were input manually and measurements were then collected using the ProsodyPro (Xu 2013) Praat script. All vowels were time-normalized into 10 equal intervals. Measurements included throughout this analysis are the mean F0 (Hz), minimum F0 (Hz), maximum F0 (Hz), drop/rise in F0 (Hz), duration (ms), and intensity (dB). All measurements were compiled into a database for statistical analysis, which was conductedusing R (R Core Team 2014).

4.2 Phonetic results of forms exhibiting the blocking of tone doubling

We first establish that there is a difference between the mean F0 of the vowel following ‘blocker’ consonants and the vowel following ‘non-blocker’ consonants (38) in the range of forms presented and discussed in Section 3. A t-test confirms that this difference is statistically significant and not coincidental: $t(28) = 17.94$, $p < .001$. The final vowel has a lower tone when following a blocker consonant (with an average of 147 Hz) and a higher tone when following a non-blocker consonant (with an average of 185 Hz).

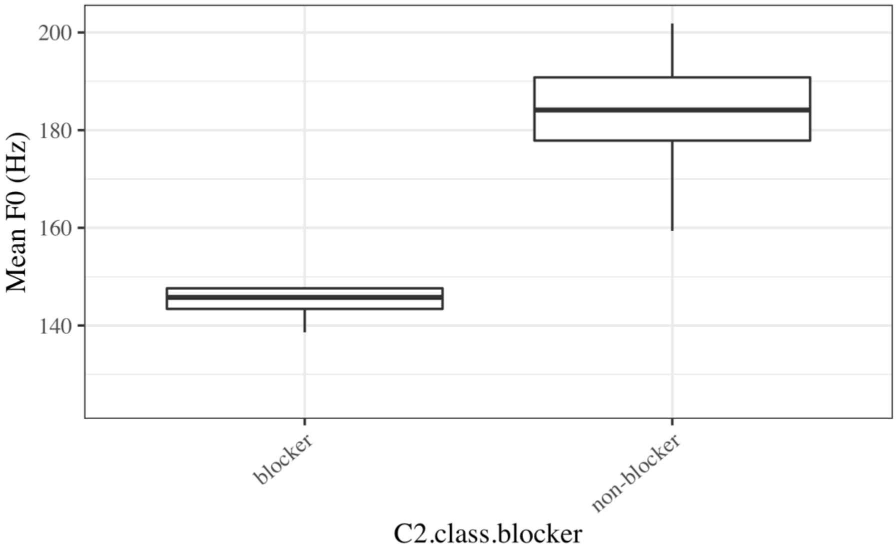


Figure 1: Distribution of tone (Hz) on vowels following a blocker consonant and a non-blocker consonant

An analysis of variance was conducted comparing the effect of the class of the preceding blocker consonant on the mean F0 of the following vowel in the context of tone doubling, and the results showed that the effect was insignificant: $F(3, 16) = 0.337$, $p = 0.799$. An identical test was conducted on non-blocker consonants and the results showed likewise that the class of the consonant did not affect the F0 of the final vowel: $F(2, 74) = 0.558$, $p = 0.575$. Based on this data, reflected in the figure below, it can be concluded that the lowness of the tone on the following vowel is equal after a blocker consonant regardless of class, and that the highness of the tone on the following vowel is equal after all non-blocker consonants.

