

Aaron Braver and Wm. G. Bennett

## Phonotactic c(l)ues to Bantu noun class disambiguation

**Abstract:** While a number of phonologists assume that phonotactics can provide clues to abstract morphological information, this possibility has largely gone unconsidered in work on Bantu noun classes. We present experimental evidence from isiXhosa (a Bantu language of the Nguni family, from South Africa), showing that speakers make use of root phonotactics when assigning noun classes to nonce words. Nouns in Xhosa bear class-indicating prefixes, but some of these prefixes are homophonous – and therefore ambiguous. Our findings show that when speakers are presented with words that have prefixes ambiguous between two classes, phonotactic factors can condition them to treat the nouns as one class or the other. This suggests that noun class (and other abstract morphological information) is not only stored in the lexicon, but is also redundantly indicated by phonotactic clues.

**Keywords:** phonotactics, noun class, NC, Xhosa, isiXhosa, Bantu

### 1 Introduction

Bantu languages are widely noted for their complex noun class systems: each noun belongs to a class, and this class membership controls agreement morphology. Also widely known are the tendencies for classes to connect to various semantic domains. For example, humans are prototypically in classes 1 and 2; plants often in classes 3 and 4; languages and various tools in classes 7 and 8; long, thin things in class 11; abstractions in class 14, and so forth.<sup>1</sup> Such categorizations are mere tendencies, though, and the class of a noun root cannot be definitively determined from its meaning, nor is the semantic domain of a noun's meaning predictable from its class. As such, it is standardly assumed that information about noun class membership must be lexically stored, rather than computed from semantic information. This raises a question: how do speakers manage such complex systems with so many distinct categories? The observation that different classes align with various semantic criteria suggests a deeper internal structure beyond mere arbitrary memorization. In other domains, based on evidence from languages outside of Bantu, it is noted that clues about abstract morphological or lexical information can be derived from phonology (Tucker et al. 1977, Corbett 1991, Moreton and Amano 1999, Gelbart 2005, Moore-Cantwell 2016, etc.). Along very much the same lines, there are languages where certain grammatical genders are systematically assigned on the basis of phonological form (see, for example, Foley (1991) on Yimas; Aronoff (1992, 1994) on Arapesh; Sande (2016) on Guébie).

In this paper, we argue that the noun class system of isiXhosa has not only internal semantic structure, but also phonological structure; we further speculate that Xhosa is not unusual in this respect, and that it is probably the case for Bantu noun class systems much more generally. The basis for our claim is that speakers of Xhosa are influenced by phonotactic patterns when assigning nonce words to noun classes. Since these nonce words are (by definition) not lexically stored, and were presented with no semantic content, we conclude that phonological factors are the primary basis on which speakers decide their noun class. Our findings suggest that abstract noun class features are not as arbitrary as they would seem on the face of it: rather, the phonological forms of the roots themselves may provide overt and accessible surface clues to this abstract information. More generally, this suggests that seemingly arbitrary morphological information may not be quite as arbitrary as is commonly assumed, as it may be identifiable from phonotactic prototypes.

### 2 About the noun class system of isiXhosa

#### 2.1 Background

Xhosa (called isiXhosa [isiɬʰóʂà]<sup>2</sup> in the language) is a Bantu language in the Nguni family, spoken primarily in south-eastern South Africa, with smaller communities of speakers in Zimbabwe (Kunju forthcoming), and major urban centers throughout the region. The language has in excess of 8 million speakers according to *Ethnologue* (Lewis et al. 2016), and has written traditions in the form of newspapers, bibles, and hymns

---

<sup>1</sup> For overviews that refer to relevant sources, see Katamba (2003), Idiata (2005), and many others.

<sup>2</sup> The first tone is not marked here because it varies predictably between dialect groups. We follow the convention of *The Greater Dictionary of IsiXhosa* (Tshabe et al. 1989/2003/2006) in leaving such tones unmarked here and throughout.

dating back to early-mid 1800s. There is a small but long-running descriptive literature, including grammars by McLaren (1942), Jordan (1966), Pahl (1978), and a three-volume dictionary (Tshabe et al. 1989/2003/2006). Generic background information reported here comes from these sources and first-hand observations by the authors.<sup>3</sup>

Xhosa nouns normally consist of a stem and a prefix. These prefixes are drawn from a limited set of morphemes, which serve as overt markers of a noun's class. Xhosa has 15 noun classes, shown in the table in (1). We follow the Bantuist convention of referring to them by numbers, assigned by convention based on the classes reconstructed in Proto-Bantu (see, e.g., Doke 1954:52 for details about the noun class systems of Nguni and Proto-Bantu). Some sources (including Doke 1954) admit two further classes, 16 and 17, historically used with locatives. Class 16 is not productive; class 17 is homophonous with class 15, and it is not clear that any real distinction is made synchronically.

Most of the classes are organized into singular/plural pairs, with odd numbers being classes of singular nouns, with their plurals typically being in class  $n+1$ . Thus, class 1 nouns have plurals in class 2, class 5 nouns have plurals in class 6, etc. Class 11 makes its plurals in class 10, however; members of classes 14 and 15 typically do not have plural forms. Classes 1a and 2a are distinct only in the prefixes on the nouns; they trigger the same agreement marking as classes 1 and 2, respectively. For ease of identification, we split the class prefixes with hyphens here in orthographic forms, but note that the position of this boundary is sometimes difficult to determine. This is because prefixes may interact with roots phonotactically, as described in the next section.

