Phonological and phonetic factors affecting the early consonantal development in Setswana

by
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Abstract

This dissertation focuses on the phonological and phonetic development of three typically developing children of age ranging between 1;10 and 3;02 who are learning Setswana as their first language. We provide a detailed analysis of these children's early speech development patterns, with a primary focus on the potential origins of these patterns. The aim is not to provide normative data, but to understand early patterns of phonological development in Setswana, whose acquisition by young children is relatively under-documented within the literature.

Our data display the following trends: (1) early acquisition of obstruent stops, nasals, and N̩C sequences: (2) production of fricatives through various substitution patterns (e.g. stopping, affrication as well as debuccalization); (3) simplification of target affricates (e.g. deaffrication, deaspiration and delabialization). Non-lateral affricates also yielded fewer errors (and earlier mastery) than their lateral counterparts, whose production displayed patterns of delateralization and velarization to velar [k], in addition to deaffrication. The target approximants |j, w| and |l, r| were generally acquired early, with the exception of the rhotic |r|, whose production was the most variable of all consonants documented in this study, also characterized by the lowest accuracy rates for all the children.

We analyze these phenomena through current models of phonological emergence (MacWhinney 2015), as conceived within the area of phonology through the A-map model (McAllister Byun, Inkelas & Rose 2016). We highlight how the substitution patterns observed in the data can be captured through a consideration of the auditory properties of the target speech sounds, combined with an understanding of the types of articulatory gestures involved in the production of these sounds. These considerations in turn highlight some of the most central aspects of the challenges faced by the child toward learning these auditory-articulatory mappings. Beyond theoretical issues, this dissertation sets an initial foundation towards developing speech-language pathology materials and services for Setswana learning children, an emerging area of public service in Botswana.

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Praise be to the Most High God for He is good; His love endures forever.

(1 Chronicles16:34)

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Chapter 1: Introduction

1. General introduction

This thesis presents a longitudinal study of the phonological development of three typically developing children at ages ranging between 1;10 and 3;02[1] who were learning Setswana, the national language of Botswana, as their first language. The aim is to identify and provide a detailed analysis of these children's early speech development patterns within an emergentist approach to segmental development (e.g. MacWhinney 2015), with a primary focus on the potential origins of these patterns. The study does not aim to provide normative data, but it is directed towards contextualizing and explaining early patterns of phonological development in Setswana, whose development is relatively under-documented within the literature.

As we will see, the children's general production patterns relate almost always directly to phonetic aspects of the consonants they attempt to produce. While all target plosives (obstruents and nasals) and nasal+consonant sequences were generally acquired early by all the children, target fricatives, rhotic and labialized consonants showed considerable variability. Common segmental processes include stopping and affrication of fricatives; deaffrication and palatalization of affricates; deaspiration of both aspirated stops and affricates; gliding, stopping and lateralization of rhotics; and delabialization or full labial vocalization of labialized consonants.

In the analyses presented in Chapter 5, situate the origins of the majority of the substitution patterns observed in specific aspects of speech phonetics, involving either auditory properties of the target speech sounds or the types of articulatory gestures

1 Children's ages are represented as follows: 1;5 = 1 year 5 months.

involved in the production of these sounds. We claim that these combinations of factors offer as many reliable predictions about the child learner who is unable to accurately produce certain target consonants the same way adults would.

The thesis is structured as follows: throughout the remainder of this chapter, we present an overview of Setswana phonology. Chapter 2 explores the background literature on phonological development across languages, also with a special focus on African languages especially relevant to this research. We also set the goals motivating the current study at the end of this chapter. Chapter 3 presents the research design of our naturalistic, longitudinal study of three first-language Setswana speaking children, two of whom were under three years of age at the beginning of the observation period. In Chapter 4 we describe the speech data at hand, including target stops, nasals, fricatives, affricates, laterals, rhotics, glides, labialized consonants as well as nasal+ consonant sequences. Data analysis follows in Chapter 5, where we analyze the children's segmental processes affecting these target consonants. We rely on a general emergentist framework (e.g. MacWhinney 2015) through the A-Map model (McAllister Byun, Inkelas & Rose 2016) to capture the patterns of segmental development observed in the data. Chapter 6 ties data and analysis through a more general discussion of this research from both theoretical and practical perspectives, the latter in the context of Botswana.

As we discuss in Chapter 2, the data at the centre of this dissertation could in principle be analyzed within a number of different theoretical frameworks, some of which argue for rather concrete views of phonology and phonological processing, while others favour more abstractionist analyses. We will also see that these frameworks differ significantly from one another on the very central question concerning the origins of phonological knowledge. For the purposes of this dissertation, we adopted the general Emergentist framework (e.g. MacWhinney 2015), which aims to explain the origins of linguistic knowledge in a way that assumes little to no categories at the beginning of the acquisition process. In this view, the source of children's phonological knowledge (e.g., phonological features units; prosodic representations) is the set of phonetic and distributional properties that define the ambient (target) language(s) during the course of acquisition. We selected this framework primarily for its focus on acoustic (auditory) and articulatory properties of speech sounds, which we take as a primary source of explanation for the emergence of language-specific speech patterns, also commonly referred to as phonological processes, that emerge during the course of acquisition. For example, as discussed by Rose & Penney (2021), cross-linguistic variation in the acquisition of rhotic consonants cannot be analyzed on phonological grounds only, for example through the presence or absence of a [rhotic] feature in the learners' systems. Instead, both the different rates of acquisition observed across languages and variation observed within individual languages can be captured based on the phonetic properties of the different rhotics found in each language.

2. Overview of Setswana phonology

Linguistically, Setswana, also known as Tswana (S31), is a member of the South-eastern Sotho subgroup of Bantu languages, alongside Southern Sotho (S32) and Northern Sotho (S33) (Guthrie 1967). Setswana is spoken in Botswana as well as neighbouring South Africa, Namibia and Zimbabwe. It is an official language and the national lingua franca in Botswana where, according to Batibo, Mathangwane & Tsonope

(2003), there are 1.3 million mother tongue speakers, constituting about 78.6% of the population.

There are eight major dialects of Setswana, which are found in the following geographical zones of Botswana: Ngamiland district (SeTawana dialect); Central district (SeNgwato dialect); Kgatleng district (SeKgatla dialect); South East district (SeLete dialect); Southern district (SeNgwaketse and SeRolong dialects); and, finally, Kweneng district where the SeKwena dialect is found (Anderson & Janson 1997; Nyathi-Ramahobo 1999). The dialects are mutually intelligible but display variations concerning their phonological inventories (Cole 1955). The data of the current study is based on the SeKwena dialect.

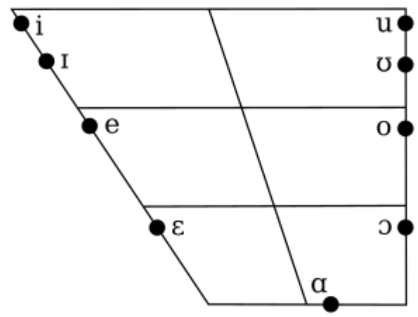
In the subsections below, we provide a sketch of the phonological system of Setswana. We begin by introducing the vowel and consonant inventories in 2.1.1 and 2.1.2, followed by additional notes on syllabic consonants and consonants with secondary articulation, in 2.1.3 and 2.1.4, respectively. We present an overview of the syllable structure of Setswana in 2.2, which is followed by a brief summary of the accentual and tonal properties of the language.

2.1 Phonemes and allophones

2.1.1 Vowel inventory

There are two views pertaining to the vowel system of Setswana. The first view consists of a seven vowel inventory /i ɪ ɛ a ɔ ʊ u/ in which [e] is the allophone of /ɛ/ and [o] is the allophone of /ɔ/ (Cole 1955; Kruger & Snyman 1987; Department of African Languages & Literature 1999 (henceforth, DALL)). The second view involves a nine-vowel inventory consisting of vowels /i ɪ e ɛ a ɔ o ʊ u/ where the mid vowels /e/ and /o/ are phonemic (Chebanne, Creissels & Nkhwa 1997; Gowlett, 2003), as illustrated in Figure 1.

Figure 1: Setswana vowel chart



The following (near) minimal pairs illustrate the distinctive mid vowels.

(1) Near minimal pairs of Setswana vowel (Chebanne, Creissels & Nkhwa 1997: 11)

[ɲtʃʰe]	‘ostrich’	[ɲtʃʰɛ]	‘sweet-reed’
[kʷena]	‘crocodile’	[wɛna]	‘you’ (2nd person singular pronoun)
[koɲa]	‘stint on’	[kɔɲana]	‘lamb’
[enà]	‘this one’	[ɛná]	‘him/her’

We do not discuss vowel acquisition in this study, building on the widely held assumption that vowel acquisition is generally complete by the time the children reach their 3rd birthday (Bankson & Bernthal 1998). In addition to younger participants, any study of vowel development should also involve acoustic analysis (e.g., Buder 1996), which transcends the scope of the current dissertation. However, the dissertation will descriptively assume the nine-vowel inventory of Figure 1 whenever we discuss vowels.

2.1.2 Consonant inventory

There are 28 distinctive consonants in Setswana (Table 1). Among other characteristics, this inventory displays a wide range of affricate consonants as well as plain and aspirated series of stops and affricates. Voicing distinctions are limited to the labial plosives /b p/ and coronal affricates /ʤ ʧ/. However, Cole (1955:33) asserts that the distinction between /ʤ ʧ/ is dialectally allophonic, whereby /ʧ/ is common in Eastern dialects and /ʤ/ in Southern dialects of the language. Plain stops contrast with aspirated stops and affricates. The rhotic /r/ is an apical trill. The glide /w/ is characterized as a labio-velar approximant. We discuss /w/ in more detail in subsection 2.1.4.

Table 1: Setswana consonant inventory adapted from DALL (1999:10)

	Labial	Alveolar	Latero-alveolar	Post-alveolar	Palatal	velar	Uvular	Laryngeal
Plosives	p pʰ [b~β]	t tʰ				k kʰ	qʰ	
Fricatives	[f~ɸ]	s		ʃ			χ	h
Affricates		ʦ ʦʰ	tɬʰ tɬ	ʤ ʧ ʧʰ				
Nasals	m	n			ɲ	ŋ		
Trill		r						
Lateral			[ɬ~d][2]					
Glides	w				j			

2.1.3 Allophonic distributions

The bilabial plosive /b/ has a free fricative variant [β], and [ɸ] is a variant of the labio-dental /f/ (Cole 1955; Kruger & Snyman 1987). [d] only occurs as an allophone of /l/

2 [d] is an allophone of /ɬ/ and the two occur in complementary distribution as we will see in subsection 2.1.3.

before the high tense vowels [i, u], while /l/ is produced as [l] before the high lax vowels [ɪ, ʊ] and before the non-high vowels /e, ɛ, a, ɔ, o/ (Cole 1955; Dickens 1977; Kruger & Snyman 1987).

2.1.4 Secondary articulation

In addition to the 28 canonical consonants already presented above in Table 1, Setswana displays a set of consonants with a secondary place articulation, often characterized as labio-velarized (Mogapi 1984; Otlogetswe 2017), while Mathangwane (1999) and Rogers (2009) classify these consonants as complex segments, the term we will henceforth use to describe these consonants, also referring to them as /C^{w}/. The complex consonants of Setswana involve the co-occurrence of lip rounding and raising of the back of the tongue (velarization). Table 2 presents the 20 Setswana /C^{w}/ as identified by Otlogetswe (2017). The absence of labial /C^{w}/ in the table is not surprising as Kawasaki (1982: 16–17) states that languages generally tend to prohibit labialized labial consonants whereas labialized velars and coronals are typically more common.