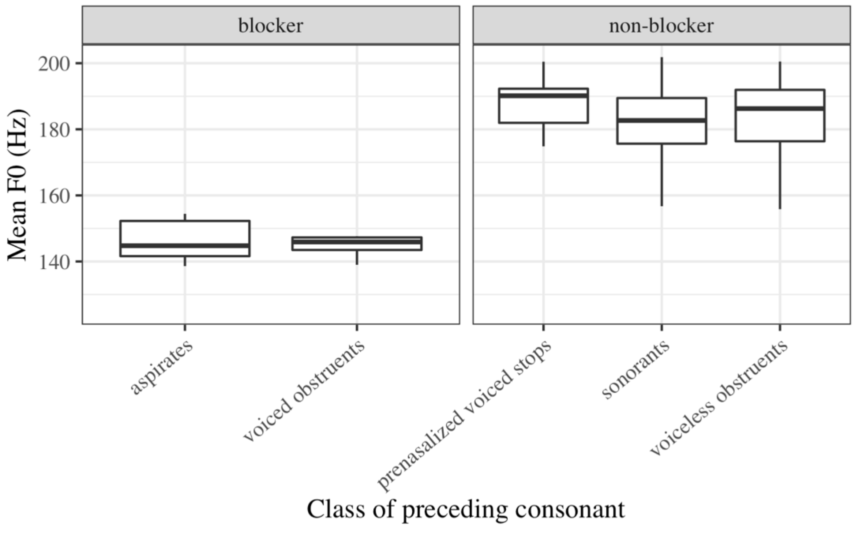


Figure 2: Distribution of tone (Hz) on final vowels by class of preceding consonant

4.3 Phonetic effects of consonants on pitch of following vowel

Having established that there is a set of depressor consonants which block tone doubling (38), let us now ascertain whether consonants can have a lowering effect on the pitch of a following TBU linked to a high tone. For example, in a $C_1V_1C_2V_2$ stem, when C_2 is a DC, it will block a high on V_1 from doubling onto V_2. But what if, instead, C_1 is a DC (and C_2 is not)? Tone doubling will apply, but what effect if any will a DC in C_1 have on V_1? It turns out that the DCs shown above to block tone doubling (viz. voiced obstruents and aspirates) also have a lowering effect on an immediately following high-toned TBU. We will now show, however, that this lowering of tone found after DCs, which we refer to below as tone lowering (TL), is different from the blocking of tone doubling by a DC described above, which we refer to as high blocking (HB), in two important respects.

First, we showed above (Figure 2) that the phonetic effects of high blocking were the same regardless of which DC was present – e.g. the low pitch on the following vowel was statistically the same whether the blocking consonant was /d/, /z/, /kʰ/, or /ntʰ/. By contrast, we show below that tone lowering is gradational rather than categorical. Within the set of DCs, some have a greater lowering effect on a following H than others. Furthermore, we will show that within the set of consonants which do not block tone doubling, there are some significant differences in lowering effects.

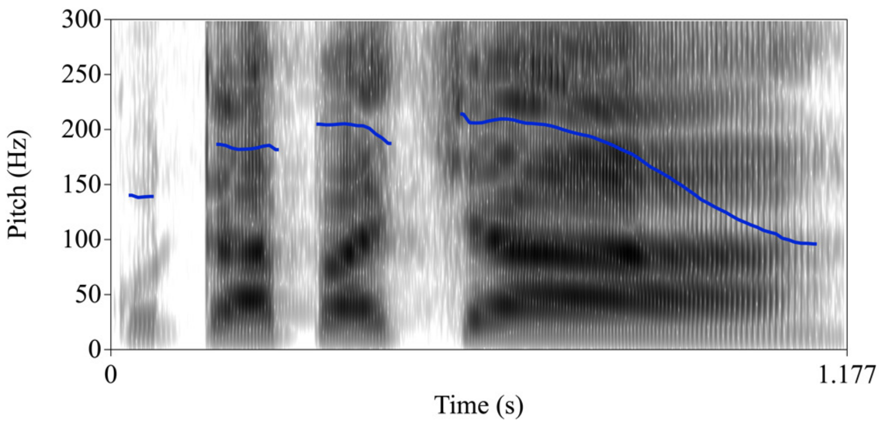
Second, whereas blocking led to a following TBU being pronounced at the same pitch as other low tones in the form (consistent with the characteristics of phonological neutralization), we will show that tone lowering generally does not have this effect. In the context of tone lowering, while the pitch of a TBU following a DC is significantly lower than one following a non-DC, the pitch does not generally descend to the level of a phonologically low tone. Having said that, those DCs which have the greatest lowering effect bring the tone down to a range which does overlap with a phonological low, resulting in a near neutralization, something taken up in Section 4.4 below.

