Nasal-Consonant Sequences in Setswana

KENEILWE MATLHAKU

This paper aims to provide a unified analysis of nasal-consonant (NC) sequences in Setswana. The discussion follows the following key points: strengthening of the consonant (C) in NCs, behavior of the C in NCs and how best to analyze NCs in Setswana. The analysis is carried out using Government Phonology (GP) (Kaye, Lowenstamm, and Vergnaud 1985; 1990). The fundamental idea in GP is Phonological Licensing, whereby all phonological processing is driven by asymmetrical licensing and governing relations. The data of the study come from Matlhaku (2020). The study concludes that NC sequences in Setswana are not consonant clusters but a sequence of two onsets that enter into a government relation.

1. Introduction

This paper aims to provide a unified analysis of nasal-consonant (NC) sequences in Setswana (Tswana, S31), a language spoken in Botswana. The main points discussed include strengthening of C in NC clusters, illustrated in (1); phonological behavior of C in NCs; how to analyze NCs in Setswana. The paper employs Government Phonology (GP) (Kaye, Lowenstamm, and Vergnaud 1985; 1990; henceforth KLV) as a framework to analyze the attested NCs as formerly a sequence of two onsets that enter into a government relation.

(1) Strengthening of C in NC clusters

a.	/f̲a/	→	[mp^{h}a]	‘give me’
b.	/nr̲ɔ /	→	[nt^{h}ɔ]	‘wound’
c.	/utlwa/	→	[ŋk̲utlwa]	‘hear me’

The paper is organized as follows: §2 is a brief introduction of Setswana. §3 introduces the phonology of Setswana. §4 reviews the previous analyses on the phonological behavior of postnasal consonants. In §5, I discuss strengthening and its contexts. §6 and §7 incorporate the results of an acoustic study in GP and present a unified analysis of strengthening in Setswana NC clusters. §8 concludes the study.

2. Background

2.1. Sound Inventory

The vowel inventory of Setswana consists of seven phonemic vowels: /i, ɪ, ɛ, a, ɔ, ʊ, u/ (Cole 1955; Department of African Languages and Literature 1999) (DALL henceforth). The consonant inventory, shown in Table 1, comprises 28 distinctive phonemes (Cole 1955; DALL 1999; Kruger and Snyman 1987).

MUN Occasional Student Papers in Linguistics 3, ed. S. Abdelhady, A. Cucinelli and T. Fatema
(St. John’s: Memorial University of Newfoundland, 2020), pp. 1-20

Table 1: Setswana consonant inventory

Place / Manner	Labial	Alveolar	Latero-Alveolar	Post-Alveolar	Palatal	Velar	Uvular	Glottal
Plosives	b p p^h	t t^h				k k^h	q^h	
Fricatives	f [1]	s		ʃ			χ	h
Affricates		ʦ $ʦ^h$	$\widehat{tl}^h$ $\widehat{tl}$	ʤ ʧ $ʧ^h$				
Nasals	m	n			ɲ	ŋ		
Liquids		r	[l~d]					
Glides	(w) [2]				j	(w)		

Aspiration is phonemic in this language. There is a contrast between aspirated and unaspirated plosives and between aspirated and unaspirated affricates. This is illustrated in (2).

(2) Plosives

a. Coronal stops

i. [tuma] ‘famous’
ii. [t^huma] ‘swim’

b. Bilabial stops

i. [pala] ‘refuse’
ii. [p^hala] ‘whistle’

(3) Affricates

a. [tsʊla] ‘to undress’
b. [ts^hʊla] ‘to give birth’
c. [tlʊla] ‘jump’
d. [tl^hʊla] ‘defeat/lose faith’

Voicing is phonemic, however it is limited to labial plosives /b/ and /p/ and coronal affricates /ʤ/ and /ʧ/ as illustrated in (4).

(4)

a. Labial plosives [b/p]

i. /b̲ala/ ‘read’
ii. /p̲ala/ ‘fail/refuse obstinately’

b. Coronal affricates [ʤ/ʧ]

i. /ʤ̲aa/ ‘eat’
ii. /ʧ̲aa/ ‘lapse in time’

The coronal series lacks voicing contrast hence the lack of phonemic /d/. [d] only occurs as an allophone of /l/. /l/ surfaces as [d] before the high tense vowels [i, u] whereas /l/ surfaces as [l] before the high lax vowels [ɪ, ʊ] and before the non-high vowels /ɛ, a, ɔ/ (Cole 1955; Dickens 1977; Kruger and Snyman 1987).

[1] The bilabial fricative [ɸ] is a variant of labio-dental /f/ and the bilabial fricative [β] is a variant of plosive /b/ (Cole 1955; Kruger and Snyman 1987).

[2] /w/ is characterized as a labio-velar approximant. It becomes [ʤ] whenever it occurs with labial consonants (Cole 1955; Kruger and Snyman 1987).

In the dorsals, there is no phonemic /g/ because *g lenited to /Ø/ historically. Orthographic <g> represents the phoneme /χ/ as in words like <gana> [χana] ‘refuse’.

2.2. Syllable Structure

There are two types of syllables in Setswana: V and CV (or syllabic C). The following examples are illustrative.

(5) Syllable shapes

a.	[lʊː.ma]	‘bite’
b.	[yo]	‘this one’
c.	[k^{w}aː.la]	‘write’
d.	[mʊ.aː.iː.si]	‘messenger’
e.	[raː.χ^{w}a]	‘be kicked’
f.	[di.ɛː.χa]	‘to delay’

Onset-less syllables in the words <moaisi> and <diega> have obligatory onsets [ʔ] or the glides [j, w] as (6) illustrates. However, [ʔ] is not represented in the orthography (Cole 1955). Epenthetic [ʔ] precedes all the vowels. Epenthetic [j] is only found with [-back] vowels and [w] is an epenthetic onset for [a] and [+back] vowels.