Table 2: /C^{w}/ in Setswana (adapted from Otlogetswe 2017)

Orthography	Phone	Orthography	Phone	Orthography	Phone
gw	χ^{w}	tlw	tɬ^{w}	nw	n^{w}
jw	ʤ^{w}	tshw	ʦ^{hw}	nyw	ɲ^{w}
kgw	q^{w}	thw	t^{hw}	ngw	ŋ^{w}
khw	k^{hw}	tlhw	tɬ^{hw}	rw	r^{w}
kw	k^{w}	tšhw[3]	ʧ^{hw}	sw	s^{w}
tw	t^{w}	tšw	ʧ^{w}	šw	ʃ^{w}
lw	l^{w}	tsw	ʦ^{w}		

3 The inverted circumflex was commonly used in orthography to distinguish between alveolar /s/ and palatal /ʃ/ (Cole 1955). Cole instead suggested the use of a cedilla to make a distinction between the two. However, both the circumflex and the cedilla are rarely or no longer found in recent written forms, instead the phonemic /s/ and /ʃ/ are written identically as *s*.

The examples in (2) illustrate words with /C^{w}/ (adapted from Cole 1955).

(2) Words with secondary articulation consonants

a. Stops

i.	[t^{hw}ala]	‘find something’
ii.	[k^{w}ala]	‘write’
iii.	[mʊq^{hw}a]	‘manner/custom’
iv.	[k^{h}uk^{hw}anɪ]	‘beetle’

b. Affricates

i.	ʦ^{w}ala	‘shut/wear’
ii.	utɬ^{w}a	‘hear/feel’
iii.	tɬ^{hw}are	‘python’
iv.	ts^{hw}ara	‘catch/touch/seize’
v.	ʧ^{hw}amʊla	‘set oneself free’

c. Plain liquids

i.	r^{w}ala	‘wear an accessory’
ii.	l^{w}ala	‘get sick’

These consonants are not traditionally captured as part of the canonical Setswana consonant inventory. However, Gouskova, Zsiga & Boyer (2011: 2122) argue that they consist of distinct phonemes and should be recognized as labialized phonemes. This is because they can contrast with their unrounded counterparts, as the examples in (3) illustrate.

(3) Minimal pairs between labialized and unrounded phonemes (examples in (a) from Gouskova, Zsiga & Boyer 2011:2122; in (e) from Cole 1955:34; all other examples are our own)

- a. Stops (velar)
  - i. k’^{w}ala ‘write’
  - ii. k’ala ‘branch’
- b. Stops (coronal)
  - i. nt^{w}a ‘war’
  - ii. nt^{h}a ‘tendon’
  - iii. t^{hw}ala ‘find’
  - iv. t^{h}ala ‘draw a line on the ground’
  - v. ʦ^{w}ala ‘wear’
  - vi. ʦala ‘give birth’
- c. Nasals
  - i. χʊ-n^{w}a ‘to drink’
  - ii. χʊ-na ‘to rain’
- d. Fricatives
  - i. go-s^{w}a ‘to die’
  - ii. go-sa ‘to become dawn’
- e. Liquids
  - i. l^{w}ala ‘get sick’
  - ii. lala ‘lie down’

According to Ladefoged & Maddieson (1996: 356) labialization (or rounding) is cross-linguistically more commonly attested for dorsal sounds (velars and uvulars), than for coronals and labials. This tendency is reflected in adult Setswana as well as the children’s data. We have already seen in examples (2) and (3) that labialization occurs contrastively in the adult language especially in the context of velar and alveolar sounds. However, labialization of /b, p, p^{h}, f, m/ also results in palatalization of these sounds, such that /b^{w}, p^{w}, p^{hw}, f^{w}/→[ʤ^{w}, ʧ^{w}, ʧ^{hw}, ʃ^{w}], respectively, while /m^{w}/ undergoes velarization to [ŋ^{w}] (Cole 1955; DALL 1999).[4] Because the focus of this dissertation is

4 Palatalization in Setswana and other Southern Bantu languages occurs in the context of the passive morphemes /-iw-/ and /-w/ and diminutive *nyana* /-ɲana/ (Cole 1955). For /-iw-/, firstly, /i/ is syncopated and then /w/ triggers palatalization (Cole 1955; Kotzé & Zerbian 2008).

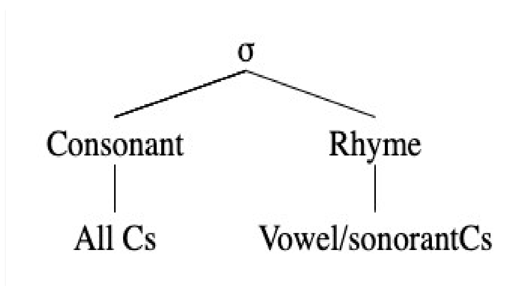
primarily on children's early speech productions; we generally ignore issues related to morphological acquisition.

2.2 Syllable structure

2.2.1 Syllable template

Setswana has a strict CV syllable structure (Figure 2). This implies that a word can begin either with a consonant or a single vowel, but must always end with a vowel, e.g., *mosadi* /mʊ.sa.di/ 'woman' (DALL 1999: 31), *peo* /pe.ʊ/ 'seed' and *aba* /a.ba/ 'give away' (Otlogetswe 2017: 404) and imperatives such as *opela* /ɔ.pɛ.la/ 'sing'; *bua* /bu.a/ 'speak', *tshwaa* /ts^{hw}a.a/ 'mark'.

Figure 2: Setswana syllable structure template



The onset can be any of the 28 and 20 consonants listed in Table 1 and Table 2. Vowels and sonorant consonants are syllabified within the rhyme (Cole 1955).

2.2.2 Onset-less syllables

Evidence of strict CV requirement for syllables comes from vowel-initial stems, characterized by glottal stop [ʔ] or glide [j, w] epenthesis in prevocalic positions (Cole 1955), neither of which were represented earlier in *bua* [buːa] 'speak' and *eng* [ɪːŋ] ‘what’, for sake of simplicity. Glide and glottal stop epenthesis supply an onset to the underlying vowel-initial syllable. This is illustrated by the examples in Table 3.

Table 3: [ʔ] or glides [j, w] epenthesis in onset-less syllables

Imperative	[w] or [j] epenthesis	[ʔ] epenthesis	Gloss
/bu.a/	[buːwa]	/buːʔa/	‘speak’
/e.ng/	[jɪːŋ]	[ʔɪːŋ]	‘what’
/ts^{hw}a.a/	[ts^{hw}aː.ja]	[ts^{hw}aː.ʔa]	‘mark’ (v)

/w/ is the glide corresponding to the round, back vowels /ɔ, ʊ, o, u/; /j/ is the glide corresponding to front vowels /i, ɪ, e, ɛ/; the glottal stop can precede all the vowels. Both /w/ and /j/ can also be epenthesized before /a/.

2.2.3 Syllabic consonants

The sonorant consonants [l̩, r̩, n̩, m̩, ŋ̩, ɲ̩] can appear in syllable nuclei (Cole 1955). These consonants can even be stressed and undergo tonic lengthening, as shown in (4) below. The nasals are syllabic when they occur next to other syllable-initial consonants (i.e., in nasal-consonant sequences) including identical non-syllabic nasals (i.e., /N̩N/s). Syllabic [l̩] and [r̩] can only precede syllable onset [l] and [r], respectively (Cole 1955; Kruger & Snyman 1987). /ŋ̩/ can occur word finally in words such as *bojang* [bʊʤː.ŋ̩] ‘grass’ and *mang* [maː.ŋ̩] ‘who’.

(4) Syllabic consonants (Cole 1955:31)

a.	[ŋ̩.ˈŋaː.pa]	‘scratch me’	e.	[r̩.ˈraː.χʊ]	‘your father’
b.	[ˈn̩ː.na]	‘me/myself’	f.	[mʊ.ˈl̩ː.lɔ][5]	‘fire’
c.	[ˈr̩ː.rɛ]	‘father’	g.	[ˈn̩ː.ʧa]	‘dog’
d.	[m̩ː.pʰɔ]	gift’			

2.2.4 Stress and tone

Setswana displays a fixed system of syllable prominence, with stress consistently realized on the penultimate syllable of each word. Stress manifests itself in this position through Tonic Lengthening (TL). Setswana is also a tone language in which High (H) and Low (L) tones are distinctive. The examples in (5) show contrastive tonal melodies, in addition to Tonic Lengthening.

(5) Contrastive tonal melodies (DALL 1999: 33)

a. LH melody

/maˈbɛ̀ːlɛ́/	‘sorghum’
/ˈqʰàːbá/	‘dress nicely & elegantly’
/ˈbùːá/	‘remove the skin of an animal’
/ˈʦʷàːlá/	‘close’

b. HL melody

/maˈbɛ́ːlɛ̀/	‘breasts’
/ˈqʰáːbà/	‘bad omen’
/ˈbúːà/	‘speak’
/ˈʦʷáːlà/	‘wear’

2.3 Word minimality

Setswana imposes word minimality restrictions on verbs, nouns and some pronouns, requiring them to be disyllabic (Cole 1955; Coetzee 2001). In the next two sub-sections, we illustrate this requirement for nouns and verbs respectively. Again here, these are aspects of the language which may reflect themselves in our acquisition data.

2.3.1 Nouns

Basic nouns are classified into grammatical genders according to their prefixes, marked as singular-plural pairs (Nurse 2008) and in relation to their semantics (Cole 1955;

5 Note that *mollo* [mʊ.l̩ː.lɔ] ‘fire’ and *lla* [l̩ː.la] ‘cry’ are written as *molelo* and *lela* but the *e* is not realized phonetically.

Katamba 2003). Noun classes 1, 1a, 3, 5, 7, 9, 11, 14 are singulars for classes 2, 2a, 4, 6, 8 and 10 respectively. Class 6 is also plural of classes 11 and 14. Setswana nouns canonically consist of a prefix and stem (Table 4). Table 4 provides an illustration of the Setswana noun class system. Additional classes are 15, which consists of infinitives, and 16, 17, and 18, all of which are locatives.[6]

Table 4: Setswana noun classes[7]

Class	Prefix	Examples	Class	Prefix	Examples
1	/mo-/	*mo-tho* ‘person’; *m-musi*[8] ‘leader’; *m-moki* ‘poet’; *m-henyi* ‘winner’	2	/ba-/	*ba-tho*; *ba-busi*; *ba-boki*; *ba-fenyi*
1a	/Ø/	*Ø-nnake* ‘my younger sibling’	2a	/bo-/	*bo-nnake*
3	/mo-/	*mo-lala* ‘neck’; *m-mutla* ‘rabbit’; *m-hikela* ‘flu’	4	/me-/	*me-lala*; *me-butla*, *me-hikela*
5	/le-/	*le-rama* ‘cheek’; *le-godu* ‘thief’; *le-rato* ‘love’	6	/ma-/	*ma-rama*, *ma-godu*, *ma-rato*
7	/se-/	*se-tlhare* ‘tree’	8	/di-/	*di-tlhare*
9	/N-/	*N-ko* ‘nose’; *m-pho* ‘gift’; *tlhogo* ‘head’; *kgomo* ‘cow’	10	/di-N-/	*di-n-ko*; *di-m-pho*; *di-tlhogo*, *di-kgomo*
11	/lo-/	*lo-rama* ‘cheek’; *lo-godu* ‘thief’; *lo-rato* ‘love’	6	/ma-/	*ma-godu*; *ma-godu*; *ma-rato*
14	/bo-/	*bo-tshelo* ‘life’	6	/ma-/	*ma-tshelo*

6 See Mogapi (1984) for a comprehensive discussion of Setswana noun classes.

7 The astute reader might notice that there are no classes 12 and 13. This is because these classes are no longer used to describe the language.

8 In some nouns in classes 1 and 3, the prefix /ʊ/ is elided whenever it is followed by stems beginning with /b-/, resulting in a syllabic /m̩/, and the /b/ assimilating to /m̩/ as illustrated by these nouns: *mmu* 'soil/sand' *mmutla* 'rabbit' *mmusi* 'leader', *mmoki* 'poet'. The same nasal is a 2sg object prefix in human nouns (Cole 1955; Mogapi 1984).