To substantiate these claims, let us first review the phonetic pattern that results from tone doubling. As seen above in (36), within the surface bisyllabic high tone domain (where a high on the first TBU has spread to the second via tone doubling) the pitch rises through the first TBU, reaching its peak at the beginning of the second TBU, through which the H remains fairly level. This is the attested peak target pattern in all $C_1V_1C_2V_2$ stems where both C_1 and C_2 are non-depressors.

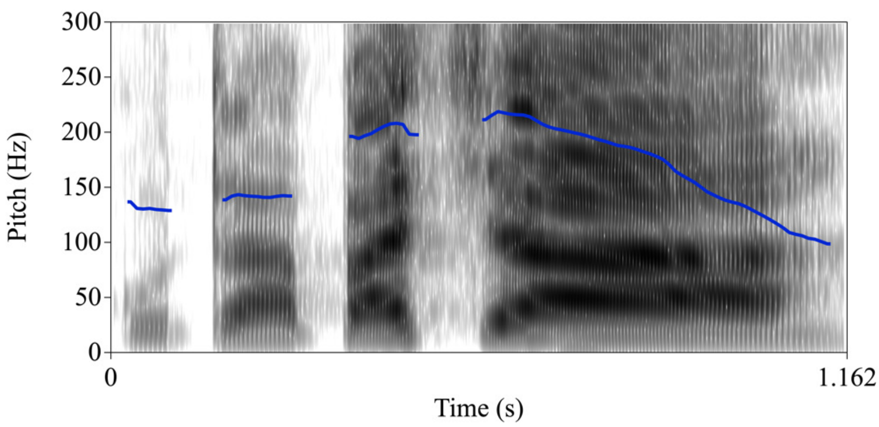
This can be usefully contrasted with the low-high phonological output in bisyllabic stems such as the one in (10a), which results from Reverse Meeussen's Rule (14). As noted above, in bisyllabic stems with H-toned roots, the MH (melodic high) which docks onto the final vowel will cause the immediately preceding root H to delete, accounting for minimal pairs such as the one shown below in (39), the pitch tracings of which are shown in (40) and (41). In the examples below, as an aid to the reader, the (near) underlying representations presented in the slanted brackets on the right reflect the initial docking of the underlying highs – one in the case of verbs with toneless roots and two in the case of roots with H-toned roots (see e.g. (11)).

(39)	a.	kù-táp-á cáà	'not to take from'	/ku-táp-a/	Ø root; tone doubling (7)
	b.	kù-tàp-á cáà	'not to take extra cards'	/ku-táp-á/	H root: Reverse MR (14)

(40) Pitch trace of *kù-táp-á cáà* ‘not to take from’ (39a); toneless root, no DC



(41) Pitch trace of *kù-tàp-á cáà* ‘not to take extra cards’ (39b); H root, no DC

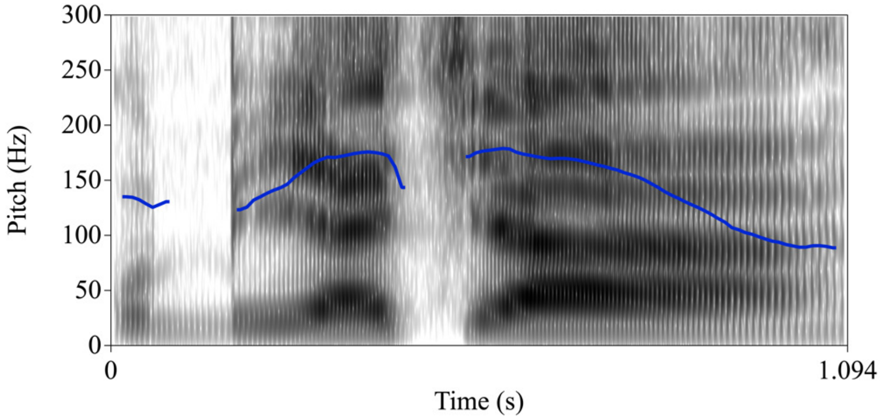


In the L-H-H form shown in (40), the pitch of the first TBU in the stem is considerably higher than the preceding [ku-], though again, the maximum pitch height is not achieved until the beginning of the second stem TBU (see (36)). (The fact that the pitch is more level in the first TBU (40) and rising in (36) can be attributed to the manner of articulation and voicing of the adjacent consonants.) In the L-L-H form in (41), by contrast, the pitch of the stem-initial TBU is basically at the same general level as the preceding low-toned [ku-] and then goes up significantly on the following TBU, reaching maximum height at the beginning of the TBU after that (the first TBU of the negative *cáà*).