(6) Obligatory onsets

a. Epenthetic [ʔ]

i.	[di.ʔɛː.χa]	‘to delay’
ii.	[mʊ.ʔa.ʔiː.si]	‘news bearer’

b. Epenthetic glides

i.	[di.jɛː.χa]	‘to delay’
ii.	[mʊ.wa.jiːsi]	‘news bearer’

Since Setswana is a strict CV language, whenever sonorant consonants [l̩, r̩, n̩, m̩, ŋ̩, ɲ] appear in syllabic contexts they function as a syllable nucleus and not onsets or codas (Cole 1955). They can even be stressed and undergo tonic lengthening (as shown in (7) by [lː] in [mʊ.ˈl̩ː.lɔ] ‘fire’, [rː] in [ˈr̩ː.rɛ] ‘father’, [r̩.ˈraː.χʊ] ‘your father’, [ŋ̩ː] in [ŋ̩ː.kɔ] ‘nose’, [nː] in [ˈn̩ː.na] ‘me/myself’, [ˈn̩ː.ʄa] ‘dog’, [mː] in [mː.p^{h}ɔ] ‘gift’). Therefore, (7) illustrates that there are no real NC clusters in Setswana.

(7) Syllabic consonants

a. Liquids

i. [mʊ.ˈl̩ː.lɔ] ‘fire’
ii. [ˈr̩ː.rɛ] ‘father’
iii. [r̩.ˈraː.χʊ] ‘your father’

b. Nasals

i. [ˈɪː.ŋ̩] ‘what’
ii. [ŋ̩ː.kɔ] ‘nose’
iii. [ˈn̩ː.na] ‘me/myself’
iv. [ˈn̩ː.ʧa] ‘dog’
v. [mː.pʰɔ] ‘gift’

Nasals in NC clusters are also syllabic (Cole 1955; DALL 1999). This is the case in Bantu in general, where NC clusters are realized as a syllabic nasal followed by an onset consonant, rather than as singleton complex [ⁿC] segment. The main evidence in Bantu languages is that NC *clusters* fail to pattern with other singleton consonants which occur in word-initial position (Kula 1999; 2006; Kula and Marten 1998).

3. Review of Related Literature

This section reviews the NC cluster literature in order to determine the nature of strengthening. In the literature, changes to post-nasal Cs have commonly been attributed to: (i) Postnasal voicing (PNV), (ii) Postnasal devoicing, (PND), and (iii) Enhancement or Strengthening. I discuss each of these processes next.

3.1. Postnasal Voicing (PNV)

PNV is a process in which underlying voiceless obstruents are neutralized to voiced ones after a nasal (Herbert 1975; Ohala and Ohala 1993; Hyman 1999; Pater 1999b; Hayes and Stivers 2000). This process is typologically and phonetically motivated. This process results from the combination of a *nasal leak* inhibiting oral air pressure and a compression of the velum which promotes continuous voicing onto the postnasal consonant (Hayes 1999; Hayes and Stivers 2000). As a result, Pater (1999) posits a high ranking markedness constraint that bans nasals and obstruent sequences. He defines this constraint, represented in this paper as *NT, as “no nasal/voiceless obstruent sequences” (p.51). This constraint accounts for the neutralization of voicing contrasts due to PNV.

PNV is attested in many languages and language families, such as Luyia, Yao, Kikuyu, and Austronesian (see Clements 1985; Herbert 1986; Pater 1999; Hayes and Stivers 2000; Hyman 2001). The examples in (8) below illustrate this process in the Yao and Kikuyu languages.

(8) PNV in Yao and Kikuyu

a. /ku-N-peleka/ ~ [kuu-m-beleka] ‘to send me’ (Yao: Hyman 2001: 155)
b. /n+koma/ ~ [ŋgɔm- ɛɛtɛ] ‘sleep’ (Kikuyu: Clements 1985: 244)

As (8) shows, *NT repairs nasal and voiceless obstruent sequences whenever they are encountered by voicing an obstruent. Cross-linguistically, languages avoid the occurrence of post nasal voiceless consonants by processes such as (i) denasalization (substituting a nasal with another an obstruent sound) (ii) fusing a nasal and a voiceless obstruent, (iii)

nasal substitution and a deletion of the obstruent, (iv) nasalization of the obstruent (Pater 1999). Therefore, Pater (1999), among others, proposes that a phonological rule of post-nasal devoicing is impossible, unnatural or rare (Pater 1999; Hayes and Stivers 2000).

3.2. Postnasal Devoicing (PND)

PND is a phonological process in which underlying voiced plosives become devoiced whenever they occur in a sequence following a nasal. Hyman (1999) shows that languages, such as Setswana, Shekgalagari, Bubi, Makua, and Punu, have an active rule of PND. See the examples in (9).

(9) Postnasal devoicing

a.	/ɣandum/ ~ [ɣantum]	'wheat'	
b.	/ʃkamb/ ~ [ikampa]	'stomach'	(Yaghnobi: Xromov 1972)
c.	/N-bɔna/ ~ [m-pɔn-a]	'see me'	
d.	/N-disa/ ~ [n-tisa]	'look after me'	(Setswana: Hyman 2001: 157)

Hyman (2001)[3] argues that PND, in Setswana, came about due to historical changes, and it is not motivated by articulatory considerations. He posits a markedness constraint, *ND, to account for the conspiracies enforcing PND or the avoidance of PNV. According to Hyman (2001: 157) *ND, "no nasal/voiced obstruent sequences", ranks higher than *NT.