The prefix is either a CV syllable (i.e., *motho* /mʊ-tʰʊ/ ‘person’) or a single syllabic and homorganic nasal /N-/[9] which is overtly realized whenever the nominal root is subminimal (i.e., a monosyllabic stem or single vowel), as shown in examples (6) and (7). The nasal prefix /N̩-/ precedes any subsequent syllable-initial surface consonant and functions either as a class 9 prefix, involving nouns as well as a 1sg object prefix in derived verb contexts, whereas the C can be any surface voiceless obstruent or affricate.[10]

(6) Overt realization of initial nasal prefix on monosyllabic stems (Cole 1955; Mogapi 1984: 82–83)

/n̩-ʧa/	[n̩ːʧa]	‘dog’
/n̩-tʰɔ/	[n̩ːtʰɔ]	‘wound’
/ŋ̩-kɔ/	[ŋ̩ːkɔ]	‘nose’
/m̩-pa/	[m̩ːpa]	‘tummy’

However, the nasal prefix is not pronounced in words that are disyllabic or longer (Cole 1955; Mogapi 1984; Miti 2006), where the minimal word requirement condition is met by the stem (Coetzee 2001). The data in (7) illustrates this.

9 The homorganic nasal and its phonological influence, is represented as /N̩-/ in our discussions, in line with Cole (1955: 39). We discuss the production of nasal-consonant clusters (/N̩C/)s in detail later in Chapter 4, section 10.

10 In derived verb contexts involving /N̩C/s, the singleton obstruents /p, pʰ, t, tʰ, qʰ/ within /m̩p, m̩pʰ, n̩t, n̩tʰ, N̩qʰ/, respectively, are underlyingly /b, f, l, d, r, χ/, respectively, derived through the post-nasal strengthening (fortition) rule banning voiced sounds and continuants in post-nasal position (Cole 1955; Gouskova, Zsiga & Boyer 2011). Also noteworthy, a sequence of N̩+voiceless obstruent stops, affricates does not change under the post nasal strengthening rule because the obstruent is already strong (Batibo 2000; Gouskova, Zsiga & Boyer 2011).

(7) Covert realization of initial syllabic nasal in polysyllabic words (Cole 1955; Mogapi 1984; Miti 2006)

/n-χomʊ/	→	[qʰoːmʊ]	‘cow'
/n-tsɪla/	→	[tsɪːla]	'road'
/n-tsʰʊsʷanɪ/	→	[tsʰʊsʷaːnɪ]	‘ant’

2.3.2 Verbs

The verbs of Setswana also always have at least two vowels and, as such, are never subminimal. Prefixal and suffixal elements act as ‘stabilizers’ in order to avoid monosyllabic verbs (Cole 1955; Coetzee 2001), similar to nouns. As we can see in (8), monosyllabic verbs stems tend to appear with an infinitive prefix /χʊ-/ as in /χʊː-fa/ ‘to give’ or with the stabilizer vowel suffix /-a/ as in /faː-a/ ‘give’ (imperative).

(8) Realization of monosyllabic stems (Cole 1955: 240)

Imperative	with stabilizer /-a/		with infinitive prefix /χʊ-/	
/fa/	[faːa]	‘give'	[χʊːfa]	‘to give’
/ʤa/	[ʤaːa]	‘eat’	[χʊːʤa]	‘to eat’
/nʷa/	[nʷaːa]	‘drink’	[χʊːnʷa]	‘to drink’
/tsʷa/	[tsʷaːa]	‘get out’	[χʊːtsʷa]	‘to get out’

2.4 Interim summary

The descriptions presented above provide a basis for an understanding of the data at the centre of this project. As we discuss in the current chapter, this understanding must also be attained in light of current models of phonetics, phonology, and phonological acquisition. In the next chap, we turn to a summary of the literature on child phonological development, which sets a basic trajectory for this dissertation.

Chapter 2: Background literature

Setswana phonology has received a fair degree of attention within the literature (Cole 1955; Mogapi 1984; Kruger & Snyman 1987; DALL 1998; Chebanne, Creissels & Nkhwa 1997; Gowlett 2003; Gouskova, Zsiga & Boyer 2011; Otlogetswe 2017). However, studies on phonological development in Setswana learning children are not as plentiful (i.e., Tsonope 1993; Mahura 2014; Mahura & Pascoe 2016), particularly concerning the origins of the phonological processes that can be observed in Setswana child language productions. This dissertation aims to fill this knowledge gap, particularly concerning the speech of children under three years of age. In later chapters, we will attribute the patterns observed to the children's under-developed speech-phonetic abilities, which manifest themselves more or less systematically, as they reflect the children's emerging phonological knowledge of each auditory category they aim to reproduce in speech. Section 1 provides an overview of the literature on phonological development. It begins with an overview of the literature on phonological development in Bantu languages and in Setswana in particular. This is followed by a summary discussion of segmental development by first language child learners. We then build on this discussion to set the goals of the current study.

1. Phonological development

Children's development of the speech abilities required for their own language entails knowledge of the phonological forms of words and phrases whilst, at the same time, they "learn the articulatory and phonatory movements needed to produce the words in accordance with adult forms" (Stoel-Gammon & Sosa 2009:238). This implies the progression from an immature system (i.e., child speech) to a developed system (i.e., adult speech) over time (Smith 1973; Stampe 1979; 2004; Bernhardt & Stemberger 1998; Dodd et al. 2003). Due to their immature articulatory skills, which limit their capacity to produce perfect adult forms, children perform various adjustments in the form of phonological processes so as to achieve word production.

1.1 Phonological development in Bantu languages

Research on language development has traditionally focused on European languages. These studies have provided empirical data needed by speech pathologists toward an understanding of both typical and delayed or disordered development. In Southern Africa, research on language development has focused on the acquisition of the Bantu languages Swati, Sesotho (Sotho), isiZulu (Zulu), isiXhosa (Xhosa) and Setswana. These studies document language acquisition in the areas of morphology, morphophonology, syntax as well as phonology. Kunene (1979) focused on the acquisition of nominal morphology (i.e., noun class prefixes and nominal agreement) in Swati. Connelly (1984) and Ziesler & Demuth (1995) investigated the acquisition of Sesotho noun class prefixes and nominal agreement. Demuth et al. (2010) focused on the acquisition of syntactic constructions (question routines, relative clauses and cleft construction), while Demuth & Weschler (2012) studied the acquisition of Sesotho passives. Concerning Setswana, Tsonope (1993) discussed the acquisition of the noun class system and nominal agreement, focusing mainly on demonstratives and possessives.

Regarding phonological development more specifically, the Southern African languages that have received the most attention in the literature include Sesotho, spoken in Lesotho, the South African languages isiXhosa and isiZulu and, more recently, one study of Setswana in two papers discussed below (section 1.2). In isiXhosa, scholars have discussed the acquisition of consonants and clicks (Mowrer & Burger 1991; Lewis 1994; Toumi et al. 2001; Gxhilishe et al. 2007; Gxhilishe et al. 2008). Research on isiZulu development mainly focused on consonants and syllable structure (Naidoo et al. 2005). Studies of Sesotho development looked at the acquisition of segmental and prosodic structure (tone and syllable structure) (Demuth 1992; 1995; 1996; 2003; 2007). Note that Sesotho is closely related to Setswana within the Sotho-Tswana language family. This is particularly relevant to the current study as these two languages are mutually intelligible in spite of some lexical, phonological and morpho-syntactic differences (Demuth 1992).

Studies of the development of Bantu languages outside Southern Africa include works on Chichewa (Chimombo & Mtenje 1989), Swahili (Gangji 2012; Gangji et al. 2014) and Sangu (Idiata 1988). These will not be discussed in this dissertation; however, examples will be drawn for comparison purposes where relevant. The overriding themes in all these studies include the establishment of age norms, relational analyses of children's productions compared to adult target forms and the order of acquisition of phonemes. Overall, and unsurprisingly, these studies reveal comparable trends across languages. However, language-specific patterns are also noted, highlighting the need for documenting acquisition in more languages and learners.

1.2 Studies in Setswana phonological development

To our knowledge, there are three studies of Setswana language development. One study (Tsonope 1993), as already established, focuses on nominal morphology while two other studies (Mahura 2014 and Mahura & Pascoe 2016) focus on phonological development. However, it is worth noting that Tsonope's (1993) study also touches on aspects of phonological development (e.g., syllable structure development), as part of a longitudinal documentation of the acquisition of word forms by two children aged 1;11-2;6 and 2;5-3;0, respectively. In a nutshell, Tsonope (1993) found that both of these children went through similar stages of development in their formation of words as children learning Sesotho, Swati, isiXhosa and isiZulu, as follows: in their earliest productions, the children omit initial syllables (usually weak syllables), which results in initial words that are predominantly disyllabic. The "shadow" vowel /e/ then emerges as the child gets exposed to more polysyllabic noun forms. This vowel can be analyzed as a prosodic "placeholder" for the initial syllable (Demuth 2007). Finally, this initial syllable is acquired during the third stage of development. Example (9) provides an illustration of the production of the word *motogo* 'soft porridge' across the three stages.

(9) Setswana children's early syllable patterns (Tsonope 1993: 111)[11]

	Adult form	Child form	
Stage I:	|mʊtɔ:χó|	[tɔ:χó]	(omission of the 1st CV syllable)
Stage II:	|mʊtɔ:χó|	[etɔ:χó]	(place-holder vowel)
Stage III:	|mʊtɔ:χó|	[mʊtɔ:χó]	(adult-like production)

The studies by Mahura (2014) and Mahura and Pascoe (2016) are both based on a cross-sectional corpus documenting 36 Setswana learning children aged between 3;0 and 5;11. These studies report on the segmental inventory and prosodic properties of words produced by these children, and use the Percentage of Consonants Correct

11 Transcriptions between vertical bars represent adult-like target forms; arrows indicate correspondence between adult and child forms.

(PCC) and Percentage of Vowels Correct (PVC) measures to assess the children's levels of phonological performance.

The general observations are that younger children make more errors than older ones, and that older boys make more errors than girls their age or slightly younger. The authors also report the early emergence of stops and nasals, while other consonants such as fricatives, affricates and complex consonants are acquired later. The rhotic alveolar trill is typically acquired last. Mahura (2014) and Mahura & Pascoe's (2016) observations, particularly those concerning the order of emergence of consonants, are consistent with patterns reported in isiXhosa (Mowrer & Burger 1991; Lewis 1994; Tuomi et al. 2001), Sesotho (Demuth 1992; 2007), Swahili (Gangji 2012), isiZulu (Naidoo et al. 2005) and Akan (Amoako 2020), among other African languages, as well as in other unrelated languages (e.g., English: Ingram 1978; Bernhardt & Stemberger 1998; Stoel-Gammon 1985; Dodd et al. 2003; Cantonese: So & Dodd 1995; French: Rose & Wauquier-Gravelines 2007); Portuguese: Costa 2010; Putonghua: Hua 2002; and Spanish: Jiménez 1987.

In addition, Mahura (2014) and Mahura & Pascoe (2016) report on phonological processes such as fricative stopping, simplification of complex consonants, gliding, backing, and unstressed syllable truncation. The latter process can be caused by issues in morphological development. These phonological processes are also consistent with cross-linguistic patterns observed more generally (Rose & Inkelas 2011; Rose, McAllister & Inkelas 2020).

Beyond the acquisition of simple consonants, Setswana offers a test bench for the development of affricates and complex consonants, both of which are acquired relatively late, and generally involve simplification during early stages (Mahura 2014; Mahura & Pascoe 2016). (See also So & Dodd (1995: 491), for similar observations from the speech of children learning Cantonese.) The late acquisition of complex consonants documented in these studies can be attributed to the nature of their articulatory gestures. However, the detail of how children eventually incorporate secondary articulation to consonants remains undocumented in these studies.