(1) Noun class system of Xhosa

Classes (in sg/pl pairs)	Singular	Plural	Gloss	
1/2	um-/aʔa-	<i>um-ntu</i> [umnt'u]	<i>aba-ntu</i> [aʔant'u]	person(s)
1a/2a	u-/oo-	<i>u-mama</i> [umama]	<i>oo-mama</i> [o:mama]	mama(s)
3/4	um-/imi-	<i>um-lambo</i> [umlambo]	<i>imi-lambo</i> [imilambo]	river(s)
5/6	i(li)-/ama-	<i>i-gama</i> [igama]	<i>ama-gama</i> [amagama]	name(s)
7/8	isi-/izi-	<i>isi-tya</i> [isica]	<i>izi-tya</i> [izica]	dish(es)
9/10	i(N)-/i(z)i(N)-	<i>i-nkomo</i> [iŋk'omo]	<i>ii-nkomo</i> [i:ŋk'omo]	cow(s)
11/10	u(lu)-/i(z)i(N)-	<i>ulu-su</i> [ulusu]	<i>izin-tsu</i> [izints'u]	stomach(s)
14	uʔu-	<i>ubu-ntu</i> [uʔunt'u]	(no plural)	humanity
15	uku-	<i>uku-tya</i> [ukuca]	(no plural)	food

## 2.2 The role of phonotactics

A number of class markers are potentially homophonous; as such, it is not always possible to predict which class a noun belongs to from its prefix alone. This situation arises most notably for classes 5 and 9. With short, monosyllabic, roots, these classes have distinct exponents: class 5 is *ili-*, while class 9 is *i-*.<sup>4</sup> However,

<sup>3</sup> Modern standard Xhosa orthography is mercifully similar to IPA, and diverges from it in ways familiar from English spelling conventions. Key differences are as follows: <ty> = [c], <bh> = [b], <b> = [ʔ], <sh> = [ʃ], <tsh> = [tʃ, tʃʰ], <hl> = [h], <tl> = [tʰ], <j> = [dʒ], <y> = [j], <ny> = [ɲ]. Aspiration on voiceless stops is indicated with <h>, and <n> before velars is [ŋ]. <c x q> are clicks [! ! !], respectively, and may have nasality, aspiration, or voicing marked as digraphs of form <n\_> <g\_> <\_h> respectively. Unaspirated voiceless stops are systematically ejectives after nasals, and may be variably ejective in general; see Jessen and Roux (2002) for more details on the phonetics of the voicing distinctions. In older orthographic conventions, aspiration on stops and clicks is simply left unmarked (cf. language name *Xosa*); spellings of this sort are extremely common in personal and place names, and can still be found in casual contexts (e.g. SMS messages, and social media).

<sup>4</sup> The class 9 prefix is sometimes analyzed as /iN-/, with a homorganic nasal consonant (see, e.g., Taraldsen 2010). We take the nasal segment in question to be part of the following stem, and thus give the class prefix simply as *i-*, rather than *iN-*. Note however, that even if words like [iŋk'omo] 'cow' are parsed as [iŋ-k'omo], with the nasal in the prefix, the

with nouns that are two syllables or longer (which are most nouns of the language), the class 5 prefix surfaces as the allomorph *i-*, which is identical to the class 9 prefix. As such, nouns of the shape *i-CVCV* could be either class 5, or class 9: the class marker fails to distinguish them overtly. This is not to say that they collapse into the same class: they are discernibly distinct because they form plurals in canonically different ways, and also trigger distinct agreement morphology. But, the class information is not fully determinable from the noun (prefix + stem) itself, despite the presence of an overt class-marking morpheme.

(2) Potential for homophony of class 5 and class 9 prefixes

	Normal roots (-CVCV+)	Short roots (-CV)
Class 5: {i-, ili-}	<i>i-khaya</i> [ik <sup>h</sup> ájà] ‘home’	<i>ili-wa</i> [ilíwá] ‘cliff’
	<i>i-gama</i> [ígâmà] ‘name, word’	<i>ili-tye</i> [ilícè] ‘stone’
Class 9: {i-}	<i>i-nkomo</i> [iŋk <sup>h</sup> òmó] ‘cow’	<i>i-nja</i> [índzà] ‘dog’
	<i>i-moto</i> [ímòtó] ‘car’	<i>i-nto</i> [ínt’ó] ‘thing’

### 2.3 Historical development

The homophony of class 5 and class 9 is an innovation of Xhosa; the two classes were historically distinct in Proto-Bantu. Doke (1954) analyzes class 5 as \*li-, and class 9 as \*ni-, with both having the same CV shape, but having different consonants. The \*l of class 5 is transparently retained in the *ili-* allomorph that appears with short roots. The \*n of class 9 is the presumed source of the nasal in words like [índzà] ‘dog’, and many class 9 nouns still retain a nasal in this stem-initial position. However, there are also nouns of class 9 that do not have any segmental reflex of this historical \*n, as in (3). These include recent borrowings from English and Afrikaans (3a), as well as much older presumed borrowings from Khoe (3b-e), and also at least some words of discernibly proto-Bantu origin (3f) (Bennett 2014:122, Tshabe et al. 1989/2003/2006). As such, the presence or absence of a nasal is also not a fully reliable indicator of whether a noun is class 5 or class 9.

(3) Historical nasal of classes 9/10 is not always present

- a. *i-ti* [ítí] ‘tea’
- b. *i-tyuwa* [ícùwà] ‘salt’
- c. *i-hagu* [ifhàgù] ‘pig’
- d. *i-qhilika* [i<sup>h</sup>ílikà] ‘traditional honey mead’
- e. *i-qhiya* [i<sup>h</sup>íjà] ‘traditional-style head scarf’
- f. *i-hambelo* [ifhámbe<sup>h</sup>lò] ‘a visit to a place or person for some purpose’ (<-hamba ‘go, walk’)

When present, the nasal of class 9 (and its plural counterpart, class 10) induces certain changes to following consonants. These changes include de-aspiration of stops (which become ejectives); voicing of clicks; fortition of fricatives and /l/; and neutralization of implosive [ɓ] to voiced [b].<sup>5</sup> Such changes can be observed synchronically, but are only visible in nominalization of stems into class 9 or class 10; with a handful of nouns not in class 9 that take plurals of class 10; and with the adjectival agreement marker of class 9 and 10, which systematically retains its nasal. Some examples of synchronic occurrences of these changes are given in (4).