3.3. PND and Enhancement

Phonetic enhancement through strengthening process is another explanation for PND (Xromov 1972; Kula and Marten 1998; Kula 1999; Kula 2002; Hamann and Downing 2017). Instead of neutralizing the postnasal voicing contrast in favor of voicing, some languages prefer to maintain the postnasal laryngeal contrast through the aspiration of a post nasal stop (Hamann and Downing 2017). Postnasal enhancement is common in languages such as Kongo (Meinhoff 1932), the Ndau dialect of Shona (Mkangawi 1972), Chichewa (Downing and Mtenje 2017), Swahili and Pokomo (Hyman 2001; Gouskova, Zsiga, and Boyer 2011).

(10) Enhancement of voicing contrast in Chichewa

a. [t ~ tʰ]

i.	[t̲uu-ŋg-a]	'pierce'
ii.	[nt͡ʰuuŋg-o]	'sharp piercing object'

b. [p ~ pʰ]

i.	[p̲ee-l-a]	'grind'
ii.	[mp͡ʰeel-o]	'grinding stone' (Downing and Mtenje 2017)

Enhancement entails adding extra feature(s) to a sound in addition to its more basic features with the goal of either increasing its perceptual salience or the perceptual salience of a contrast between two sounds (Stevens and Keyser 1981). According to Flemming (1995), its motivation is to make contrasts more distinct because less distinct contrasts are more prone to neutralization than more distinct contrasts. Enhancement, therefore, can

[3] For more details on this issue, see Hyman (2001) and Coetzee, Lin and Pretorius (2007).

explain why voicing contrasts like /t, d/ become aspiration contrasts like [tʰ, t]. However, enhancement cannot explain the full range of changes that occur post-nasally in Setswana.

3.4. PND and the Syllable Contact Law

In this section, I explore the literature which states that enhancement is a part of a larger set of fortition phenomena that are due to Syllable Contact Law (SCL) effects (Gouskova, Zsiga and Boyer 2011). According to their acoustic study of Setswana NC clusters in word initial, intervocalic and postnasal positions, (Gouskova, Zsiga, and Boyer 2011) concluded that [±voice] consonantal alternations, historically, described as PND in Setswana, are mainly effects of initial faithfulness, intervocalic lenition and post nasal fortition. According to their analysis, /b/∼[p'] and /d/∼[t'] alternations for example, are not due to post nasal devoicing as initially claimed by Hyman (2001) and Coetzee, Lin and Pretorius (2007) but due to processes which improve syllable contact such as plain stops becoming (stronger) ejectives in post nasal position. They also claim that the SCL effects cause fricatives and liquids to either become ejective plosives or aspirated stops post-nasally. The SCL constraints posited in Gouskova, Zsiga, and Boyer's (2011) analysis produce the hierarchy of consonants in Table 2 relevant for Setswana in their order of increasing strength, where '1' indicates the weakest and '8', the strongest consonants.

Table 2: Consonant strength hierarchy in Setswana

1	2	3	4	5	6	7	8
Glides	Rhotics	Laterals	Nasals	Voiced fricatives	Plain/ voiced stops	Voiceless fricatives	Aspirated/ ejective stops

The table is such that ejective consonants and aspirated stops are less sonorous or stronger than their plain and voiced counterparts. In the next section, I discuss strengthening in NC clusters, then by a brief discussion of the data obtained for this study.

4. Strengthening in NC clusters in Setswana

Strengthening is a phonological process that entails an increase in the magnitude or duration of an articulatory gesture or movement (Batibo 2000; Bybee and Easterday 2019). According to Bybee and Easterday (2019), a sound considered to be less strong or weak changes into a stronger one.

Strengthening is common in Southern African Bantu languages. In Setswana, sounds whose underlying representations (henceforth URs) of fricatives and sonorants become strengthened in the postnasal context. Table 3 illustrates this. In addition, Setswana strengthening affects stem-initial consonants nasal /n/ and high front vowel /i/ across a syllable/ morpheme boundary (Batibo 2000).

Table 3: Strengthening in NC clusters

	UR	STRENGTHENED
Fricatives	f	p^h
	χ	q^h
	s	ts^h
	ʃ	$tʃ^h$
	h	k^h, p^h [4]
Epenthetic [k]	Ø	k
Sonorants	r	t^h
	l~d	t
Unaspirated plosives	p	p
	t	t
	k	k
Aspirated plosives	p^h	p^h
	t^h	t^h
	k^h	k^h
	q^h	q^h
Affricates	ts	ts
	tʃ	tʃ
	dʒ	dʒ
	ts^h	ts^h
	tl	tl
	tl^h	tl^h

As started previously, Gouskova, Zsiga, and Boyer (2011) assert that SCL effects are the primary reason behind fricatives and liquids becoming either ejective plosives or aspirated stops post-nasally. Therefore, as stated in Table 2 above, glides, rhotics, laterals, fricatives, plain or voiced stops, voiceless fricatives are weaker than aspirated or ejective stops are bound to alternate with aspirated or ejective stops postnasally. Therefore, as indicated in 0, plain and aspirated plosives or affricates remain the same in postnasal position because they are already strong or least sonorous and so do not violate the SCL constraints (Batibo 2000), Gouskova, Zsiga, and Boyer (2011) and Nkolola-Wakumelo, Rantrso, and Matlhaku (2012).

4.1. Strengthening Contexts

Strengthening appears in the following environments: after a nasal and after a reflexive prefix vowel /i/ whose role is to express the idea of English *-self* or *-selves*[5].