In summary, in spite of their contributions, Mahura (2014) and Mahura & Pascoe (2016) are relatively general studies because they are mostly based on PCC/PVC results derived from cross-sectional data, which do not offer enough detail to understand the full developmental process relevant to the language. For example, how does a child transition from one speech pattern to the next during the course of development? Further, these studies do not document the early stages of phonological development for children under three years of age.

1.3 Segmental development across languages

In his seminal work on phonological development, Jakobson (1941) suggested the notion of universality in child phonology, stipulating a certain level of uniformity between children concerning the course of phonological development, irrespective of the language they are learning. Children were thus universally predicted to acquire nasals before oral sounds; stops before fricatives; anterior stops before posterior ones and voiceless unaspirated stops before voiced ones. Data from languages such as Cantonese (So & Dodd 1995), English (Ingram 1978; Stoel-Gammon 1985; Bernhardt &

Stemberger 1998; Dodd et al. 2003), French (Rose & Wauquier-Gravelines 2007), Putongua (Hua 2002), Spanish (Jiménez 1987), Sesotho (Demuth 2007), Swahili (Gangji 2012), isiXhosa (Mowrer & Burger 1991; Lewis 1994; Toumi et al. 2001), and isiZulu (Naidoo et al. 2005), among others, support the cross-linguistic prediction that stops are acquired before fricatives.

Other consonants such as laterals and rhotics however appear to present a more complicated picture. For example, according to Rose & Penney (2022), the development of rhotics can be predicted across languages through differences between phonetically different types of rhotics, with the Spanish and Portuguese trill [r] and tap [ɾ] substituted by [j] or [l], the English approximant [ɹ] substituted by [w], while debuccalization to [h] and deletion are more prominent processes affecting the uvular rhotic [ʀ]. Rose & Penney (2022) conclude that the children's substitution patterns are fundamentally governed by the segmental contrasts of the ambient language and the phonetic space that these contrasts define, in relative independence from other factors such as word shape or syllabic complexity. We return to this issue later in section 1.4 of Chapter 5.

1.4 Children's phonological processes

According to Smith (1973), there are three main categories of phonological processes, namely (1) syllable structure processes, which govern the overall shape of words; (2) phoneme substitutions; and (3) assimilation processes, which cause vowels or consonants to harmonize with one another. Phonological processes may affect entire classes or sequences of sounds, in which case they take the form of rule-governed patterns. These processes are shaped by both the input from the ambient language as well as by the characteristics (some universal, some individual) of developing speech systems (Rose, McAllister & Inkelas 2020). Table 5 below provides illustrations of common processes documented in phonological development studies of English and other European languages.

Table 5: Phonological processes in children's speech
(adapted from Rose & Inkelas 2011: 2015-2019)

	Pattern	Illustration	Language
a. Place	Fronting/backing	|k|→[t]; |t|→[k]	English
	Labialization	|t|→[p/tʷ]	Dutch
	De/palatalization	|ʧ|→[k]; |k|→[ʧ]	English; Japanese
	Dentalization	|s|→[θ]	English
	Debuccalization	|s|→[h]	Dutch
b. Manner	Gliding	|ɹ|→[w]	English
	Stopping	|s|→[t]	English
	De/affrication	|ʧ|→[t]; |t|→[ʧ]	English
	De/denasalization	|m|→[b]; |b|→[m]	
	De/vocalization	|j|→[l]; |ɫ|→[u]	English
c. Voicing	De/voicing	|d|→[t]; |t|→[d]	English
	De/aspiration	|tʰ|→[t]; |t,d|→[xʰ]	English
	De/glottalization	|ʔ|→[k]; |k|→[ʔ]	English; Quiche
d. Whole segment	Deletion	*snow*→[no]	West Germanic
	Epenthesis	*blue*→[bəlu]	European Portuguese
e. Between segments	C/V interactions	*dot*→[bot]	West Germanic

As we can see from this classification, processes may affect specific components (place, manner or voicing) of speech sounds, leaving other components unaffected.

As Inkelas & Rose (2011) highlight, the most central challenge to the analysis of patterns such as these consists of attaining an understanding of their emergence within the child language data, also in ways that are compatible with mainstream models of phonology. we turn to this topic in the next section.

2. Prosodic and segmental theories of phonological development

In this sections, we overview current theories of phonological development, focusing in turn on prosodic and segmental acquisition. In the area of prosodic development, a central tenet is that phonological systems involve abstract prosodic units of different sizes, organized in a hierarchical fashion at and below the level of the word (Selkirk 1980; Selkirk 1986; Nespor 2007; McCarthy & Prince 1996). Example (10) illustrates the prosodic hierarchy, as it is generally posited for adult languages.

(10) Prosodic hierarchy (McCarthy & Prince 1996: 6)

Prosodic word (PrWd)
|
Foot (Ft)
|
Syllable (σ)
|
Mora (μ)

Prosodically, children generally begin to speak by producing CV or V syllables, which represent the typologically unmarked syllable prior to producing more complex syllables or syllable combinations (Levelt 1994; Fikkert 1994; Demuth 1995b; Demuth & Fee 1995; Demuth 1996; Levelt, Schiller & Levelt 2000).

The general consensus emerging from this research is that children's prosodic development operates within the confines of the prosodic hierarchy. This entails the expansion of prosodic constituents from the smallest, or least complex, to the larger, more complex ones. Children's first utterances are thus made up of open syllable structures and over time gain complexity, for example through the addition of complex onsets or codas, following the prosodic properties of the target language (Fikkert 1994;

Demuth & Fee 1995; Saaristo-Helin, Kunnari & Savinainen-Makkonen 2011). It follows from these predictions that prosodic development in first language acquisition is generally governed by markedness relations governing syllable and higher prosodic structure (e.g. Spencer 1986).

Theories of segmental development, on the other hand, are concerned with explaining the acquisition of segmental inventories and related patterns observed throughout the acquisition process. Central to most theories of segmental development is a reference to phonological features, which are considered, in mainstream approaches to phonology, to be the smallest units of language processing (Jakobson 1941; Levelt 1994; Yamaguchi 2012). For example, describing the difference between the words *mama* and *papa* involves features such as [±nasal], which distinguishes between /m/ and /p/ (Jakobson 1941). However, within the area of segmental development, an in-depth explanation of segmental complexity, as well as the origin of the features, or of the phenomena observed throughout segmental development, are topics that remain relatively unexplored to this day (e.g. Rose 2017, for a recent summary).

To set the stage for the discussion of our findings below, we begin by providing epistemological summaries of mainstream as well as alternative theories of segmental development, also as a way to appreciate where we currently are and, possibly, where we are going. This discussion is guided by the following themes regarding phonological features and their acquisition: (1) structuralism and universal features (e.g. Jakobson 1941), in section 2.1; (2) universality and innateness (e.g. Chomsky 1957; Chomsky & Halle 1968; Smith 1973; Levelt 1994), in section 2.2; (3) self-termed ‘radical’ approaches to phonology rejecting the existence of features (e.g. Bybee 2001; Vihman & Croft 2007;

Vihman 2014) in section 2.3; (4) emergentist approaches to feature development (Sosa & Stoel-Gammon 2006; Mielke 2008; Dresher 2008; Rose 2009; Zamuner, Kerkhoff & Fikkert 2012; McAllister Byun, Inkelas & Rose 2016; Rose 2014) in section 2.5.

2.1 Structuralism and universal features

The notion of phonological feature is widely acknowledged as central to the description of phonological systems including those pertaining to children's early acquisition of phonology. We provide the traditional definition of phonological feature below:

(11) Phonological feature (traditional definition):
A universal abstract unit of phonological representation relevant to all languages; universally-available set of contrastive specifications combined with segmental units (Jakobson 1941)

The theory of distinctive features, pioneered by Roman Jakobson, building on Nikolai Trubetzkoy's seminal work within the Prague Linguistic Circle (Jakobson 1941), has been pivotal to the study of segmental development since the early 1940s. Jakobson's original theory makes the following predictions: there is a universal order of development and acquisition of primitives (i.e., features)[12] and the phonological contrasts that these features encode. For example, children's earliest stages of acquisition comprise an inventory with the following features characterized by the principle of maximal contrasts: (1) consonant vs. vowel (i.e., /a/, /i/, /u/) combinations (i.e., forming these CV forms *ma* and *pa* or *mama* and *papa*)[13]; (2) labial vs. dental (forming these patterns, *ma* and *na* or

12 Crucially, world languages can be described using 12 acoustically-based oppositions: vocalic/non-vocalic; consonantal/non-consonantal; abrupt/continuant; checked/unchecked; strident/mellow; voiced/unvoiced; compact/diffuse; grave/acute; flat/non-flat; sharp/non-sharp; tense/lax; nasal/oral (Jakobson, Fant & Halle 1952: 41–45).

13 According to Ferguson (1964), the view relating to the early *mama* and *papa* has fundamentally laid a robust foundation for investigations of child language cross-linguistically.

mama and *nana*); (3) front and back consonants (Jakobson 1941, as cited by Ingram 1989: 192–196).

Further, Jakobson's theory predicted that the distribution of phonological features is cross-linguistically governed by the "laws of irreversible solidarity" (as cited in Ingram 1989: 193) which employed the notion of universal markedness in predicting the order of acquisition of features. In a nutshell, children's segmental development is characterized by the earlier emergence of the less marked feature specifications, in comparison to their marked counterparts. Hence the following predictions regarding the order of acquisition of consonants, cross-linguistically: stops (including nasals) are acquired before fricatives, front consonants (i.e., labial and coronal) are acquired before back consonants (i.e., velar), within fricatives the emergence of /s/ precedes all other fricatives, voiceless stops are acquired before voiced stops, fricatives are acquired before affricates (Ingram 1989: 193-194).

Another central aspect of Jakobson's general approach is the different representational properties between the child's phonological system and the adult systems in the sense that the former is less marked relative to the latter (Jakobson 1941; Stampe 1979).

This theory of universal markedness of features became a central tenet of generative linguistics for several decades, as we discuss next.

2.2 Generative linguistics and innate features

At the centre of Noam Chomsky's theory of Generative Grammar is the observation that human beings are born with the capacity to learn language (one or many languages) and use it analytically and creatively for communication. Within Generative linguistics, the origin of this capacity is commonly referred to as Universal Grammar (Chomsky 1957; Chomsky & Halle 1968), as defined in example (12) below.

(12) Universal grammar (Chomsky & Halle 1968: 43)
A system of innate conditions that characterize any human language, a theory of essential properties common to all human languages.

According to this definition, linguistic categories (including phonological categories) are innate, as part of the knowledge endowed to human beings through Universal Grammar (see, also, Hale & Reiss 2008; Lidz 2010).

This view of the human language faculty generally encapsulates the hypothesis originally proposed by Chomsky (1957), in an attempt to explain the observation, dating back to Jakobson (1941), that the world's languages share a set of universal properties. Under Chomsky's hypothesis, observations about universality were thus reinterpreted in nativist terms which, when applied to first language acquisition, can be described in terms of a language acquisition device (e.g. Pinker 1994).

In a nutshell, this hypothesis implies the following: (1) endowment (through Universal Grammar/language acquisition device) is the primary source of children's early linguistic knowledge and analysis; this includes (2) knowledge of abstract categories (e.g. phonological features); this implies that (3) phonological acquisition can be described in terms of the learners assigning features to the phones of the ambient language. In other words, there is no acquisition of phonological categories per se; phonological features are provided by Universal Grammar and are thus available at the onset of the language acquisition process. In the words of Hale & Reiss (2008: 660): "children have full access to the full set of universal features in constructing underlying representations which they store fully and accurately specified to the ambient language". In this view, learning takes place in a virtually automatic fashion from exposure to auditory categories, which are then assigned to innately available features. From the perspective of speech production, all errors or deviations from the ambient language are due to the fact that the children's speech organs and related motor control are still under-developed, while the children's actual knowledge, captured in terms of linguistic competence, is intact, given that is it supplied by Universal Grammar from birth.