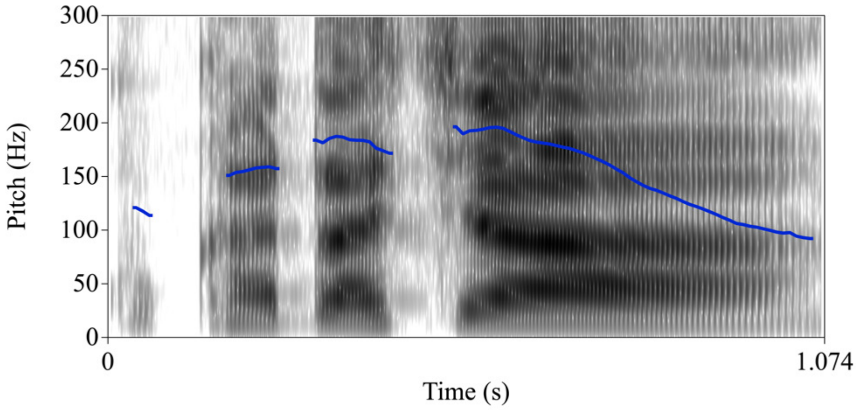
We are now in a position to examine what happens when a $C_1V_1C_2V_2$ stem with a toneless root begins with a DC. Let us begin by considering the pitch pattern of two forms with a DC in C_1 (and no DC in C_2). The pitch tracings of the two forms in (42) are given in (43) and (44).

(42) a. kù-b-íj-á cáà ‘not to steal for’
b. kù-kʰát-á cáà ‘not to cut lightly’

(43) Pitch trace of *kù-b-íj-á cáà* 'not to steal for'



(44) Pitch trace of *kù-khát-á cáà* 'not to cut lightly'



The form in (43) can be usefully compared to the one in (36), the latter of which does not contain any DCs. Whereas the stem V_1 in (36) began on a pitch higher than that found on the preceding [ku], this is not the case in (43), where V_1 begins on a pitch slightly lower than [ku], due to the immediately preceding DC /b/. The rise through V_1 in (43) is somewhat steeper than it was in (36) in order to reach the maximum pitch height within V_2, where that maximum height occurs in the middle of V_2 instead of at the very beginning of it.

Likewise, the form in (44) can usefully be compared to (40). Whereas in (40) the tone on V_1 is much closer to that of V_2 than it is to [ku], in (44), the tone on V_1 is more equidistant between [ku] and V_2. All this suggests that tone lowering is a gradient phonetic process and not a phonological one. We thus consider the forms in (42), as well as those below in (45), where C_1 is a DC, to have stem tone patterns which are phonologically high-high, the same as the stem tones in (26)–(29) which contained no DCs.

(45)	a.	kù-bál-á	'to bear offspring'
	b.	kù-dán-á	'to call'
	c.	kù-ɟám-á	'to dance'
	d.	kù-gál-á	'to ride horse'
	e.	kù-vún-á	'to harvest'
	f.	kù-zíl-á	'to reject'
	g.	kù-pʰút-á	'to blow on'
	h.	kù-tʰél-á	'to arrive'
	i.	kù-kʰát-á	'to cut lightly'
	j.	kù-ntʰóny-á	'to leak'
	k.	kù-hól-á	'to receive

Given the clear bifurcation of consonants which either block or do not block tone doubling (38), one hypothesis at this point might be that in the context of phonetic (non-phonological) tone lowering, the group of consonants which blocked tone doubling would have a uniform lowering effect on the following vowel, and those which did not block tone doubling would likewise behave identically in not showing any lowering effect. We now show that neither of these turns out to be true.