Morphologically, strengthening appears after the 1st person object prefix, after prefixes of noun classes 9 and 10[6]. Phonologically, it appears after syncope (Cole 1955).

[4] Strengthened /h/ has two dialectal variations [k^h] and [p^h]. Also, [p^h] is a standard form whilst [k^h] is a non-standard one.

[5] It indicates that the action is reflected or directed back upon the subject of the verb is used as an object to refer to the subject of the verb (Cole 1955).

[6] Setswana has a productive noun class system where basic nouns have grammatical genders consisting morphologically of a class prefix and root. Nouns are assigned to their classes according to their prefixes (Nurse 2008). There are 18 noun classes in total which are morphologically, marked with singular/plural pairings. Classes 1 /mo-/, 1a /ø/, 3 /mo/, 5 /le-/, 7 /se-/, 9 /N-/, 11 /lo-/ and 14 /bo-/ are singulars for classes 2 /ba-/, 2a /bo-/, 4 /me-/, 6 /ma-/, 8 /di-/, 10 /D-n-/ respectively. Nouns are assigned to their classes in accordance to their semantic meanings (Cole 1955; Katamba 2003).

Table 4: Strengthening after the nasal

ENVIRONMENT	UR		STRENGTHENED	GLOSS
1st sg	/n-fa/	→	[m-pʰa]	'give me'
	/n-Øitsɪ/		[ŋ-kitsɪ]	'know me'
Class 9/10 prefix	/n-tʰɔ/	→	[n-tʰɔ]	'wound'
	/di-n-tʰɔ/		[di-n-tʰɔ]	'wounds'
Syncope[7]	/bɔ-n-s-a/	→	/bɔ-n-tsʰ-a/	'cause to see'

In addition, the examples in (11) below are an illustration of strengthening from the seNgwato dialect of Setswana[8]. As the data shows, the nasals that are part of a strengthening environment are obligatorily homorganic with the following consonant. For example, fricatives become aspirated stops, as illustrated in (11a-(11b); sonorants become aspirated stops (11c) whilst plain and voiced stops become ejectives, as shown in (11c)-(11d) respectively. Affricates (voiced and voiceless) as well as aspirated and unaspirated plosives do not alternate in (11e).

(11) Strengthening in seNgwato

a. /n-supa/ ~ [ɳtsʰupʼa] 'point at me'
b. /n-χata/ ~ [ɳqʰatʼa] 'stamp on me'
c. /n-ruta/ ~ [ɳtʰutʼa] 'teach me'
d. /n-bata/ ~ [mpʼatʼa] 'look for me'
e. /n-dʒɛla/ ~ [ɲdʒɛla] 'eat for me' (Gouskova, Zsiga, and Boyer 2011: 2134)

An epenthetic [k] is added to onsetless syllables after /N-/ in strengthening contexts as Table 5 shows.

Table 5: Strengthening after epenthetic [k]

1ST PERSON SINGULAR OBJECT	[K] EPENTHESIS	GLOSS
/n-utlwa/	[ŋkutlwa]	'hear me'
/n-atla/	[ŋkatla]	'kiss me'
/n-itsɪ/	[ŋkitsɪ]	'know me'

Cole (1955) argues that [k] is underlyingly /ʔ/ which acts as an onset-filler in vowel-initial syllables. According to Cole epenthetic [k] is inserted postnasally as a result of *g lenition which historically lenited to /Ø/.

Because there is no /g/ in Setswana, Hyman (2001) asserts that [k] is inserted via default because it is closest to *g.

Strengthening of the following consonant is also found after the reflexive prefix which is the vowel /i/ (Cole 1955). "The reflexive prefix expresses the idea of the -self or -selves[,] and it indicates that the action is reflected or directed back upon the subject of the verb" (Cole 1955: 233). This is illustrated by Table 6.

[7] The nasal that is part of the strengthening environment is also found word internally when the causative suffix stem /-is/ is added, /-is/ undergoes syncope to [-s], creating the environment for strengthening (Cole 1955).
[8] In the seNgwato dialect, plain plosives are weakly ejective.

Table 6: Strengthening after the reflexive prefix [i-]

UR		SURFACE FORM	GLOSS
/i-utlwa/	→	[i-kutlwa]	'hear oneself'
/i-rɒma/	→	i-t^{h}ɒma]	'send oneself'
/i-fa/	→	[i-p^{h}a]	'give oneself'

In Setswana as well as in other Bantu languages such as Bukusu, Rundi and Tharaka, the reflexive prefix is a single vowel which is /i/ (Marlo 2015). The reflexive prefix exhibits similar traits to the 1SG in the sense that it also immediately precedes the verb stem, indexes the subject, and triggers strengthening at the same time, like the nasal prefix in Table 4 and Table 5 (Cole 1955; Marlo 2015). According to Cole (1955), the reflexive /i-/, in Table 6, is originally followed by a nasal which has since been elided, as is symbolized in *i*-(N)-*utlwa* ~ *i*-(N)-*kutlwa* 'hear oneself' and *i*-(N)-*rɒma* ~ *i*-(N)-*thɒma* 'send oneself'. The nasal is placed in brackets because it is overt. Cole (1955) asserts that the nasal causes strengthening of the following consonant.

I present an alternative analysis which does not require positing an abstract /N/ later in the paper.

5. Data

The data of this study come from an acoustic study of seLete (a dialect of Setswana) reported in (Matlhaku 2020) unpublished manuscript titled: "Nasal Consonant Sequences in Setswana". Her data involves a voice onset time (VOT) measurement of obstruents in word initial, mid and postnasal environments. Data comprises voice recordings of adult native speakers of the seLete dialect who participated in a picture-naming and direct translation task. I only report the results for postnasal consonants (Table 7). The table shows a post nasal contrast between aspirated and unaspirated stops. Unaspirated stops are realized with short-lag VOT. Aspirated stops have a long-lag VOT.