(4) Synchronic examples of post-nasal consonant changes in class 9

- a. De-aspiration: -k<sup>h</sup>ùlù ‘big’ > éŋk<sup>h</sup>ùlù ‘CL9.big’
- b. Click voicing: -!wé<sup>h</sup>bà ‘accumulate, store up’ > iŋ-<sup>h</sup>!wé<sup>h</sup>bò ‘the act of accumulating possessions’
- c. Fortition: -lé ‘pretty, fine’ > éntlé ‘CL9.pretty’
- d. Implosive neutralization: -fù<sup>h</sup>tà ‘gather together to pass time’ > im-bù<sup>h</sup>t<sup>h</sup>bò ‘informal social gathering’

Most noun stems do not show such alternations, however, because the same changes have also occurred historically. Though we do not know of any readily available lexical frequency data, our impression is that the same effects still hold synchronically as morpheme structure constraints. For example, Proto-Bantu \*k has the

---

ambiguity of class 5 and 9 still does arise in words that (i) have a root-initial nasal, like [i-moto] ‘car’, and those that have no nasal like the examples in (3).

<sup>5</sup> For more on the phonetic characteristics of these alternations, see Halpert (2012), and Bennett (2014).

reflex [k'] after homorganic nasals, but [k<sup>h</sup>] elsewhere. Likewise, homorganic [ŋk'] clusters can be found root-internally, but [ŋk<sup>h</sup>] clusters are systematically absent; the same is true for stops at other places of articulation.<sup>6</sup>

The changes induced by the nasal of class 9 did not occur with class 5, which had no nasal historically. This asymmetry implies a phonotactic possibility to disambiguate classes 5 and 9, on the basis of the initial consonant of the root. If a root begins with a consonant that looks like the result of post-nasal alternations (a “post-nasal output”), it is reasonable to infer that it has undergone such changes historically – and therefore presumably belongs to class 9, which historically had a nasal. Conversely, if a root begins with a consonant that *should undergo* post-nasal changes but has not done so (a “post-nasal input”), it is reasonable to infer that it did not historically follow a nasal – and therefore that it must not be class 9, and must rather be class 5.

The pathway leading to this state of phonotactic disambiguation is illustrated in (5) below, with the root /-k<sup>h</sup>ûlù/ ‘big’, from Proto-Bantu \*-kúdu. This root has reflexes in both class 5 and in class 9: [iŋk<sup>h</sup>ûlù] ‘hundred’ (cl.5) and [iŋk'ûlù] ‘eldest son of a family’ (cl.9). These two words show a difference in the initial consonant: the form in class 5 has aspirated [k<sup>h</sup>], while the form in class 9 has undergone post-nasal de-aspiration, yielding [k']. The quality of the initial consonants thus serves a redundant indicator of their class membership: initial [k'] signals class 9, while initial [k<sup>h</sup>] signals class 5. As such, even if the nasal in the class 9 form were subsequently deleted, it should still be possible to distinguish between nouns of these two classes because of the phonotactic “footprint” left by post-nasal consonant changes. Consequently, even though the class marking prefixes are homophonous, speakers should be able to disambiguate based on whether the initial consonant looks like one that has undergone post-nasal de-aspiration as in (i), or looks like one that would have undergone de-aspiration as in (ii).

(5) Pathway leading to phonotactic disambiguation

	PB	Stage 1	Stage 2	Stage 3	Result
(i) Class 9:	*-kudu	> *ni-k <sup>h</sup> ulu	> *i-N-kulu	> iŋ-k'ulu	/-k'ulu/ ‘eldest son’ (De-aspiration → cl. 9)
(ii) Class 5:	*-kudu	> *li-k <sup>h</sup> ulu	> *i-li-k <sup>h</sup> ulu	> i-k <sup>h</sup> ulu	/-k <sup>h</sup> ulu/ ‘hundred’ (Aspiration → cl. 5)

### 3 Hypothesis and predictions

Given that the historical remnants of various phonological processes are detectable synchronically, we set out to examine whether speakers of Xhosa can make noun class judgments based on these phonotactic clues. In particular, speakers may be expected to use knowledge of the phonotactic patterns set up by the historical post-nasal sound changes as clues to noun class. Generalizing to the post-nasal alternations as a whole, we can state our hypothesis as follows.

(6) **Hypothesis:** phonotactic disambiguation of class 5 and class 9 nouns

- a. If the root-initial consonant is a potential *output* of post-nasal consonant changes (a “post-N output”), then speakers can infer that it is class 9
- b. If the root-initial consonant is a potential *input* of post-nasal consonant changes (a “post-N input”), then speakers can infer that it is not class 9 (and therefore must be class 5)

These hypotheses predict that when Xhosa speakers are uncertain of the class of a noun, such as when its morphology is ambiguous between class 5 and class 9, they will be biased towards one interpretation or the other based on the initial consonant of the root. To test this hypothesis, we conducted an experiment, described in the next section.

<sup>6</sup> Modulo /m/ before labials: Xhosa allows syllable-final [m], which allows for potentially non-homorganic m+C clusters (e.g. [ml] in *-pʰefumla* ‘breathe’), many of which are derived from historical loss of a high vowel (cf. Zulu *-pʰefumla*). Such m+C clusters do not induce the same post-nasal alternations, even if the C is labial: *-mphotyo* [-mp<sup>h</sup>oco] does not de-aspirate, for instance. This is not a quirk of labials, but rather a difference between underlying /m/ and the nasal of class 9/10 prefixes, given here as /N/. The latter is normally homorganic, and does cause de-aspiration and other changes to following labials.