In a similar way, constraint-based models of phonology developed during the 1990s such as Harmonic Grammar (Legendre, Miyata & Smolensky 1990; Smolensky & Legendre 2006; Pater 2009) and Optimality Theory (Prince & Smolensky 1993; 2004; McCarthy & Prince 1993) formulate predictions about acquisition around the assumption that phonological constraints are both universal and innate. Within these frameworks, phonological constraints as well as their weightings or rankings within the child's developing phonological grammars are the primary source of children's early production patterns and subsequent developmental milestones. Accordingly, similar to models of phonology in the tradition of Chomsky & Halle (1968), mainstream constraint-based models of phonology assume formal correspondences between adult and child grammars, thus predicting a continuity between the two, making the prediction that universal properties of language should also be reflected in children's early grammars and subsequent developmental milestones (Macnamara 1982; Pinker 1984).

Within the recent literature on phonological theory, perhaps the most explicit nativist approaches to phonological development come the general framework of Substance-Free Phonology (e.g. Volenec & Reiss 2020; Chabot 2021; Odden 2022 for recent articles; see also Hale & Reiss 1998, 2002 in the context of phonological development). Within this framework, phonological units of representation and structures are assumed to be innately available to the learner. Further, all issues in phonological computation are assumed to take place independently of substantive phonetic content. Therefore, within this framework, there is no necessary correspondence between phonology and phonetics in the sense that "phonetic information does not play a role in phonology; phonological features are "substance free", containing no articulatory or acoustic information" (Chabot 2021:175). Note in this regard that Substance-Free approaches to phonology, alongside all precursor approaches aiming at a maximal (or total) separation between phonetics and phonology, are centrally concerned with issues in morpho-phonology which largely transcend the types of patterns that we observe in child speech productions.

Already in the early 1970s, the literature on phonology and phonological development offered challenges to both nativist approaches to linguistic theories and the notion that (innate) phonological features represent the primary units of phonological systems (e.g. Braine 1974, 1976; Priestly 1977). This literature instead highlights functional pressures on both speech perception and production, in order to understand issues in phonological development (Waterson 1971; Menn 1971; Vihman & Croft 2007; Menn & Vihman 2011; Vihman 2014). Key to this literature is a more holistic view of phonology at the level of the child's lexicon, referred to as the whole-word approach to segmental development, with the implication that bigger size units such as words (or word templates) are efficient in describing early stages of phonological development. We briefly discuss the criticisms brought forward by this school of thought below.

2.3 Radical Templatic Phonology

In contrast to theories which emphasize segments or features as independent, psychologically real, and core units of phonological analysis, Vihman & Croft (2007) propose a self-termed ‘radical’ argument to de-emphasize these constructs, all the way to dismissing phonological features as relevant to theoretical modelling. Instead, Vihman & Croft, building on earlier work by Waterson (1971; 1987) and Menn (1983) emphasize language-specific phonotactic ‘templates’ or generalizations at the lexical level as the most central domains of phonological analysis. According to Vihman & Croft (2007), phonological templates emerge from the child’s ‘preferred’ babbling patterns and are therefore fundamental in shaping individual children’s early patterns of phonological development. In a nutshell, the child’s phonological learning begins with a limited number of word shapes which form the basis of later phonological behaviours.

In this view, phonological features are claimed to be irrelevant to phonological processing, contra Jakobson (1941), or as innate primitives to phonological processing, contra Chomsky & Halle (1968). Phonological generalizations are instead inferred by the child from the articulatory properties of the words he/she produces. The child is thus the sole determiner, through his/her articulatory abilities, of what he/she allows within his/her word templates. Hence, early productions reflect neither cross-linguistic patterns nor language-specific properties of phonological systems (Vihman & Croft 2007:692).

The reasons behind Vihman & Croft’s (2007) trivializing features as primary units of phonological processing is, as they argue, that features cannot adequately capture the variable nature of children’s early word productions. This includes the inability to capture children’s varying production patterns early on, even among children learning the same languages and, at times, among individual children's own productions. According to Vihman & Croft (2007), variation in early child speech is more efficiently captured through word-level templates which only partially specify word shapes, leaving room for variability in speech production. Phonological patterns such as consonant harmony or the devoicing of word-final obstruents can also be captured in terms of word-level templates (Vihman & Croft 2007: 689).

In sum, Vihman & Croft maximally reject the notion, commonly held in mainstream models of phonology, that abstraction is key to phonological development and later phonological processing. They also reject approaches based on perceptual or statistical considerations that focus on segmental or prosodic units of speech (e.g. Pierrehumbert 2003). They instead emphasize more or less defined word-level generalizations, attained by individual learners based on their own phonological productive abilities, and attribute all aspects of variation to memory limitations on retaining and processing complex amounts of phonological information.

2.4 Interim discussion

So far we have discussed the following foundational approaches concerning phonological theory and phonological development: (1) the universality of phonological features in shaping patterns of phonology attested in the world's languages (Jakobson 1941), in particular through the notion of phonological contrast. (2) the interpretation of universality in terms of innateness of linguistic categories (Chomsky 1957; Chomsky & Halle 1968). This reinterpretation has yielded a view of phonological development whereby the learner cognitively assigns innate features to the phones perceived as auditory categories within the ambient language (Hale & Reiss 2008). This view of acquisition however involves the necessity for learners to prune the innate inventory of features down to only the set relevant to their target language, a view which poses challenges in terms of learnability and the subset principle (Rose 2017). In reaction to this proposal are (3) radical approaches to phonology which completely deny the existence of units such as phonological features and instead focus on word-based generalizations (Vihman & Croft 2007). These word-based approaches to phonological theory and acquisition however only focus on very early child speech and largely ignore centrally important generalizations in terms of segments and phonological features which have been at the core of phonological investigation since the early 1900s.

In sum, these summaries of current theories of phonological development showcase different ways of thinking about issues in child phonology. However, if one takes as a starting point the fact that phonological analysis almost unavoidably involves degrees of abstract knowledge, for example concerning sub-segmental or prosodic aspects of speech, these summaries more or less explicitly ignore the fundamental issue as to where such abstract knowledge actually comes from, or how it comes to manifest itself in patterns of child speech (Rose 2017). From the perspective of segmental development, tackling this issue requires a theory of features and feature acquisition which should make predictions about complexity inherent to given features or feature combinations. Among other questions, one can wonder what determines segmental complexity; is it inherent to given features, or can it be assessed in terms of the number of features involved in a given segmental representation (e.g. Rice 1992; see also White & Morgan 2008 in the area of speech perception). In this context, how can we compare the relative complexity of different features and determine the relative complexity of different feature combinations? Indeed, to our knowledge, there is no theory stating that a given feature inherently involves a greater or lesser degree of complexity than another feature. As we will see below, however, degrees of complexity of different phones or classes of phones can be defined through a consideration of both the auditory cues relevant to the identification of these phones within the speech stream and the articulatory gestures involved in their production. Another issue relates to the order of acquisition for different classes of phones, both within individual languages and across different languages. In this context, we offer that while individual phones or phone classes may involve properties (e.g. auditory or articulatory) which make them inherently more or less complex, language-specific properties of phonological systems, including in usage, for example concerning usage frequency,[14] may also offer foundations to capture the facts observed in the data. In the next section, we encapsulate these considerations as part of an emergentist view of phonological development which combines these various factors mentioned above toward data analysis.

2.5 Emergentism and the acquisition of phonological features

According to MacWhinney (2015), emergentism differs from nativist views of language acquisition based on a strong interpretation of Universal Grammar (UG). While nativist

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14 However, Demuth (2007) states that frequency is not a reliable predictor of the order of emergence of phonological development cross-linguistically. In order to understand the role that frequency may play in phonological development, we first need to consider (1) cross-linguistic variations as well as (2) the nature of the learners' computing statistics (e.g. whether it involves tokens or types, and of what units). Other factors (i.e., syntactic, semantic, discourse, phonological, prosodic, processing etc) may also be influencing the effects of frequency relations within the data, therefore creating biases in the outcome. In this context, it is not impossible that frequency of speech articulations or of particular articulators (especially, coronal) play a role in the emergence of processes such as consonant harmony (e.g. section 1 of Chapter 4); however, the systematic study of this question transcends the scope of the current work.

views capture development through the triggering of innately-available units or rules (Chomsky 1957; Chomsky & Halle 1968), emergentist views of development reject the hypothesis that any linguistic knowledge is innate, and instead consider a broad range of factors, from structural complexity to usage in both perception and production, toward an understanding of the facts observed (MacWhinney 2015). In a nutshell, emergentism focuses on the interaction of three core analytic principles: (1) competition between all the factors at play; (2) complexity/structural levels involved in the units being acquired; and (3) time or processes involved in the emergence of linguistic knowledge, through actual language use (MacWhinney 2015; MacWhinney et al. 2022). This involves unravelling the complex and dynamic interactions that are involved at different levels of language processing, for example cognitive and biological factors, which evolve together across different timeframes, yielding varying processes throughout development (MacWhinney et al. 2022: 8). In the area of phonology, emergentist studies can trace these interactions within and across hierarchically organized linguistic structures (e.g. segmental and prosodic representations), the lexicon and the learner's grammar more generally (Lin & Mielke 2008; MacWhinney et al. 2022:8).

In this view, the acquisition of phonology entails the extraction by the learner of smaller units (e.g. abstract phonological categories) out of larger complex parts of speech (e.g. words, phrases, sentences, e.g. see Ferguson & Farwell 1975 for an early discussion). It also requires the learner to attain and process different types of representations, often across multiple levels of abstraction (Pierrehumbert 2003). At the level of phonology, emergentism thus consists of the learning of (segmental and prosodic) categories based on generalizations emerging from the different speech sounds and the patterns they present in the ambient (target) language (Mielke 2008).

As highlighted by MacWhinney (2015) and MacWhinney et al. (2022), one general consensus within emergentism is that the development of phonological structures, which we can describe in terms of abstract phonological categories, is driven by language-specific properties of the input as well as by other, external factors such as the mechanisms involved in auditory perception (e.g. categorization) and speech motor articulation. In this context, the acquisition of phonological features must involve interactions between “the speech apparatus, the auditory system, the perceptual system and the tendency of the human mind to form generalizations about data” (Mielke 2008: 73). Language development must also be placed within its context of use, given that “the phonological system is built while being used” (Pierrehumbert 2003: 117).

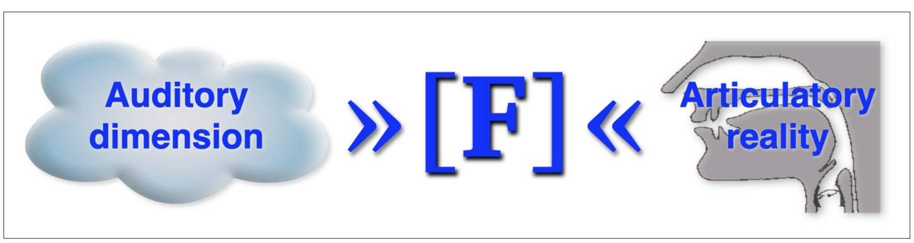
Regarding the importance of features for phonological analysis, relatively recent research on the topic (i.e., Pierrehumbert 2003; Mielke 2008) provides new ways of thinking about language typologies, under the hypothesis that features are needed to describe phonological behaviours but that they are also emergent, not innate. According to Pierrehumbert (2003:116), human beings learn through categorization and hierarchical compartmentalization. At the level of phonology, this involves (at least) the following four cognitive levels: (1) parametric level (mapping acoustics and articulatory space); (2) phonetic encoding; (3) the lexicon (lexical representations of word forms linking form and meaning; and (4) the phonological grammar (constraints on metrical structure and segment sequences in forming lexical words).