Table 7: VOT of groups of plosives in postnasal position

SOUNDS	AVERAGE VOT	VOT TYPE
Unaspirated stops	38	Short-lag VOT
Aspirated stops	91	Long-lag VOT
Underlying fricatives/liquids	96	Long-lag VOT
Underlying onset-less syllable	43	Short-lag VOT

The seLete data is consistent with seNgwato (Gouskova, Zsiga, and Boyer 2011), Standard Setswana (Cole 1955; Mogapi 1984), and Bemba, a spoken dialect/language in the northern province of Zambia (Kula 1999; 2002; 2006; Kula and Marten 1998). The data shows that underlying onset-less syllables gain an epenthetic unaspirated [k] in post nasal position.

In this study, I use GP (KLV 1985; 1990) as a framework for data analysis. The following section introduces this framework and shows its suitability for the current data.

6. Government Phonology (GP)

GP is a phonological framework that is based on the following ideas: (a) phonological processes are structure preserving (and so there is no resyllabification), (b) strings are fully

syllabified in the lexicon, (c) all skeletal slots are dominated by a syllabic constituent—nothing is under-parsed, and (d) ordered rules are undesirable (Scheer 2004).

GP recognizes three basic constituents, namely, the Onset (O), Nucleus (N) and Rhyme (R). Parsing is achieved through associating segments with these constituents, which are maximally binary branching units (KLV 1990; Hulst and Ritter 1999; Hulst 2006). Relations between constituents, and segment ordering, are defined by the government and licensing relations between O, N, and R. Government is a kind of asymmetric licensing that holds between a governor and a governee where the governed position is impoverished (Dienes and Szigetvári 1999). The central principle of GP is Phonological Licensing (12).

(12) Principle of Phonological licensing (p-licensed)
   a. Within a domain, all phonological units must be licensed except one, the head of that domain
   b. Licensing relations are local and directional

Constituents—in particular, nuclei—can be empty or inaudible (KLV 1990; Kaye 1990; Harris 1994). The location of empty nuclei is constrained by the Proper Government principle explained in (13).

(13) Proper government
   α properly governs β iff:
   a. α is adjacent to β on the nuclear position
   b. α is not itself p-licensed
   c. α is not a government licensor for its onset (KLV 1985; 1990)

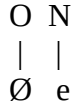
According to proper government segments that are adjacent at some projection are permitted to be in a proper relationship if and only if the realized member allows the adjacent member to be 'silent' or unrealized.

6.1. Strict CV Structure

Because Setswana has a strict CV syllable structure, I assume the Strict CV version of GP (Lowenstamm 1996; Dienes and Szigetvári 1999; Scheer 2004): phonological representations are strictly composed of a string of CV units, regardless of the types of strings observed on the surface. Hence, structures with clusters, geminates, diphthongs and long vowels universally contain alternating CV units, and must include an empty V or C, as appropriate, in their representation (Scheer 2004). The reason for using strict CV phonology in my analysis is simply because Setswana has a strict CV syllable structure.

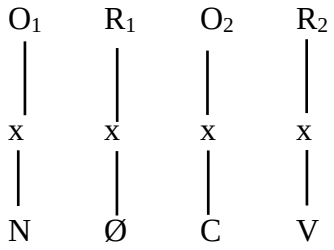
Strict CV phonology assumes an empty N position within consonant clusters, and another empty N after word-final Cs. Similarly, because onsets are obligatory, a surface vowel-initial syllable begins with an empty-headed onset in Strict CV phonology (Figure 1).

Figure 1: Empty onsets



The structure of NC clusters in Setswana is an 'onset sandwich', shown in Figure 2. (To avoid confusion in terminology, I will use R(hyme) in place of N(ucleus) in the remainder of this paper.) In onset sandwiches, O_2 must license O_1, because R_1 is empty. The Empty Category Principle, defined in (14), and the notion of what constitutes a proper governor, both serve to constrain which allophones appear in O_2 position (Kula 2002).

Figure 2: Onset sandwich



6.2. The Empty Category Principle (ECP)

The Empty Category Principle (ECP) (Kaye 1992a) constrains where empty categories can appear. Empty categories must be p(rosodically)-licensed. A p-licensed (empty) category receives no phonetic interpretation.

(14) The Empty Category Principle (ECP)
A p-licensed (empty) category receives no phonetic interpretation.

a. P-licensing
An empty category may be p-licensed if it is:

i. Domain-final (parameter)
ii. Properly governed
iii. A nucleus within an inter-onset domain
iv. Magically p-licensed (Kaye 1992a: 305)

Of all four points in (14), (14a.ii) and (14a.iii) are the only ones relevant to the analysis of NC clusters in Setswana.

6.3. Government and complexity

The Complexity Condition, in (15), defines government relations between constituents which depend on the governing properties of segments. In this condition, governees must be equally or less complex than governors.

(15) Complexity Condition
Let α and β, be segments occupying the positions A and B respectively.
Then, if A governs B, β must be no more complex than α.
(Harris 1990: 274; 1994:170)

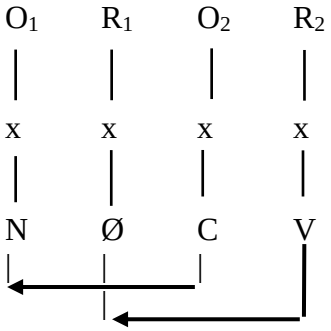
Segmental complexity generally correlates with sonority, such that the least sonorous segments are the most complex whereas the most sonorous segments are the least complex (Harris 1990; Kula 1999; 2006). I illustrate how the ECP, government, and complexity

apply to NC clusters or 'onset sandwiches' by reviewing analyses of Bemba by Kula (1999) and Kula and Marten (1998) in the next section.