An ANOVA test with a post-hoc Tukey test reveals that the 7 onset types form four statistically significant groups in terms of their effect on the pitch of the following vowel, shown below with the highest to lowest pitch on the vowel following the onset.

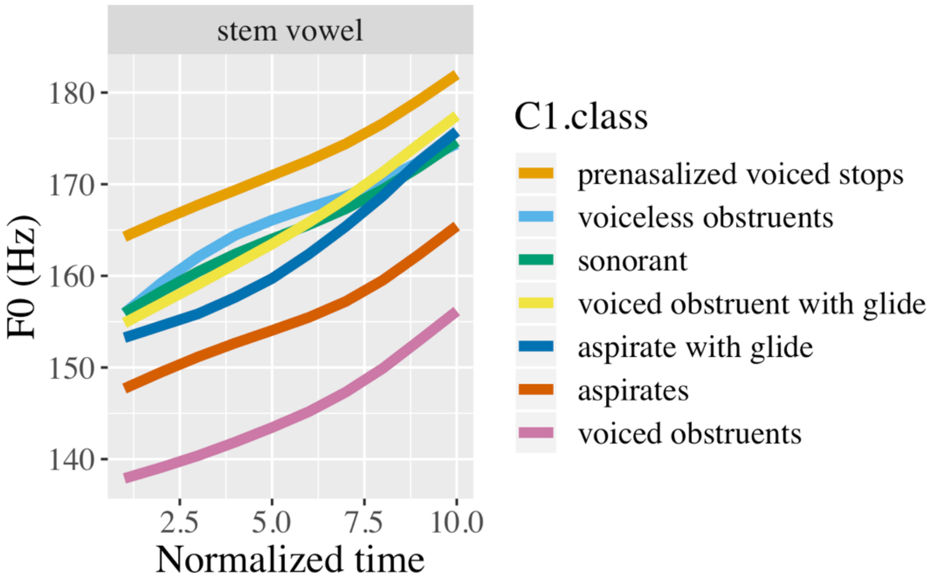


Figure 3: Pitch on vowel according to class of onset consonant

The phonetically motivated groups of consonants with respect to pitch depression are as follows. Those groups which were demonstrated to block tone doubling are shown in red.

(46) a. Prenasalized voiced stops
b. Voiceless obstruents, sonorants, aspirates + glides, voiced obstruents + glides
c. Aspirates
d. Voiced obstruents

We saw in Section 3 that all voiced obstruents and aspirates (optionally followed by a glide) had a uniform effect in blocking tone doubling. In the TL context, however, these two classes of consonants do not behave as an undifferentiated block, but rather form two blocks. Voiced obstruents as a group have a greater lowering effect than aspirated consonants. Prenasalization of an aspirated stop does not have a consistent effect in making the sound more or less depressive.

In addition, recall that obstruents and aspirates will categorically block high tone doubling regardless of the presence or absence of a glide. However, in Figure 3 we see that lone voiced obstruents and voiced obstruent + glide sequences pattern differently, as do lone aspirates and aspirate + glides. Voiced obstruents have the greatest depressing effect and aspirates have the second greatest depressing effect. In contrast, sequences of aspirate + glide and voiced obstruent + glide behave similarly to voiceless obstruents and sonorants in terms of their depressing effects. We propose to account for this in terms of adjacency. In the phonetic implementation, what triggers a depression effect is the segment immediately preceding the vowel. In the case of depressor + glide onsets, it is the [+sonorant] glide which is adjacent to the vowel, explaining why these onsets behave like other lone sonorants. This follows directly if these glides are segmental, forming a complex onset (e.g. [zj]) rather than being secondary articulations (e.g. [z^j]). By contrast, as discussed in Section 3, what blocks tone doubling is the presence of a depressor consonant (aspirate or voiced obstruent), regardless of whether it is immediately adjacent to the following vowel or separated from the vowel by a glide.

4.4 Audio discrimination test

It will be recalled that in infinitive forms with bisyllabic stems, the surface difference in forms with toneless versus high-toned roots lies in the surface tone of the root vowel. This is illustrated clearly in (39), repeated below for convenience.