At the level of segmental (speech sound) development, emergentist approaches to phonology must therefore consider properties of speech phonetics as part of any analysis. In this context, phonological features, considered by mainstream models of phonology as the component categories (building blocks) of speech sounds, can thus be defined as follows:

(13) Phonological feature (adapted from Mielke 2008; Stevens & Keyser 2010): Quantal (non-linear) relationships between articulatory configurations and regions of perceptual stability

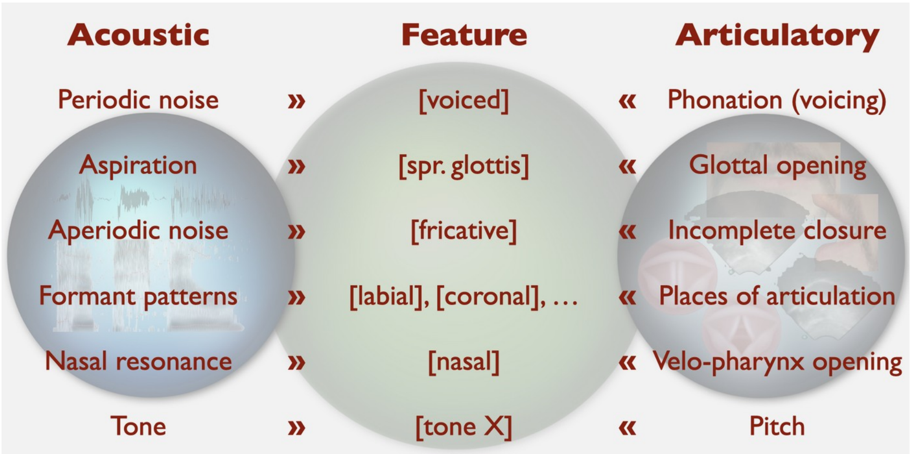
According to Rose (2018a), the perception-production pairings inherent to this definition require children to make generalizations about their ambient languages at three different levels: (1) perceptual level, in particular the identification of the relevant units of speech and their auditory properties; (2) distributional level, for example concerning the distribution of speech sounds and related co-articulatory effects in the signal; and (3) articulatory level, toward the reproduction of the auditory properties of the different target speech units in their own speech. The phonological feature finds thus its place at the cognitive/abstract level as a formal link between the two. This is illustrated in Figure 3.

Figure 3: Auditory-articulatory origin of features (adapted from Rose 2022)



In this view, the acquisition of phonological features thus involves formal mappings between (1) auditory dimensions of sounds (as perceived by the learner), and (2) related articulatory realities needed to reproduce these dimensions in speech, for example, the mapping of fricative noise with incomplete constrictions at different places of articulation, also in combination with airflow production (see also Lin & Mielke 2008 in the area of computational modelling). Figure 4 further illustrates that each feature present in mainstream models of segmental representation indeed corresponds to a unique mapping between auditory properties of speech and their articulatory correlates.

Figure 4: Phonological features and their phonetic correlates (Rose 2022)



Fundamental to this depiction is the fact that segmental categories are not innate and that their patterning is not universal: “they are not innately available to the child but emerge from within his/her lexicon through learning” (Rose 2018a: 46). As Pierrehumbert (2003:120) sums it up: “phonological categories (segments and their phonetic implementations), prosodic features and intonation have different quantitative properties that must be learned and produced accurately by speakers in exactly the same way they are used in the language”.

More generally, we also note that this approach to emergentism does not reject all the tenets of the Universal Grammar hypothesis. For example, under the current approach, the behaviour of learners (and speakers, more generally) are driven by inborn cognitive mechanisms and the constraints these mechanisms impose on linguistic processing, for example binarity, locality and adjacency on grammatical constituency and processing as well as recursivity in syntactic processing. Such universal properties of human grammars are fundamentally innate in the sense that they are relevant to all humans and human languages; it is thus important to recognize the importance of embodied cognition (MacWhinney 2015).

In the next section, we formally operationalize these considerations through the Articulatory Map model (A-map) (McAllister Byun, Inkelas & Rose 2016). Note, however, that while the analyses of this dissertation are informed by the A-map model, we do not pursue the implementation of these analyses within a formal model of phonology; instead we discuss the patterns observed with an emphasis on auditory and articulatory dimensions of speech.

2.6 The A-map

The A-Map is an internal model of phonological representation which focuses on the learner's acquisition and processing of mappings between auditory categories in speech perception, the motor plans aimed at reproducing these categories, and the actual sensory outcomes of these motor plans (McAllister Byun, Inkelas & Rose 2016). Within the A-map, learning consists of attaining phonological representations that successfully link between the speaker's internal knowledge of auditory inputs (present in the ambient language) and the corresponding outputs produced through speech articulation.

In addition, performance limitations characteristic of child-specific phonological patterns are imposed by structural and motor immaturity. It is thus, in part due to these anatomical and motor-control differences (i.e., children's challenges in the physical act of producing speech) that children's outputs vary from adult target forms (McAllister Byun, Inkelas & Rose 2016: 147). The A-map makes a number of general predictions, as follows. During the earliest stages of development, children's productions are predicted to be both highly variable and highly inaccurate,[15] given that the motor plans used by the child for different speech categories may not align fully with the ones needed to reproduce these categories in speech and, independently of their degrees of (in)accuracy, may also not be performed in a consistent way by the learner. With time, during later stages, while motor plans may still be inaccurate, they are predicted to become more stable (or precise, to use the terminology used in the context of the A-map's original formulation). From there, and possibly after a small succession of intermediate stages, also depending on the sound or auditory dimension being acquired, the child is predicted to attain the final (adult) stage; at this point his/her productions become both accurate (adult-like) and precise (stable). Finally, returning to the topic of variation, the A-map also predicts more fluctuation in the data during periods of transition between different stages, where the learner may be alternating between the 'old' and the 'new' patterns, possibly also producing intermediate forms in between (Munson et al. 2010). Beyond acquisition, the A-map remains relevant throughout the speaker's lifetime in that it is involved in the maintaining and updating of the speaker's phonological representations, themselves influenced, at least in part, by the speaker's own linguistic and related social experience, all the way to the potential occurrence of

15 The A-map model operates within the confines of two functional constraints (ACCURATE and PRECISE) which mirror the requirements that the child (1) makes accurate productions of the ambient language form but, in the contexts where this is not (yet) possible, produce speech in a reliable (even if inaccurate) manner to maintain a functional degree of communication.

acquired speech impairments affecting the speaker's speech perception or production later in life (Buchwald & Miozzo 2011; see also McAllister Byun, Inkelas & Rose 2016).

2.7 Factors influencing the emergence of phonological processes

Building on McAllister Byun, Rose & Inkelas (2016), Rose, McAllister & Inkelas (2020) argue that phonological explanations alone cannot capture in sufficient detail why children's early productions exhibit phonological processes such as those listed in Table 5, particularly those that are formally idiosyncratic but cross-linguistically attested (i.e., fronting). These divergent patterns are documented in the literature as arising from differences between children and adults in terms of (1) the anatomical and physiological configuration of the vocal tract (Kent 1992; Vorperian et al. 2005) as well as (2) motor control pressures (Inkelas & Rose 2003). Part of our understanding of segmental development thus relies on a consolidation of factors inherent to developmental phonetics (Rose, McAllister & Inkelas 2020). We provide a preview of each of these general factors next, in subsections 2.7.1 and 2.7.2.

2.7.1 Anatomical and physiological factors

According to Vorperian et al. (2005) and Kent (1992), the vocal tract of infants differs significantly from that of adults, and undergoes tremendous transformations between birth and approximately age six. For example, the child's vocal tract is significantly smaller than that of the adult, with the implication that speech organs are disproportionately closer together compared to that of the adults' vocal tract. Further, the larynx is situated higher in the oral cavity, the infant's tongue is disproportionately large, as it almost completely occupies the forward area of the oral cavity, and is motorically passive. This significantly affects the child's lingual manoeuvrability and, consequently, hinders accurate production of linguo-palatal sounds (Kent 1992).

Given this, the infant's tongue, lips and the lower jaw initially operate together as a unit, with the mandible largely controlling the shaping and manoeuvrability of the former two during early speech production (McAllister Byun 2009, 2011). This mandibular dominance constrains the production of sounds requiring complex gestures, yielding asymmetries such as a general preference to substitute posterior lingual consonants with those produced with an anterior point of constriction. Children's early productions also display co-occurrence preferences whereby the C and V within CV syllables share major places of articulation (i.e., English labial consonants co-occurring with central vowels; coronal consonants co-occurring with front vowels whereas velar consonants co-occur with back vowels; MacNeilage 1998; MacNeilage et al. 2000).

2.7.2 Motor control: ballistic vs. controlled sounds

As briefly established above, the interdependence between vocal tract development and the maturation of motor skills may result in children's failure to produce certain sounds of their ambient language accurately (McAllister Byun & Tessier 2016). On this basis, Kent (1992) categorizes sounds in accordance to their 'ease' of production: (1) ballistic vs. (2) controlled sounds. Ballistic sounds (i.e., oral stops and nasals) are those sounds whose production is largely supported by the mandible, involving movements of short duration, high velocity with rapid acceleration and deceleration of the speech articulators (Kent 1992:85). Ballistic sounds are thus easier to produce because their production only requires the closing and opening gestures largely devoid of specialized manipulations required for varied jaw heights.

On the other hand, the production of controlled sounds requires specialized articulatory precision and timing (e.g., mastery in creating a close approximation between two articulators in order to create a turbulence or audible friction, involved in the production of fricatives, or precise manipulation of tongue body gestures such as tongue bending, rolling or vibration in the production of rhotics and laterals) (Kent 1992:57). These are the most difficult sounds for children to master because they require complex timing and coordination between articulatory gestures (Kent 1992; Green et al. 2002). According to Rose, McAllister and Inkelas (2020), these limitations in motor control and anatomical factors due to vocal tract configurations (i.e., speech phonetics) “contribute to the emergence of phonological processes in child language” (p.579). As such, the scholars propose a consideration of the properties of developmental phonetics together with that of developmental phonology in studying the patterns observed in the speech of a language developing child.

2.7.3 Effects of auditory issues on development

In addition to the properties of speech phonetics and developmental phonology mentioned above, Rose and Penney (2022) state that the auditory signal of a speech sound may potentially affect speech development as a result of this sound having weaker auditory cues for place or manner of articulation. According to these scholars, this may result in the child misinterpreting the speech signal of this sound, especially during the early period of development, resulting in either a deletion of this sound or an erroneous mapping between the target auditory category and the child’s articulatory plan for this. They take as an example the acquisition of the uvular fricative rhotic |ʀ|, whose articulation involves both subtle and intricate articulatory control (i.e., partial raising and backing of the tongue dorsum; subtle constrictions of the velopharyngeal area; combined with the particular aerodynamic control of the more or less voiced airflow making way through these constrictions; Ohala 1983), as well as no obvious visual cues, generally lead to slow development. Also predicted in this context is cross-linguistic variation of the production of rhotic |ʀ|, and of the rhotics is general, again based on the phonetic properties of each type of rhotic found across languages (Rose and Penney 2022).

3. Toward analysis of the Setswana data

In the analyses below, we embrace the central mechanisms of the A-map for segmental development. Given the definition of phonological features adopted in (13) above, we focus in particular on the auditory properties of the speech sounds of Setswana and on the children's attempts at reproducing these properties as part of their linguistic productions. As we will see, the definition in (13) applies fully in virtually all cases where the data reveal patterns of substitution, which we discuss in terms of either perceptual effects on the development process, which may at times even mislead the learners toward inaccurate articulatory targets, or articulatory effects, themselves understood in terms of speech gestures and their relative timing. In this respect, our analysis focuses primarily on subsegmental (feature-level) aspects of sound representations, as opposed to individual phones. In addition to its adherence of the definition in (13), also following the tenets of the A-map model, this approach is most compatible with our observations about segmental deletions or substitutions detailed in the previous chapter, which are best described not in terms of individual phones but in terms of phone classes whose descriptions can be captured through phonological features.