## 4 Methods and materials

### 4.1 Stimuli

Two sets of 10 nonce nouns were created.<sup>7,8</sup> The first set contains root-initial consonants of the post-N output category (e.g., deaspirated stops) compatible with only a class 9 interpretation. The second set contains root-initial post-N inputs (e.g., aspirated stops and non-fortited fricatives and liquids) which are compatible with a class 5 interpretation. The list of stimuli is provided in (7). All nonce nouns were preceded with the noun class prefix *i-*, which is ambiguous between class 5 and class 9 for roots of two or more syllables. Among the 20 stimuli, half were of the form *i-CV* and half were of the form *i-CVCV*, evenly divided between the two sets. The stimuli items used are listed in (7), given both in Xhosa orthography and with expected pronunciation. (Tone is not marked in Xhosa orthography, so speakers were given no direct tonal information for the nonce forms; we therefore do not mark tone here. Standardized isiXhosa orthography marks aspiration with ⟨h⟩ after a stop, but older and less formal texts sometimes omit this, e.g. using ⟨t⟩ for [t], [tʰ], and [tʰ] alike. For this reason, we coded for whether root-initial consonants were faithfully rendered, and we have excluded from our data trials in which speakers added aspiration.)

(7) Nonce items presented

Post-N outputs (class 9 interpretation)		Post-N inputs (class 5 interpretation)	
<i>i-ki</i>	[iki]	<i>i-khelu</i>	[ik <sup>h</sup> ɛlu]
<i>i-tusa</i>	[itusa]	<i>i-thunka</i>	[it <sup>h</sup> uŋkʰa]
<i>i-pula</i>	[ipula]	<i>i-phe</i>	[ip <sup>h</sup> e]
<i>i-gesha</i>	[iqeʃa]	<i>i-lu</i>	[ilu]
<i>i-du</i>	[idu]	<i>i-luva</i>	[iluva]
<i>i-bhi</i>	[ibi]	<i>i-lama</i>	[ilama]
<i>i-nu</i>	[inu]	<i>i-se</i>	[ise]
<i>i-moke</i>	[imoke]	<i>i-hlonu</i>	[iɬonu]
<i>i-nyu</i>	[inyu]	<i>i-she</i>	[iʃe]
<i>i-ngoya</i>	[inɣoja]	<i>i-be</i>	[ibe]

### 4.2 Experimental design

In this experiment, native speakers of Xhosa were shown a singular nonce noun in Xhosa orthography and were asked to provide its plural form in a standard wug test paradigm (Berko 1958). Speakers were told that they would see words of Xhosa with which they may be unfamiliar, and that they should apply the most natural plural prefix. All nonce nouns were given the noun class prefix *i-*, which is ambiguous between class 5 and class 9 for roots of two or more syllables. Participants should provide the noun class 6 plural (*ama-*) if they interpret the nonce noun as class 5, and the class 10 plural (*ii-/izi-*) if they interpret the nonce noun as class 9.

For example, if a participant sees the stimulus item *i-phe*, they might reply either *ii-phe* or *izi-phe* (both possible class 10 plural prefixes, indicating interpretation of the root as class 9) or *ama-phe* (class 6 plural, indicating interpretation of the root as class 5).

Stimuli were presented on a laptop computer using SuperLab 4.5 (Cedrus Corporation) to randomize the order of nouns per participant. Test items were interspersed with 20 filler items that were part of an unrelated experiment; all fillers were nonce words of shape *i-CV* or *i-CVCV*. Stimuli are segregated here into prefix and root for the reader, but the forms presented to participants were not (e.g. *ihlonu*, not *i-hlonu*). Speaker responses were recorded onto a digital audio recorder (Handy Zoom h4n) via a head-mounted microphone (Nady HM-10). Audio was encoded as WAV files with a sample rate of 44.1kHz. These recordings were then coded to indicate which prefix was supplied by the participant on each trial. Trials in which speakers mistakenly produced orthographically non-aspirated stops with aspiration were excluded from analysis (a

<sup>7</sup> In creating these items, we avoided stimuli that were tonal or segmental near-minimal pairs of existing words. We also avoided using [o] as the final vowel, because there is a real suffix */-o/* used to derive nouns from other stems.

<sup>8</sup> We admit that the number of stimuli used is relatively small. This choice was made in part to keep the length of the experiment sessions short, and partly because the space of potential nonce items that have the right initial consonants, and meet our stimulus criteria, and do not clash with real words, is relatively small to begin with.

total of 5 trials).

### 4.3 Participants

Eighteen native speakers of Xhosa participated in this experiment (12 female, 6 male). Speakers ranged in age between 17–46 years old (mean: 27.11 years old). All participants also spoke at least some English; Afrikaans, Zulu, Sesotho, Setswana, Sepedi, Chichewa and Portuguese were also spoken by at least one participant each. At the time of the experiment, all of the participants were living in South Africa's Eastern Cape, in the area of Grahamstown. Two speakers indicated that they had grown up partly in other places: one in Johannesburg, and one in Cape Town. All participants indicated that they spoke Xhosa as their primary home language.