(47)	a.	kù-táp-á cáà	'not to take from'	/ku-táp-a/	Ø root; tone doubling (7)
	b.	kù-tàp-á cáà	'not to take extra cards'	/ku-táp-á/	H root: Reverse MR (14)

In the forms above there are no depressor consonants. Given the evidence presented above that depressor consonants in C_1 position have a lowering effect on the following vowel, we might ask whether a root-initial DC could lower a following vowel within a toneless root, such as (47a), so much that it brought it into the pitch range of a surface low within a high-toned root, such as (47b), in essence neutralizing the surface tones between underlyingly toneless and high-toned roots.

To further assess whether tone lowering has the potential to mostly or fully neutralize tonally contrastive roots, we performed an audio discrimination test with the first author. We began by recording tokens of each form in 11 pairs of verbal infinitive minimal tone pairs, given below in (48)–(58). All verbs have bisyllabic stems which have a DC in C_1 and a non-depressor in C_2. Note that the recording was also made with the first author.

(48)	a.	kù-b-íj-á	‘to steal for’	Ø root; tone doubling (7)
	b.	kù-b-ìj-á	‘to cheat’	H root: Reverse MR (14)
(49)	a.	kù-dík-á	‘to spill’	Ø root; tone doubling (7)
	b.	kù-dìk-á	‘to cover oneself’	H root: Reverse MR (14)
(50)	a.	kù-ɟám-á	‘to dance’	Ø root; tone doubling (7)
	b.	kù-ɟàm-á	‘to jam’	H root: Reverse MR (14)
(51)	a.	kù-gánd-á	‘to hit with vehicle’	Ø root; tone doubling (7)
	b.	kù-gànd-á	‘to mark an enemy’	H root: Reverse MR (14)
(52)	a.	kù-vímb-á	‘to cover; shade over’	Ø root; tone doubling (7)
	b.	kù-vìmb-á	‘to be constipated’	H root: Reverse MR (14)
(53)	a.	kù-zyáŋg-á	‘to colour; paint’	Ø root; tone doubling (7)
	b.	kù-zyàŋg-á	‘to turn against one who has been good to one’	H root: Reverse MR (14)
(54)	a.	kù-p^{h}át-á	‘to prune’	Ø root; tone doubling (7)
	b.	kù-p^{h}àt-á	‘to get stuck’	H root: Reverse MR (14)
(55)	a.	kù-t^{h}én-á	‘to castrate’	Ø root; tone doubling (7)
	b.	kù-t^{h}èn-á	‘to give too little’	H root: Reverse MR (14)
(56)	a.	kù-t^{h}él-á	‘to arrive’	Ø root; tone doubling (7)
	b.	kù-t^{h}èl-á	‘to give up’	H root: Reverse MR (14)
(57)	a.	kù-k^{h}át-á	‘to cut lightly’	Ø root; tone doubling (7)
	b.	kù-k^{h}àt-á	‘to stick in throat’	H root: Reverse MR (14)
(58)	a.	kù-hól-á	‘to receive’	Ø root; tone doubling (7)
	b.	kù-hòl-á	‘to be scored	H root: Reverse MR (14)

The speaker heard the audio of each of the 22 infinitival forms played in random order, and was asked after each to state the meaning of the verb. In these 22 attempts, the speaker produced the intended meaning 16 times (72.7%) and the non-intended meaning 6 times (27.3%). The latter 6 attempts are listed below.

(59)	Recording			Meaning given
	a.	kù-t^{h}èl-á	‘to give up’	‘to arrive’
	b.	kù-dìk-á	‘to cover oneself’	‘to spill
	c.	kù-t^{h}èn-á	‘to give too little’	‘to castrate’
	d.	kù-p^{h}àt-á	‘to get stuck’	‘to prune’
	e.	kù-ɟàm-á	‘to jam’	‘to dance’
	f.	kù-k^{h}àt-á	‘to stick in throat’	‘to cut lightly’

Two observations are in order. First, each "misidentified" case involved judging a high-toned verb to be the corresponding low-toned one. That is, all recorded low-toned verbs were judged correctly – none were judged as high-toned. Second, while Figure 3 shows that voiced obstruents have a stronger lowering effect overall than aspirated consonants, both types appear on the list of misidentified forms in (59). One might have predicted, a priori, that the misidentified cases would exclusively be those with roots beginning with a voiced obstruent, but that did not turn out to be true.