Building on the background summarized above, the goals of this current project are:

- To document the phonological development of Setswana learning children at young ages.
- To understand the source of the developmental patterns of speech observed in the productions of these Setswana learning children.

Chapter 3: Methodology

In this chapter, we describe the research design for the current study. We begin with ethical considerations, followed by the methods employed for data collection and analysis.

1. Ethics approval

This research has received ethical approval from the ICEHR Ethics Review Board of Memorial University in St. John’s, NL (ICEHR #20170104-AR) and a research permit from the Department of Research, Science and Technology at the Ministry of Tertiary Education, Research, Science and Technology in Gaborone, Botswana (reference: MOTE 1/18/6 VII (18)).

2. Research design

The proposed research follows the tradition of naturalistic studies of language acquisition, which aims at the documentation of children's phonological patterns affecting their speech production with ideally no or only minimal disruptions of their daily environments, so as to maximize the ecological validity of the dataset. Naturalistic recordings provide information about the children’s own language production skills as well as the input they receive in their daily linguistic environments. It is indeed this input which forms the basis for generalizations over language, on the one hand, and the interactional processes through which the child is exposed to their language, on the other hand (Lieven & Behrens 2012).

We recorded the data during the summer of 2019, during which we interacted with three monolingual Setswana children (2 males and 1 female) at ages ranging between 1;10

(at the onset of recording) and 3;08 (by the end of the recordings) in the villages of Molepolole and Mankgodi, both situated in Kweneng District, Botswana. We carried out the recordings bi-weekly or weekly when possible, in order to maximize data sampling, over a period of four months. We audio-recorded the children in their daily environments, at their own homes, working under the parents' or caregivers' monitoring. We required minimal to no participation of the parents and caregivers in the recordings. However, at the initial stages of the recordings, parents or caregivers participated fully in order to help familiarize the children with our presence.

2.1 Participants

All the child participants were monolingual from birth, speaking Setswana as their only language, in line with the linguistic profile of their caregivers. The corpus is restricted to the SeKwena dialect of Setswana predominantly spoken in the villages listed above. We chose speakers from the same dialect to minimize issues pertaining to dialectal variation. In Botswana, monolingualism is rare, particularly in children, as it is often expected that children who attend preschool also speak English. This was not the case for the children recorded, however. None of these children attended preschool prior to the recordings. Table 6 shows the coded names of the children documented as part of the current dissertation, their ages at the beginning of the recording sessions, and the number of sessions they participated in.

Table 6: Participants to the study

Child	Age at 1st recording	Number of sessions
W	1;10.18	11
T	2;05.03	12
B	3;02.22	10

None of the children’s caregivers had background in linguistics or related disciplines, and they agreed to their child’s participation simply out of a keen interest in their child's own language development. Prior to carrying out recordings, we obtained the caregivers’ informed written consent for each child's participation as well as for the later use of the children’s audio recorded speech data. We provide the relevant consent form in Appendix A, followed by the original English version of it in Appendix B. The caregivers also completed a questionnaire (in Appendix C) to ensure that all children had expected perceptual knowledge of basic Setswana words, one condition for the children to participate in the study. We further verified with the caregivers that all the children were developmentally and socially healthy and that they also had no vision or hearing problems. None of the children had a history of speech disorders or disordered speech; there were also no concerns about their levels of speech or language development.

2.2 Audio recording

The children’s productions were audio recorded via a Zoom H1n handy audio recorder, a small recording device with a wide-ranging and high-quality built-in microphone. The device was positioned out of sight and reach of the child in the recording setting. This method is the least intrusive, in that it involves virtually no change to the child's everyday environment, and avoids potential disruptions or issues related to self-consciousness, which could occur given children's natural awareness of, and interest toward, electronic devices. For all the children, the recording sessions lasted a maximum of one hour. However, shorter durations were inevitable with younger children, due to their typically shorter attention spans or other factors such as occasional fussiness. In instances where a recording session was less than 30 minutes in duration, we requested to return soon after for additional recording, without however attempting to enforce this on the child. Finally, unavoidable factors such as illness or family holidays disrupted the regularity of the recordings. Each time this was the case, we ensured that the child's and his/her family's well-being took precedence over the needs for regular data sampling. This limitation however yielded a few gaps in the recorded sample. The recordings were stored in WAV format at CD quality (16-bit sample size at 44.1kHz).

2.3 Data elicitation procedure

We used picture books to elicit words that together cover a maximum of the sounds of Setswana across all positions within which they can appear. There were no fixed word lists or any other means of guided speech elicitation. Consequently, this did not guarantee that all children produced all the target sounds in all of the recordings, due to the relatively free nature of the data elicited.

The picture books were used to facilitate communication and enhance engagement with the children. Elicitation started with the children asked to informally and spontaneously name pictures they saw in a picture book. A prompting question was presented to the child if they did not immediately name the object or action they saw on the picture, *golo mo ke eng?* “what is this?” or *ke eng selo se,* “what is this thing?”, and *o dira eng?* “what is he/she doing?”, *se dira eng* “what is it doing?”, or *ba/di dira eng* “what are they doing?”, to which the child answered by naming the object or the action that they were seeing. Spontaneous conversations also formed part of this study, as the participants became increasingly comfortable around us. In such cases, we allowed the children to guide the trajectory of the conversation, which enabled them to produce longer and/or more complex words, phrases and sentences. We then focused on repeating the child’s production using the adult form (as opposed to the child's own produced form, so as not to reinforce what could be an erroneous pronunciation) in order to facilitate subsequent identification of the speech forms attempted by the child. More generally, these interactional strategies followed the types of interaction that normally takes place between a child and an adult, especially in contexts where the adult is focused on providing the child with a stimulating environment for speech production and language learning.

2.4 Data preparation

In the chapter that follows, we consider all consonants produced by the children, with a specific focus on fricatives, laterals and affricates. The additional objects of focus are complex consonants as well as consonant sequences. We also note certain behaviours not related to segmental development such as post-tonic deletion as well as consonant harmony. As we will see in section 7.2 of Chapter 4, post-tonic deletion was prevalent in the production of target |j| by all children. We also observed more or less marginal instances of consonant harmony (progressive and regressive), relative to the production of some target obstruents (e.g. |p| and |k|, fricative |s|, affricate |t͡ɬʰ| and glide |j|).

Prior to carrying out data analysis and interpretation of the three children’s productions, we employed the Phon software program (Rose et al. 2013; Rose & MacWhinney 2014) toward data preparation. Phon is a software platform “with programs to segment, transcribe, annotate and analyze phonological and phonetic speech data” (Rose & Hedlund 2021: 230). Segmentation and transcription tasks were all carried out and/or verified by ourselves. We outline the steps toward preparation process below.

2.4.1 Segmentation

The first step was to carry out media segmentation, in order to identify and assign the corresponding parts of the recorded media (utterances) to each speaker involved in each of the recordings. This step resulted in a series of data records identified for each speaker.

2.4.2 Transcription

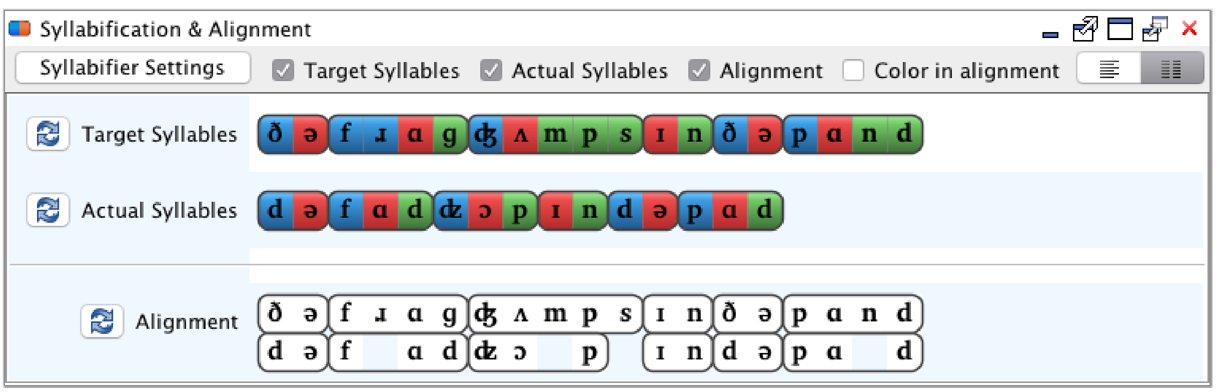
Transcription involves listening to each individual speech production and then performing the orthographic transcriptions of the forms produced. Using a transliteration system which converted Setswana orthographic forms into corresponding phonetic transcriptions, Phon then generated IPA forms in both the IPA Target and IPA Actual tiers. While the target forms correspond to the adult/models to be produced by the child, we manually adjusted the IPA Actual forms so that they matched the child's own renditions of these forms. Resulting from this was a set of IPA Target/Actual pairs which could then be compared systematically through Phon's query and analysis functions, toward a description of the learners' developing speech abilities.

Throughout this dissertation, we use the following conventions: "pipes" (i.e., |form|) to denote target forms which the child is attempting to produce; forward slashes (i.e., /form/) to denote phonological forms; and square brackets (i.e., [form]) to denote the child's actual productions. This notation makes logical sense in regard to our analysis of the patterns observed, in which we make no assumption about the phonological status of the form attempted by the child.

2.4.3 Syllabification and alignment

After the transcriptions were completed, the next step involved verification of syllabification and alignment prior to data compilation. Phon employs specialized algorithms that automatically assign information about syllable position, using syllabification parameters that correspond to the structure of Setswana described in section 2.2 of Chapter 1. Syllabification information is represented using a colour coding system indicating different positions within syllables corresponding to different parts of the syllable: onset is blue, nucleus is red and coda is green (McAllister Byun & Rose 2016; Rose & Hedlund 2021). This is illustrated by the syllabification of the sentence *the frog jumps in the pond* in Figure 5.

Figure 5: Syllabification and alignment in Phon (Rose & Hedlund 2021: 236)



Building on this information, as well as on descriptive similarities between IPA Target and IPA Actual forms, Phon generates an alignment of target-actual word pairs on a phone-by-phone basis. This is represented in the bottom part of Figure 5. For both syllabification and alignment, the user can modify the Phon-generated annotations whenever needed. Once all of the annotations are verified and/or adjusted, the data are ready for analysis.

2.4.4 Data compilation

Upon completion of data preparation, we carried out data compilations through the relevant query methods and reporting functions of Phon. These methods provide a flexible platform for phonological data mining (Rose & Hedlund 2021: 239). The choice of each method depends on the data being investigated (McAllister Byun & Rose 2016; Rose & Hedlund 2021). In the present case, in which consonants are the main focus, we mainly used query methods to make one-on-one comparisons between pairs of Target-Actual aligned consonants across syllable positions. This method enables the easy detection of all phonological processes that manifest themselves in the data such as velar fronting, fricative stopping, or consonant deletion. After the query was completed, Phon generated data reports from which we can carry out data interpretation, the topic of the next subsection.

3. Data interpretation

Approaches to phonological development have traditionally centred around the application of phonological models based on adult languages to account for developmental speech patterns (i.e., phone substitutions, deletions or insertions). These approaches presupposed that children's phonological representations correspond to the adult's produced forms from the onset of the acquisition process (Smith 1973; Stampe 1979). Some scholars analyzed children's phonological representations in terms of grammatical rankings of universal constraints (Barlow 1997; Rose 2000; Levelt & van Oostendorp 2007; Santos 2007; Fikkert & Levelt 2008; McAllister Byun 2009) or by proposing child-specific constraints to accommodate children's phonological pattens not attested in adult languages (Pater 1997; Morrisette, Dinnsen & Gierut 2003: 345).