## 5 Results

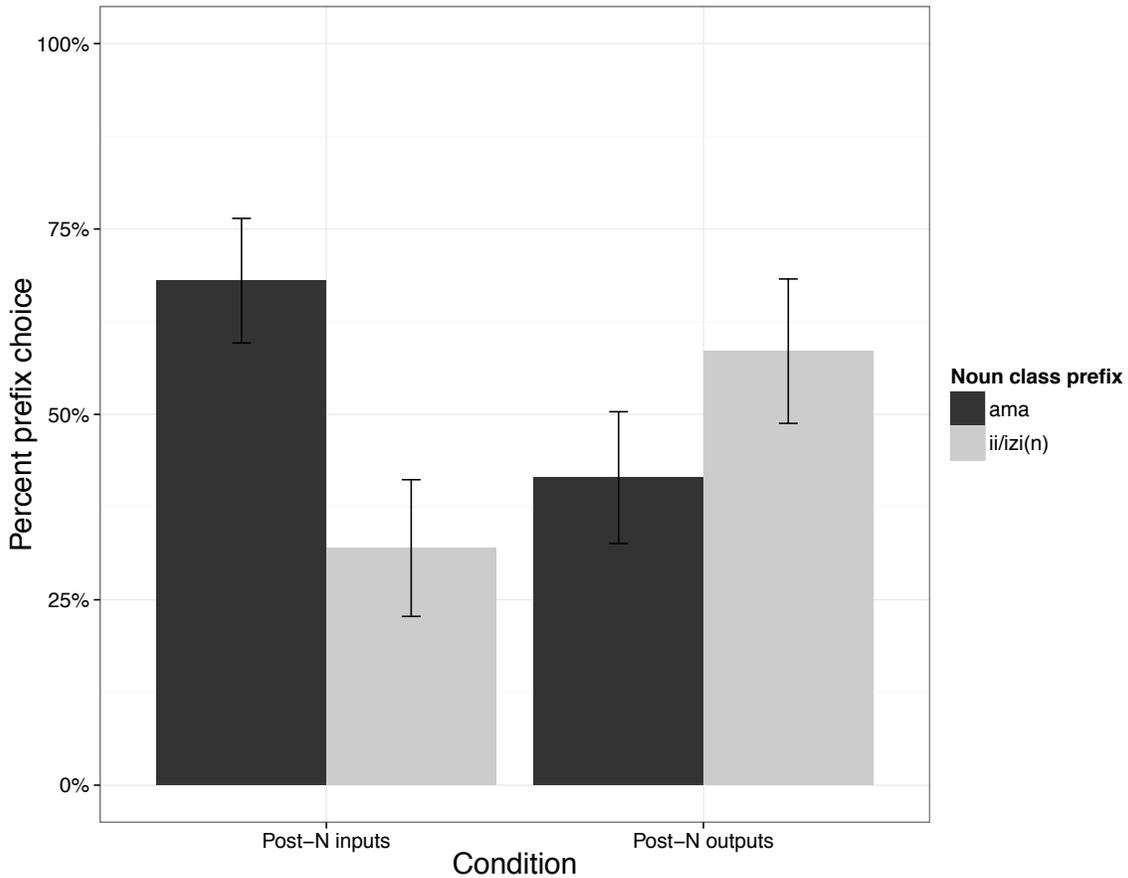
Our results show that, across long and short roots, when a nonce item starts with a consonant that is the output of post-nasal sound changes, speakers are more likely to treat it as a class 9 noun.

Participants' responses were conditioned by which stimulus set an item belonged to ( $\chi^2(1, N=348) = 23.67, p < 0.001$ ). These results are shown in the figure in (8). While 68.0% of the stimuli phonotactically compatible with class 5/6 (i.e. post-nasal *inputs*) received an *ama-* (class 6) plural prefix, only 41.5% of the stimuli phonotactically compatible with class 9/10 (i.e., post-nasal *outputs*) were pluralized in this way. Similarly, 32.0% of the stimuli phonotactically compatible with class 5 received an *ii-/izi-* (class 10) plural prefix, while 58.5% of the stimuli compatible only with class 9 did.<sup>9</sup>

---

<sup>9</sup> 1% of responses in the post-N inputs condition supplied other prefixes, such as class 1 *um-*; these were excluded from the analysis.

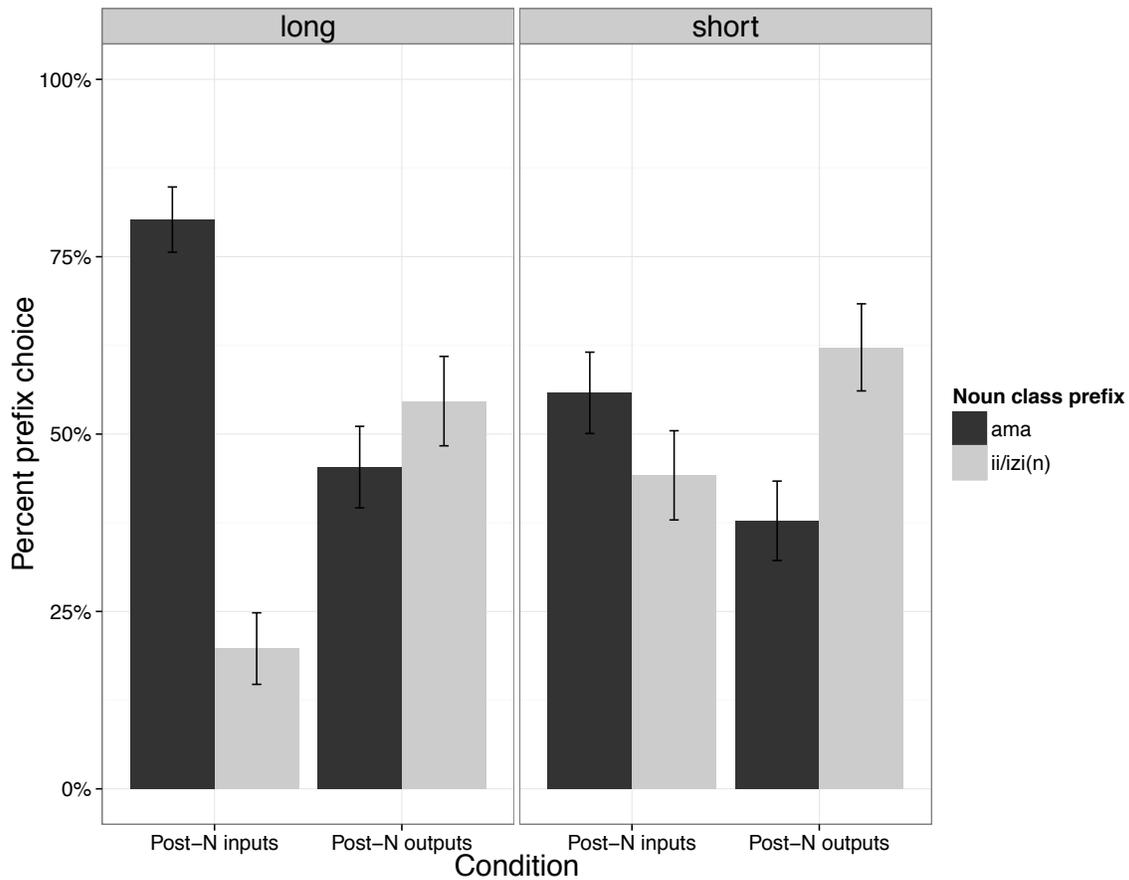
(8) Response rates across phonotactic conditions