While it is not clear what exactly accounts for the above results, it is possible that one contributing factor might be the fact that, as in closely related Chichewa, toneless verb roots vastly outnumber high-toned ones, and thus would be the unmarked choice in some sense. Another possible factor might be the relative frequency of use of the two items within the minimal pair. Additional experimentation is needed to illuminate this further.

4.5 Typological findings

Finally, we would like to compare the CiTonga hierarchy given in (46), repeated in (60), to that posited for closely related Chichewa by Cibelli (2015), given below (61). In both cases the listing is from least depressive (or even raising) to most depressive.

(60) CiTonga depressor consonant hierarchy
prenasalized voiced obstruents > voiceless obstruents, sonorants, aspirates + glides, voiced obstruents + glides > aspirates > voiced obstruents

(61) Chichewa depressor consonant hierarchy (Cibelli 2015, 185)
aspirates > voiceless obstruents > prenasalized voiceless obstruents > nasals > prenasalized voiced obstruents > voiced obstruents

Two things immediately jump out here. First is the difference in the position of aspirates. They are clearly depressors in CiTonga, blocking tone doubling ((31), (33)) and having the second greatest gradational tone lowering effect in the TL context. In Chichewa, by contrast, aspirates have the greatest raising effect. Chichewa seems more typical in this regard, as it is typologically unusual for aspirates to have a lowering effect. Notable exceptions where it is claimed that aspirates act as depressors include Xitsonga (Lee 2009), Ikalanga (Mathangwane 1998), and Tsua (Mathes and Chebanne 2018).

The second difference is the position of prenasalized voiced obstruents. While they are the second strongest depressors in Chichewa, they do not have a strong lowering effect in CiTonga. Phonologically, they are non-depressors as they do not block tone doubling (28). Hyman (2008) presents an interesting typology of pre-nasalized obstruents in Bantu languages. He shows that in languages with no underlying contrast between prenasalized voiceless obstruents and prenasalized voiced obstruents, the presnasalized voiced obstruents will have depressor effects in some languages (e.g. Lamang, Musey, Ngizim, Ouldeme, Podoko, Shona) but not in others (e.g. Bole, Geji, Miya, Zar, Yulu, Suma, Ikalanga, Mijikenda). However, when a language contrasts prenasalized voiced and voiceless obstruents, Hyman states that in all known cases the prenasalized voiced obstruents act as depressors. As we have shown above, this is not the case in CiTonga and thus it may be the first case of its kind in this regard. This assumes, of course, that the 'contrast' in question is underlying and not on the surface. In CiTonga, while plain stops have a three-way contrast between voiced, voiceless unaspirated, and voiceless aspirated (e.g.

/d/ vs. /t/ vs. /t^h/), there is only a two-way contrast in prenasalized stops. While the surface contrast is one of prenasalized voiced versus prenasalized voiceless aspirated (e.g. [nd] vs. [nt^h]), we posit that the underlying difference does not include aspiration (e.g. /nd/ vs. /nt/) as that is a predictable property of a prenasalized voiceless stop. We note in concluding this point that while it is logically possible to posit the underlying difference between the prenasalized stops as one of /nt/ versus /nt^h/, where a post-nasal voiceless stop becomes voiced, we feel that the underlying voiced-voiceless contrast is a more basic one (as opposed to aspirated-unaspirated) as it is the relevant contrast elsewhere in the system – namely for the fricatives.