6.4. Previous Analysis of Strengthening: Bemba

In GP, NCs are represented as Cs separated by an empty nucleus position (the onset sandwich in Figure 3. The government relation between the two onsets is deemed to license the intervening empty nucleus, which in turn must be licensed by a following realized vowel (Kula 1999).

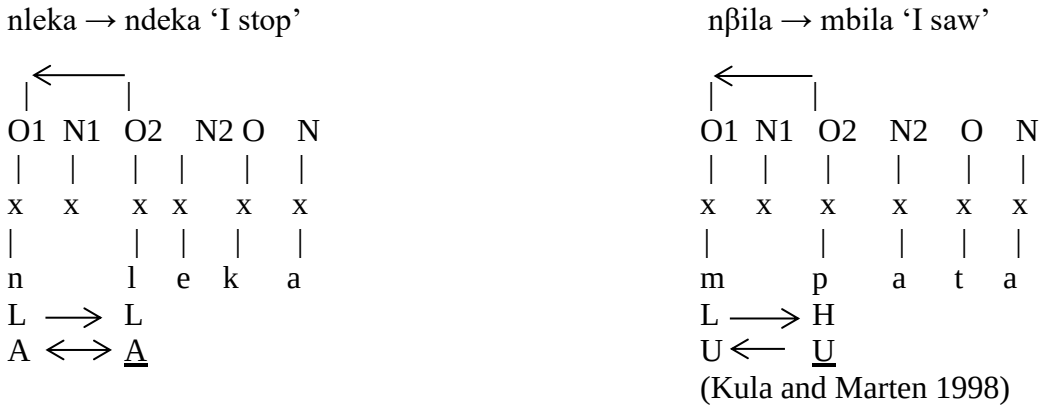
Figure 3: Onset sandwich, government, and licensing



realized as [N̥CV]

According to Kula (1999) and Kula and Marten (1998) strengthening is a means of ensuring that governers are strong enough to govern. Strengthening is achieved either by element sharing (feature sharing) between O_1 and O_2, or by feature insertion or deletion, to obtain the desired governee (O_1) – governor (O2) relationship (Figure 3). For example, a template in Figure 3 would result in the changes in Figure 4 with Bemba words, /n-leka/ → [n-deka] 'I stop' and /n-βila/→ [m-bila] 'I saw', in O_2 (/l/ and /β/) are strengthened to [d] and [b] respectively. These changes ensure that O_2 is more complex than O_1 so as to be a proper governor for O_1.

Figure 4: Strengthening in Bemba



(Kula and Marten 1998)

Instead of using elements, I will assume binary or unary distinctive features in my analysis. The manner elements that contrast stop versus non-stop will be captured by distinctive features [-continuant] in stops and [+continuant] in fricatives and liquids. Affricates will be treated as [-continuant] stops. Nasality will be captured by [-continuant,

+voice]. Finally, the glides /j w/ have the same representation as the vowels /i/ and /u/ and are only differentiated by their position in constituent structure.

6.5. Setswana NCs and GP

In order to motivate the GP analysis for NCs in Setswana, I first revisit the structure of [N̩C] sequences; then, I discuss homorganic nasal assimilation (HNA) in [N̩C] sequences, and finally, I discuss strengthening of the C in [N̩C] sequences. My analysis captures the results of my study, and it is also consistent with Cole (1955), Mogapi (1984), DALL (1999), and Gouskova, Zsiga, and Boyer (2011).

6.6. NC Clusters are [N̩C]

NC clusters in Setswana are not one unit made up of two consonants, but instead, a nucleus [N̩] followed by a C. Crucially, [N̩C] has an ONO or 'onset sandwich' structure in Setswana according to Table 8. This is discussed in detail in §6.9. -6.11. .

Table 8: Onset sandwich in Setswana

	O_1	R_1	O_2	R_2
	N	Ø	C	V
Phonetic realization of 1st ON sequence	N̩		C	V

I argue that strengthening of the C in O_2 involves spreading of the [-continuant] feature needed by the C to properly govern [N̩] (O_1). The C needs to be strengthened if it is less complex or less sonorous than the N in order to properly govern the [N̩]. The unrealized nucleus (R_1) is licensed by R_2 and can, therefore, remain silent. However, because R_1 is empty, O_1 must be licensed by something other than R_1 and so is licensed by O_2.

6.7. Homorganic Nasal Assimilation in NC Sequences

In an ONO sandwich, "[h]omorganicity is attained by the requirement that the governing related positions share at least one element" (Kula and Marten 1998:203). This results in the governed nasal (O_1).

(16) Homorganic assimilation:
- a. n → m / ___ __ /b, p, f/
- b. n → ŋ / _____/χ, k, kh, qh/
- c. n → n / _____/l~ d, r, t/
- d. n → ɲ / _____ /ʃ, ʧ, ʧh/

The fact that the nasal in NCs is homorganic to the following consonant is also not surprising because the nasal has typically been characterized as placeless, and so it needs to share a place of articulation with the following consonant.

Homorganicity is triggered by the spreading of place features of the consonants into the position occupied by the nasal (Harris 1990) as illustrated in Table 9 in which /f/ alternates with [p^h] postnasally.