A clearer picture of this effect emerges when we separate the response data based on length of the nonce roots. This is shown in (9). The panel on the left shows the responses for ‘long’ bisyllabic roots, and the panel on the right shows the treatment of ‘short’ monosyllabic roots. The effect of the initial consonant is strongest among long roots ( $\chi^2 = 20.93$ ,  $p < 0.001$ ). That is, for stimuli of the shape *i-CVCV*, if the initial C is one that should undergo post-nasal changes (i.e. a post-nasal input), the roots were treated as class 5 (and assigned class 6 plurals) more than 80% of the time. If, on the other hand, the initial C is one that results from post-nasal changes (a post-nasal output), then the bias is in the opposite direction: such roots were treated as class 9 (receiving class 10 plurals) nearly 55% of the time.

The asymmetry in strength of the phonotactic effect in the long roots likely arises because some consonants that can be outputs of post-nasal changes also exist independently. In a word like *i-tusa*, the surface [t] could be interpreted as de-aspirated from /t<sup>h</sup>/ (and thus a post-nasal output), or as underlying /t/ (not derived from t<sup>h</sup>). By contrast, a word like *i-thunka* does not offer such ambiguity; it can only be from /t<sup>h</sup>/. The post-nasal inputs may therefore present more reliable clues to a noun’s class. Additionally, there may be frequency asymmetries. While all of the consonants classed here as post-nasal outputs are attested in root-initial position in class 9 nouns, some of them appear to be somewhat uncommon. For example, there are relatively few bisyllabic roots that begin with an unaspirated stop, and many of them are loanwords, ideophones, and/or lexical items that are archaic and/or likely have a low frequency of usage (e.g. [í-tùnú], ‘the last drops of beer in a can, which only the oldest man at a beer-drink may drink’; Tshabe et al. 2006). By contrast, class 5 nouns with initial aspirated stops are far more common. So, it is perhaps unsurprising that phonotactic clues about a noun’s class may be more robust with the post-nasal inputs than the post-nasal outputs.

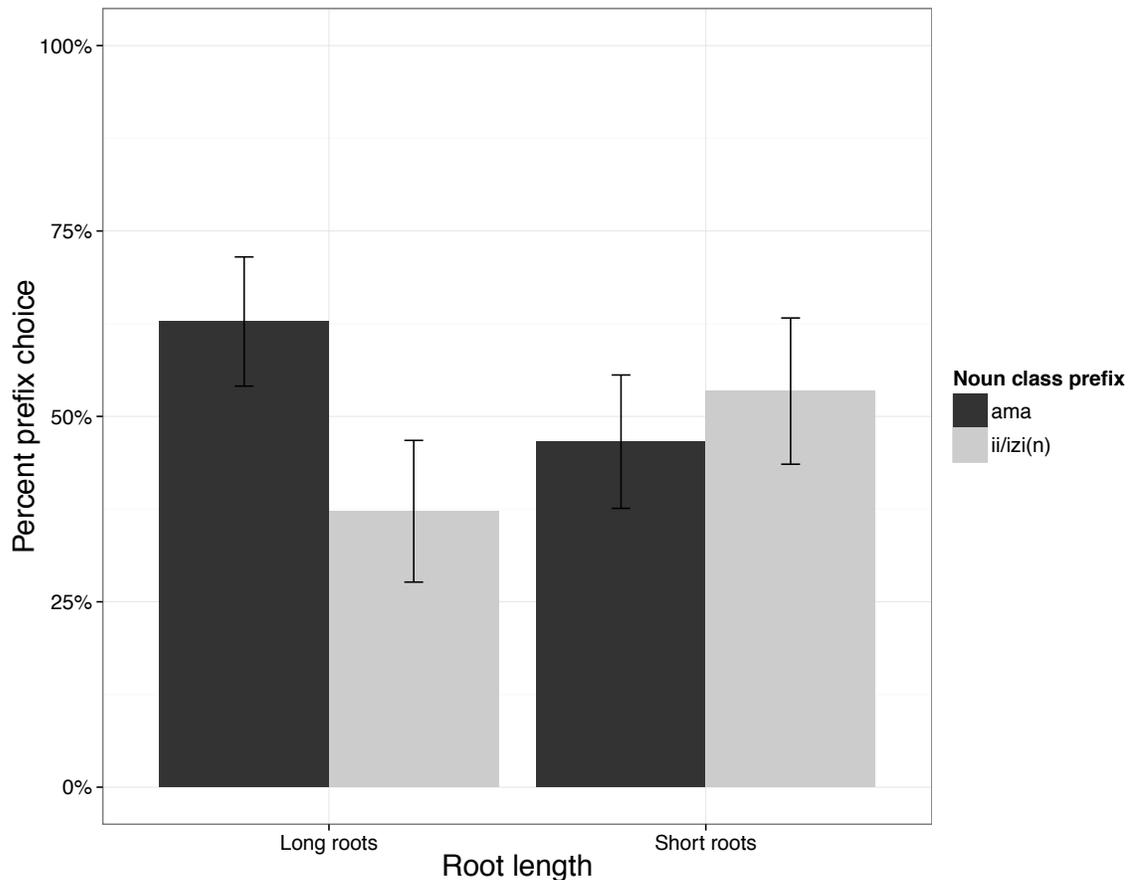
(9) Response rates, separated by length of stimuli