5 Summary

In this paper we presented newly elicited data showing that Malawian CiTonga has a range of consonants with tone depressor effects. The first phenomenon examined (in Section 3) was the blocking of high tone doubling, a systematic rule which spreads a high tone onto a following toneless TBU. A voiced obstruent or aspirate found immediately after a high-toned TBU prevents tone doubling from applying. This was argued to be a categorical effect, resulting in a high-low sequence instead of the expected high-high one when tone doubling applies. Phonetically, there was shown to be a statistically significant difference in the tone of the TBU following the high when a voiced obstruent or aspirate intervened versus any other consonant type. However, there was not a statistically significant difference in the pitch on the second TBU depending on which voiced obstruent or aspirate occurred. We therefore interpret this effect as being a phonological one.

The second depressor effect we examined (in Section 4) was the effect an onset consonant had on the pitch of an immediately following high-toned vowel (i.e. the first depressor effect examined the role of C_2 in $C_1\acute{V}C_2V$, whereas the second effect examined the role of C_1). The role of an onset C before a high-toned TBU was found to be gradational. Different consonants were shown to have different lowering effects. Statistically, these fell into four groups (46). We noted that in some cases the lowering effect of the depressor consonant was so great that the pitch on the following vowel was within the general range of a (derived) low tone, and this was confirmed by an audio discrimination test. As noted above, the discrimination test results are based on the judgments of a single speaker – the source of the Malawian CiTonga data on which this study is based. We recognize both the advantages and limitations of a single data source. On the one hand, it represents a single, uniform cognitive system. On the other, one must be careful not to extrapolate too much in terms of what can be assumed to be true for the entire dialect or language. Future phonetic research involving multiple data sources would certainly be quite welcome and important.

CiTonga is interesting theoretically and typologically in that it exhibits both phonological and phonetic effects of depressor consonants in a single language, each of which have been described and analysed here. These two kinds of effects can be related as follows. Having established a hierarchy of seven consonant classes with regard to phonetic lowering (46), it turns out that the four strongest phonetic depressor classes are phonological depressors, as diagnosed by the blocking of tone doubling. We suggest that there may well be a linguistic universal in this regard – i.e. when a hierarchy of consonant classes can be established according to their phonetic lowering effect on the pitch of an adjacent vowel, any consonants shown to have phonological lowering effects will be a contiguous subset of these consonant classes which includes the most depressive class. So, for instance, if Chichewa one day developed phonological depressors (assuming the phonetic effects in (61) remained the same), it might comprise just voiced obstruents, or voiced obstruents and prenasalized voiced obstruents, but could not comprise say voiced obstruents and aspirates, or just prenasalized voiced and voiceless obstruents. In order to test this hypothesis, more studies need to be undertaken of tone languages which document both phonetic and phonological depressor effects.

Finally, there is the question of how to formally account for the phonological blocking of high doubling. As noted above, in many languages (including Chichewa), aspirates are not depressors. But they are in CiTonga and a few other languages. Thus, it is not clear whether the group of depressors in a particular language will be unified by some specific feature or property (laryngeal or otherwise) that they all share. It might be the case, e.g., that the group of depressors always contains some or all of the language's voiced obstruents, but beyond that the other consonants included vary considerably. Importantly, in this regard, not all depressor consonants are voiced. Some depressor consonant theories (e.g. Bradshaw 1999) propose that effects such as the blocking of productive high spreading rules (as found in CiTonga) can be accounted for by having depressor Cs linked to a low (or low/voiced) autosegment. This would prevent a high tone linked to a previous vowel from spreading over the adjacent consonant onto the following vowel (given the prohibition on crossing association lines). A similar approach is taken within an OT framework in Lee (2008), where all consonants are TBUs, and a high-ranking constraint ensures that depressor consonants are linked to a low tone. In this latter approach the group of depressor consonants is not assumed to be universally defined or based on any particular feature. Rather, the consonants that comprise depressors are determined on a language-specific basis. The CiTonga facts seem quite amenable to Lee's approach. Further work on depressor consonants is needed to further elucidate and refine the formal treatment of this phenomenon.

Abbreviations

C = consonant, DC = depressor consonant, H = high tone, L = low tone, MH = melodic high, MR = Meeussen's Rule, OCP = obligatory contour principle, PL = plural, PR = phonetic representation, SG = singular, TAM = tense-aspect-mood, TBU = tone bearing unit, TD = tone doubling, UR = underlying representation, V = vowel

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