Table 9: /f/ ~[p^h] alternation

		O_1	R_1	O_2	R_2
		N̩	Ø	f	a
UR	Place	[Coronal]		[Labial]	
	Manner	[+nasal]		[-nasal]	
		[-continuant]		[+continuant]	
	laryngeal	[+voice]		[+voice]	
SR	Place	[Labial]	←	[Labial]	
	Manner	[+nasal]		[-nasal]	
		[-continuant]		[-continuant]	
	Laryngeal	[+voice]		[-voice]	

In Table 10, the silent R_2 within the onset sandwich is p-licenced through the inter-nucleus government relation with R_2 (audible rhymes license silent rhymes). The place feature [labial] from /f/ is shared with the N̩ of the NC cluster (HNA). Therefore, the feature [coronal] in the N̩ is suppressed because the nasal is the governed member, and the governor imposes that the governee be homorganic with the governor. In an onset sandwich, there has to be uniformity in place features between the governor and the governee, with the former being the originator of the place features it imposes on the latter.

6.8. Explanation of Strengthening in NCs

Strengthening within an onset sandwich involves feature spreading or sharing between the N and the C prior to entering into a governing relation seen in Table 10. According to the table, underlying stem initial /b, f, r, χ, h/ become aspirated stops following the nasal whereas stem initial /l~ d, p, t, Ø/ become [t, p, t, k] respectively, hence progressively more complex in postnasal position. Aspirated stops tend to maintain their aspiration post-nasally. Thus, postnasal strengthening (in an onset sandwich) involves spreading of the [-continuant] feature from the N to the C which is underlyingly [+continuant] so as to properly govern the N. In other words, the C has to be strengthened prior to governing the N. This accounts for strengthening in the form of aspiration post-nasally in Setswana.

Strengthening of fricatives and liquids in NC clusters is interpreted their gain of complexity or loss of sonority (Kula and Marten 1998; Kula 1999; Kula 2006). As established earlier, complexity implies sonority, and so elements are translated to features as posited in Table 10. In this table, '*after strengthening'* means 'turned into a proper governor'; SG means spread glottis.

Table 10: Strengthening of fricatives and liquids

	UR	AFTER STRENGTHENING
f →p^h	place feature	place feature
χ →q^h	[+cont]	[-cont]
s → ts^h	[+SG]	[+SG]
ʃ →$tʃ^h$		
h → k^h, p^h		Dorsal (epenthetic)
	[+cont]	[-cont]
	[+SG]	[+SG]
Ø →k	Ø	Dorsal (epenthetic)
		[-cont]
r →t^h	coronal	coronal
	[+cont]	[-cont]
	[+son / +voi]	[-son / -voi]
		[+SG] (enhances contrast between /r/ and /l~d/)
l~d →t	coronal	coronal
	[+cont]	[-cont]
	[+son / +voi]	
Plain plosives	place feature [-cont]	place feature [-cont]
Aspirated plosives	place feature [-cont] [+SG]	place feature [-cont] [+SG]
Affricates (aspirated & unaspirated	place feature [-cont] [±SG]	place feature [-cont] [±SG]

Gouskova, Zsiga, and Boyer (2011) consider [+SG] mapping of underlying fricatives and surface aspirated stops as triggered by [+SG] that is already present in fricatives.

The only feature instrumental in changing fricatives to either aspirated stops or affricates in Table 10 is [±cont]. Therefore, [-cont] is the only 'changed' feature that is not due to epenthesis or Structure Preservation, as seen in the 'after strengthening' column. [-cont] is also the feature that fricatives and approximants need to become proper governors of the N. Therefore, on the basis of Table 10, I can conclude that 'strengthening' means adding [-continuant] to the C in an [N̩C] cluster.

The only oddity we see is that of /r/ becoming [t^h] instead of just [t] (/l/ and /r/ are underlyingly [+voice, -cont]). Gouskova, Zsiga, and Boyer (2011) explain this mapping as a result of the pressure to maintain a contrast with /l/ which is realized as [t'] post-nasally (i.e., enhancement). Essentially, surface [t^h] and [t] are both strong on the scale in Table 2 and so do not violate the relevant SCL constraint. Therefore, to maintain the contrast between /l/ and /r/, /l/ surfaces as [t] whilst /r/ surfaces as [t^h]. I claim then that [+SG] enhances the contrast between underlying /r/ and /l/. Based on the table, I argue that Setswana has enhancement-like or strengthening processes post-nasally. /r/ is enhanced to aspirated [t^h] to increase its contrast from /l/ which is realized as [t] hence why /r/ is not realized as [t] in post nasal position.

In this paper, strengthening and fortition are analyzable as the spreading or sharing of [-continuant] between the governee (the N) and the governor (the C) which in turn fuses with the features already present in each of the continuants to produce a plosive. In contrast,

Gouskova, Zsiga, and Boyer (2011) interpret these alternations as constraints on the syllable contact favouring the enhancement of more sonorous liquids and fricatives into voiceless burst or aspirated stops postnasal position.

6.9. Strengthening in NCs: Analysis

Strengthening is attained by the sharing of feature(s) between the N and C (consonant to-consonant licensing) in an onset sandwich, as shown in Table 11 below (/r/ in /rʊma/ ‘send’ realized as [t^h] in /n-t^hʊma/ ‘send me’).