For short root stimuli (*i-CV*), speakers' choice between a class 5 interpretation (*ama-* plural) and a class 9 interpretation (*ii-/izi-* plurals) was not significantly affected by the root consonant ( $\chi^2 = 5.05$ , n.s.). This finding makes sense in light of other morpho-phonological prefix alternations specific to short roots. As noted previously, the class 5 prefix has two allomorphs: *i-* and *ili-*, with the latter appearing before monosyllabic roots. The consequence of this allomorphy is that *i-CV* forms are not so straightforwardly ambiguous as the *i-CVCV* ones: if a short root is really class 5, it ought to appear as *ili-CV*, and not *i-CV*. So, we may expect *i-CV* stimuli to be biased towards a class 9 interpretation, simply because they fail to exhibit the *i-/ili-* allomorphy in the normal way. This seems to fit with the results for short roots with consonants that are inputs to post-nasal change (e.g. *i-phe*). On the basis of the initial consonants, these roots should seem like class 5; but on the basis of the prefix being *i-* (not *ili-*), they should seem like class 9. The two morpho-phonotactic factors conflict, and speakers' responses are essentially at chance. Compare this to responses for short roots where the consonant is an output of post-nasal changes. This category of stimuli shows a bias towards class 9 interpretation, just like the long roots. However, the effect is even stronger in the short roots than in the long roots, likely because the shape of the prefix makes a class 5 interpretation seem odd.

We also note that root length alone biased prefix choice. Long roots were more likely to be given the *ama-* prefix (class 6), while short roots were more likely to be given the *ii-* prefix (class 10) ( $\chi^2 = 8.57$ ,  $p < 0.005$ ). This result is shown in the graph in (10). This result is consistent with the suggestion above, that *i-CV* roots are anomalous as class 5 nouns (which should normally have *ili-*).

(10) Response rates based on root length only (post-nasal input and output conditions pooled)



## 6 Discussion

Our initial hypotheses was that the results of post-nasal consonant changes can help clue speakers in to the historical presence of a nasal consonant – thereby providing a synchronically-visible clue that a noun belongs to class 9, even though the dedicated class-marking morphology is ambiguous. Our findings show that speakers are more likely to treat a nonce noun as class 9 if its initial consonant looks like the result of post-nasal consonant changes (i.e., it is a post-N output). By the same token, if the initial consonant is one that could have undergone historical post-nasal changes (i.e., a post-N input), speakers are more likely to treat it as class 5. We interpret this to mean that when speakers are deprived of syntactic and semantic cues to a noun’s class, they can still use the phonotactic vestiges left by the historical post-nasal sound changes to choose an appropriate noun class.

We note also that this tendency is not absolute — not *all* roots with initial post-N outputs were interpreted as class 9. This has consequences for the broader analysis of the phenomenon. For instance, it is not the case that features of the root-initial consonant serve as an overt marking of class morphology (as is the case with consonant mutation phenomena in various other languages; see Iosad (2010) for a broad overview of some examples). Rather, speakers seem to attend to the phonotactic norms of each class. This result has a distinctly ‘business as usual’ feel to it: it is squarely in line with previous work showing that speakers can generalize probabilistic regularities in the lexicon to novel words (Ernestus and Baayen 2003, Hayes et al. 2009, Moore-Cantwell 2016, etc.), as well as previous work that finds that speakers readily extend gender systems to new forms (see Corbett (1991) for a review of some of the relevant literature). Our results are also consistent with Kgolo’s results (Kgolo 2014, Kgolo & Eisenbeiss 2015) showing that class 9 nouns prime verbal roots even when phonological alternations obscure the formal identity between the roots: that makes sense if speakers are using the phonotactic consequences of those alternations as an aid to determining a

noun's class. Whether our participants have internalized a phonotactic generalization from known nouns of class 5 and class 9, and used it as the basis for categorizing nonce nouns, remains to be seen, pending further work quantifying these trends in the lexicon, and in corpus data.

## 7 Conclusions

In this paper, we have shown that phonotactic tendencies can serve as redundant cues to noun class in Xhosa. We have demonstrated that when speakers are deprived of syntactic, semantic, and morphological bases on which to categorize nouns, they still have intuitions about which class a noun belongs in, based on its phonotactic profile. Nonce nouns that have discernably not undergone post-nasal consonant changes are treated as being in class 5, where such alternations did not historically occur. Nonce nouns with consonants that look like the result of post-nasal changes are more likely to be treated as class 9, which is subject to such changes (both historically, and synchronically in a more limited capacity). This means the distinction between class 5 and class 9 is thus cued in part by phonotactics.

We speculate that the effect we find here for Xhosa is merely the tip of the proverbial iceberg: there are probably numerous other phonotactic generalizations to be drawn about the nouns belonging to various noun classes, and this phenomenon likely generalizes far outside of Xhosa. Numerous other Bantu languages are also reported to have phonological alternations induced by particular noun classes, especially classes 5 and 9.<sup>10</sup> We suspect that one of the reasons why Bantu languages have so robustly retained – and elaborated – their rich noun class systems is that those systems are underpinned not only by semantic structure, but also by phonotactic patterns. If so, this would link Bantu-style systems of grammatical gender to other languages with gender systems conditioned in part by the phonological form of nouns, such as Yimas (Foley 1991), Arapesh (Aronoff 1992), and Guébie (Sande 2016). These two other cases are also notable in being mixed systems: some genders are predictable from semantics, others from the phonological form of a noun. Xhosa appears to share this characteristic, echoing Aronoff's (1994:115) sentiment that such a system is “perfectly normal in its diversity”.

### Acknowledgments:

We owe thanks first and foremost to all of our experiment participants. We also thank Msindisi Sam and Danica Kreusch for invaluable assistance in preparing and conducting the experiment. For assistance collecting the data, we thank Kelly Goldstuck, and Olona Tywabi. For helpful feedback and discussion, we thank Jochen Zeller, Seunghun Lee, Maxwell Kadenge, Lionel Posthumus, Stephan Schulz, Mark de Vos, Blake Allen, Claire Moore-Cantwell, and Hannah Sande. Authors' names are in reverse alphabetical order.

### Funding:

This work was supported by a grant from the Rhodes University Research Council.

## References

- Aronoff, Mark. 1992. Noun Classes in Arapesh. In Geert Booij and Jaap van Marle, eds., *Yearbook of Morphology 1991*, 21-32. Dordrecht: Kluwer.
- Aronoff, Mark. 1994. *Morphology by Itself: stems and inflectional classes*. Linguistic Inquiry Monograph 22. Cambridge, MA: MIT Press.
- Baumbach, E.J.M. 1987. *Analytical Tsonga Grammar*. Pretoria: University of South Africa.
- Bennett, Wm. G. 2014. Some differences between clicks and labio-velars. *South African Journal of African Languages*, 34(2):115–126.
- Berko, J. 1958. The child's learning of English morphology. *Word*, 14:150–177.
- Cole, D.T. 1955. *Introduction to Tswana grammar*. Cape Town: Longman.
- Corbett, Greville G. 1991. *Gender*. Cambridge: Cambridge University Press.
- Doke, C.M. 1927. *Textbook of Zulu Grammar*. Cape Town: Maskew Miller Longman (reprinted 1984, 6th edition).
- Doke, C.M. 1954. *The Southern Bantu Languages*. London: Oxford University Press.

---

<sup>10</sup> These include at least ChiShona (Doke 1954:53ff, Fortune 1984), Setswana (Cole 1955:86ff, Kgolo & Eisenbeiss 2015), XiTsonga (Doke 1954, Baumbach 1987), and isiZulu (Doke 1927, 1954); see Doke (1954) for an overview of some of the relevant phonological effects in these languages.

- Ernestus, Mirjam, and Harald Baayen. 2003. Predicting the unpredictable: Interpreting neutralized segments in Dutch. *Language*, 79(1):5–38.
- Fortune, G. 1984. *Shona Grammatical Constructions, Volume 1 (3rd Edition)*. Mercury Press, Harare.
- Gelbart, Ben. 2005. Perception of foreignness. PhD thesis, University of Massachusetts, Amherst.
- Hayes, Bruce, Kie Zuraw, Péter Siptár, and Zsuzsa Londe. 2009. Natural and unnatural constraints in Hungarian vowel harmony. *Language*, 85(4):822–863.
- Halpert, Claire. 2012. Overlap-driven consequences of nasal place assimilation. In Philip Hoole, Lasse Bombien, Marianne Pouplier, Christine Mooshammer, and Barbara Kühnert, eds., *Consonant clusters and structural complexity*, 345-368. Mouton de Gruyter.
- Idiata, D.F. 2005. *What Bantu child speech data tells us about the controversial semantics of Bantu Noun class system*. Lincom.
- Iosad, Pavel. 2010. 'Right at the left edge: initial consonant mutations in the languages of the world'. in J. Wohlgenuth & M. Cysouw, eds, *Rethinking Universals: How Rarities Affect Linguistic Theory*. Mouton de Gruyter, pp. 105-138.
- Jessen, Michael and Justus C. Roux. 2002. Voice quality differences associated with stops and clicks in Xhosa. *Journal of Phonetics* 30:1–52.
- Jordan, A. C. 1966. *A Practical Course in Xhosa*. Cape Town: Longmans.
- Katamba, F. 2003. Bantu Nominal Morphology. In Derek Nurse and Geraldine Philippson, eds., *The Bantu Languages*, 103–120. Routledge.
- Kgolo, Naledi, and Sonja Eisenbeiss. 2015. The role of morphological structure in the processing of complex forms: evidence from Setswana deverbative nouns, *Language, Cognition and Neuroscience*, 30:9, 1116-1133
- Kgolo, Naledi. 2014. The Mental Representation of Setswana Deverbative Nouns: A psycholinguistic analysis of Class 1 and 9 nominalisations. PhD thesis, University of Essex.
- Kunju, Hleze. Forthcoming. *IsiXhosa as a minority language in Zimbabwe*. PhD thesis, Rhodes University.
- Lewis, M. Paul, Gary F. Simons, and Charles D. Fennig (eds.). 2016. *Ethnologue: Languages of the World*, Nineteenth edition. Dallas, Texas: SIL International. Online version, entry for Xhosa: <http://www.ethnologue.com/language/xho>. (retrieved 19 May 2016).
- Mclaren, J. 1942. *A Xhosa Grammar*. Cape Town: Longmans, Green, and Co. Second edition.
- Moore-Cantwell, Claire. 2016. The phonological grammar is probabilistic: New evidence pitting abstract representation against analogy. *Proceedings of the 2015 Annual Meeting in Phonology*.
- Moreton, E. and S. Amano. 1999. Phonotactics in the perception of Japanese vowel length: Evidence for long-distance dependencies. *Proceedings of the 6th European Conference on Speech Communication and Technology*.
- Pahl, H.W. 1978. *IsiXhosa*. Halfway House, South Africa: Educum.
- Sande, Hannah. 2016. An Interface Model of Phonologically Determined Agreement. In *Proceedings of the 33rd West Coast Conference on Formal Linguistics*, ed. Kyeong-min Kim et al., 339-350. Somerville, MA: Cascadilla Proceedings Project.
- Tucker, G.R., W.E. Lambert, and A.A. Rigault. 1977. *The French Speaker's Skill with Grammatical Gender: An Example of Rule-Governed Behaviour*. The Hague: Mouton.
- Taraldsen, Knut Tarald. 2010. The nanosyntax of Nguni noun class prefixes and concords. *Lingua*, 120(6): 1522–1548.
- Tshabe, S.L. et al. (eds.). 2006. *The Greater Dictionary of IsiXhosa*. Volumes 1-3, previously published in 1989, 2003. IsiXhosa National Lexicography Unit. Alice, South Africa: University of Fort Hare.