Table 11: /r/~[t^h] alternation

		O N	R Ø	O r	R ʊ	O m	R a
UR	Place	[Coronal]		[Coronal]			
	Manner	[+nasal]		[-nasal]			
		[-continuant]		[+continuant]			
	laryngeal	[+voice]		[-voice]			
SR	Place	[Coronal]	⟷	[coronal]			
	Manner	[+nasal]		[-nasal]			
		[-continuant]		**[-continuant]**			
	laryngeal	[+voice]		[-voice] **[+SG]**			

/r/ cannot govern /n/ because it is less complex than /n/. In order for O_2 /r/ to govern O_1 /N/, /r/ acquires [-continuant] from /N/. /r/ changes to [-voice] and [+SG]. Both processes can be viewed as strengthening, in order to turn /r/ into a proper governor [t^h]. This analysis fits all instances of continuant consonants in post nasal position in the sense that they obligatorily acquire the [-cont] feature qualifying them to occur in this environment.

6.10. Consonant Epenthesis

As already established, vowel-initial stems acquire an epenthetic [k] when they follow an /N-/ prefix (Cole 1955; Mogapi 1984; DALL 1999; Gouskova, Zsiga, and Boyer 2011) and in the findings of (Matlhaku 2020) acoustic study. In addition, as stated earlier, underlyingly vowel-initial stems in Setswana always begin either with glides [w, j] or [ʔ] (Cole 1955). In Strict CV phonology, vowel-initial syllables start with an empty onset. An onset is required because onsets are heads, and heads are obligatory constituents. Empty onsets occur in medial position between heterosyllabic vowels (Table 12) and in initial position of words that start with a vowel (ØVCV) as illustrated by /Ø/ in /N-Ø-utlwa/ becoming [k] in [ŋ-kutlwa] ‘hear me’.

Table 12: /Ø / ~ [k] alternation

		O_1	R_1	O_2	R_2	O_3	R_3
		N	Ø	Ø→k	u	tl^w	a
UR	Place	[Coronal]					
	Manner	[+nasal]		[-nasal]			
		[-continuant]		[-continuant]			
		[+consonantal]		[-consonantal]			
	laryngeal	[+voice]		[-voice]			
SR	Place	[Coronal]		**[dorsal]**			
	Manner	[+nasal]		[-nasal]			
		[-continuant]		[-continuant]			
		[+consonantal]	→	**[+consonantal]**			
	laryngeal	[+voice]		**[-voice]**			

The surface [k], in Table 12, is derived through feature spreading and insertion. First, [+consonantal, -continuant] spreads from the nasal (O_1) to [O_2]. Then, whenever a segment has no place feature, it acquires velar place (Kula 2002). Therefore, I argue that the empty O_2 has no place features, so HNA is not possible. But HNA is independently needed with O_1; so, the empty O_2 acquires the place feature [Dorsal]. Then it can share its place feature with the preceding nasal, O_1.

6.11. Reflexive [i-]

Strengthening is also triggered by reflexive [i-]. I explain this strengthening of Cs as another example of the onset sandwich. I argue that the strengthening process observed in NC clusters in Table 11 and Table 12 is also extendable to the words with reflexive [i-]. Analyses in Table 13 and Table 14 show the structure of vowel-initial words with the reflexive prefix (/ʔi-f̲a/ ~ [ʔi-p̲^{h}a] ‘give oneself’).

Table 13: Vowel initial words with reflexive prefix [i-]

O_1	R_1	O_2	R_2
Ø	i	f	a

Table 14: Strengthening induced by reflexive /i/

		O_1	R_1	O_2	R_2
		(ʔ)	i	f	a
UR	Place			[Labial]	
	Manner	[-nasal]		[+nasal]	
		[-continuant]		[+continuant]	
	laryngeal	[-voice]		[-voice]	
SR	Place			[Labial]	
	Manner	[- nasal]		[-nasal]	
		[-continuant]		**[-continuant]**	
	Laryngeal	[-voice]		[-voice]	
		[-sg]		**[+SG]**	

My analysis above takes its cue from Lowenstamm (1996) that all syllables are cross-linguistically CV and that the silent onset is lexically filled with the [-continuant] feature, resulting in a glottal stop [ʔ]. O_2 still has to license O_1. In order to govern O_1, O_2 acquires [-continuant] from O_1; O_2 also acquires [+SG] as part of 'strengthening', or in order to be a proper governer. HNA (and the insertion of [Dorsal]) is not necessary in this structure because O_1 is not a nasal.

My analysis unifies the account of strengthening after the prefix nasal /N-/ and after /i-/ 'reflexive' prefixes. In both cases, strengthening in NCs is needed because of the requirement that O_2 governs O_1 in an 'onset sandwich' configuration.

6.12. Summary of the Analysis

Overall, I can claim that O_2 is strengthened in the onset sandwich so as to be a proper governor of O_1 in the following instances when, firstly, O_1 is the /N-/ prefix, secondly when O_1 precedes an onsetless syllable (epenthetic /k/ contexts), and thirdly when O_1 is an onset filler in an onsetless syllable (e.g., when O_1 has to precede the reflexive prefix /i-). However, of all the reasons, the crucial reason is about being a proper governor in the normal sense (where the governor has to have more features overall). So, the only reason strengthening occurs in the second and third instances mentioned is that they need [-cont] in order to be proper governors. So, 'strengthening' just involves changing segments into [-cont] if necessary, plus adding [Dorsal] if the C has no place features, and adding [+SG] to /r/→ [t^h] to distinguish it from /l/→[t]. Lastly, prior to being proper governors, the liquids /l/ and /r/ need to lose their voicing and move down the sonority scale by becoming [-cont] segments.

7. Conclusion

I have shown that NCs in Setswana are formerly a sequence of two onsets that enter into a government relation. The C in [N̩C] sequences is 'strengthened' to support the governor-governee relation. My analysis has also explained and unified the analysis of strengthening after the /i-/ 'reflexive' prefix. Lastly, my analysis has explained the reason behind the insertion of epenthetic [ʔ, k] in empty-headed onset positions word-initially.

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