Recent approaches to phonological development, on the other hand, depart from a view of child phonology through the lens of adult systems and advocate a more interdisciplinary approach also considering issues in sensorimotor development (Menn, Schmidt & Nicholas 2009; Menn, Schmidt & Nicholas 2013; McAllister Byun & Rose 2016; Rose, McAllister & Inkelas 2020). According to Rose, McAllister & Inkelas (2020), analyses of segmental development must combine elements from both phonology and phonetics to capture all the factors relevant to the developmental patterns observed in the data. The findings emerging from the current project will offer additional grounds to discuss this approach in light of new facts.

4. The issue of consonant harmony

Consonant harmony involves feature sharing or agreement between two non-adjacent consonants within a given word (Smith 1973; Goad 1996; Pater 1997; Rose 2000; Hansson 2001; Gormley 2003). According to Vihman (1978) and Stoel-Gammon & Stemberger (1994), consonant harmony in child phonology often targets coronal consonants, in which context it can be triggered by labials and velars. We however leave such issues out of our discussion of the children's (W, T and B) development, as they transcend the goals of the current work. Indeed, consonant harmony has been argued to arise from potentially different sources, some of them being prosodic or segmental (Fikkert 2010; Yamaguchi et al. 2015), some concerning the sequencing of speech articulations (i.e., issues in speech and motor planning; Gibbon 1990; Goad 1996; Scobbie et al. 2000; Hansson 2001; Gormley 2003). Goad (1996, 2000) proposes that consonant harmony simplifies the set of articulatory instructions involved in early word productions. Finally, Hansson (2001) closely associate consonant harmony with speech errors[16] instead of outputs reflecting properties of the speech input of the child.

However, consonant harmony as a topic is tangential to the study of segmental development proper, due to the fact that it tells us rather little about the child's knowledge of the individual sounds that become harmonized, or about the specific factors influencing acquisition of the different classes of sounds in the language. Because of this, we decided as part of our methodology not to fully engage with data containing evidence of consonant harmony, so as to keep our focus on the development of individual sounds and sound classes.

16 Hansson 2001 (340–345) closely associates consonant harmony with speech errors such as slips of the tongue due to the fact that both processes have the following characteristics: (i) relative similarity of the segments involved (i.e., between the potential target and trigger; the more similar these two are in terms of features, the highly likelihood that consonant harmony and slips of the tongue will result), (ii) directionality effects of the process (i.e., interference and interaction between speech production and speech planning involving simultaneous production of the trigger and the planning of the target), (iii) transparency of intervening segments (i.e., intervening vowels are opaque to the process hence have no auditory effect on the trigger-target interaction).

Chapter 4: Data description

In this chapter, we describe the data relevant to the current study. Throughout the chapter, we present the data for the three children, W, T and B, side-by-side, in a way that enables a systematic comparison of each child's production patterns also in light of their respective ages. In this regard, each data description begins with W, followed by T and then by B. As we will see, however, in many cases, T, who is a girl, displayed more accurate productions than the two boys documented in this study, a phenomenon also observed by Mahura (2014), as mentioned already in MacCobby & Jacklin (1974); Smit et al. (1990); So & Dodd (1995); Halpern (1996); McCormack & Knighton (1996); and Dodd et al. (2003). Finally, as a group, we refer to W, T and B as WTB.

The data is presented following a 'phonological' logic, starting with obstruent stops, fricatives and affricates, followed by nasals, laterals, rhotics and glides, as per the consonant inventory of Setswana listed in Table 1. As already illustrated in Table 2, Setswana also displays complex sounds, which are realized with a secondary labial place of articulation. We discuss the development of these sounds in later sections.

All the general descriptions are represented in the form of charts, in which we use the following colour codes: green represents accurate productions; red represents deletions; and grey, which we term as "other" represents a variety of marginal processes within the current chart. Other colour codes will be specific to substitutions that are specific to each particular sound or sound class. Note further that the data below ignore all cases of deletion that are associated to syllable truncation, which itself may be the result of morpheme or full-word omission (e.g. *sekuta* |sɪkuːta|→[-kuta] 'motorbike'), given that these truncation patterns generally tell us little to nothing about the children's ability to produce the different speech sounds of the language.

As established earlier, we abstract away from explanations regarding patterns of consonant harmony, given that this process, which applies over entire word forms, does not inform us about the more specific factors that influence the acquisition of the different sound classes present in the language. Instead, we put our emphasis on individual patterns of segmental substitution, in an attempt to uncover the factors which may have yielded their emergence in the children's speech productions.

As we will see, the target obstruent stops and nasals were generally produced with higher accuracy rates relative to all other sound classes. As already established earlier in section 1 (e.g. subsection 1.3) of Chapter 2, cross-linguistic reports on phonological development generally show that, of all consonants, obstruent and nasal stops are generally acquired earlier than fricatives and approximants, whereas the rhotics are often the most variable of all the target sounds.

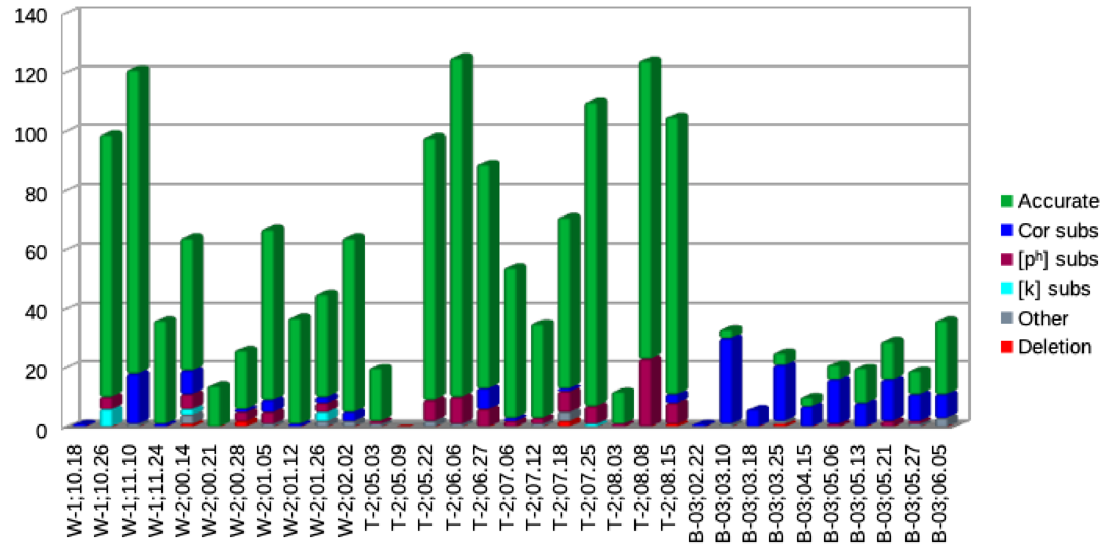
1. Obstruent stops

We start our discussion with the description of WTB's labial stops |b p|. This is followed by the coronals |t, d| and, lastly, the velar |k| and uvular |q^h|. We omit aspirated obstruents stops |p^h, t^h, k^h| in this section and discuss them in detail in section 8.

1.1 Target |p| and |b|

We begin with a comparison of WTB's production of |p|, in Figure 6, and |b|, in Figure 7. As we can see by comparing these figures, while WTB were generally accurate at their target |b|, their target |p| was produced noticeably more variably. W and B substituted a number of these target consonants with coronals. T and W also produced marginal cases of aspiration to $|p^h|$.

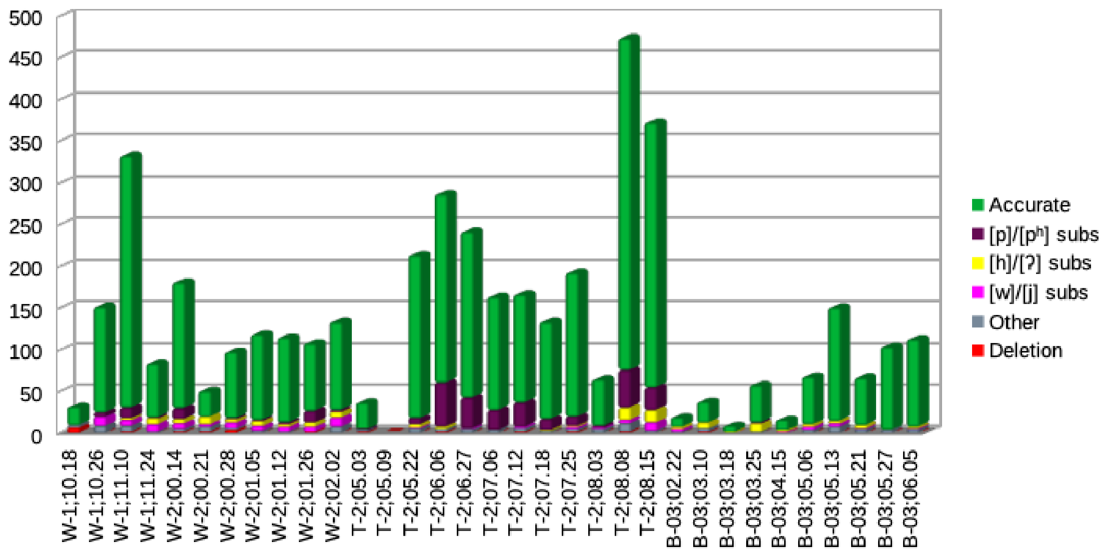
Figure 6: Target |p| for WTB



B produced the majority of coronal substitutions. Out of 200 attempts at |p|, he produced 116 coronal substitutions (58%). Key to this observation is that virtually all of these cases are found in words that contain another coronal within an adjacent syllable. We return to this observation in section 1.1.1 below.

Concerning the production of |b|, we can see that, in comparison to |p|, all the children were mainly accurate with very marginal substitutions in the form of devoicing, gliding and laryngeal substitutions.

Figure 7: Target |b| for WTB



T produced a total of 1981 accurate tokens out of 2339 attempts (85%) at |b|. B made 633 attempts and, out of those, 553 (88%) were accurate. Lastly, W produced 1170 accurate forms of |b| out of 1396 attempts (84%).

1.1.1 B’s general pattern of consonant harmony

We present data showing B’s systematic coronal substitution patterns for target |p| below. As these data suggest, this pattern of substitution was triggered by the presence of another coronal consonant within the word, the hallmark of a consonant harmony pattern. Consonant harmony indeed entails feature sharing between two non-adjacent consonants, the result of which is an agreement between the two consonants in terms of the phonological features they share (Pater 1997; Rose 2000; Hansson 2001). In the examples in (14), the trigger of this consonant harmony (CH) pattern is noted in bold and underlined, and the sound affected by it is underlined. Note as well that the harmony pattern manifested itself in both progressive and regressive fashions.

(14) B’s |p| substitution to coronals

Orthography	Adult form	Child form	Gloss	Age
pene	|pɛːnɛ|	[t̠ɛː**n̠**ɛ]	‘pen’	3;03.10-3;06.05
pitsana	|pit͡saːna|	[ji**t̠**aːla]	‘pot’	3;05.27
pitse	|piːt͡sɪ|	[t̠iː**t̠͡ʃ**ɪ]	‘horse’	3;06.05
tshaba	|t͡sʰaːba|	[t̠aː**n̠**a]	‘afraid’	3;02.02
sepe	|sɪːpɛ|	[**t̠**ɪːt̠ɛ]	‘nothing’	3;03.10-3;05.06
dipilisi	|dipiliːsi|	[dit̠i**l̠**iːti]	‘pills’	3;03.25
lapeng	|lapeːŋ|	[**j**et̠eːŋ]	‘at home’	3;05.06-3;05.27
pele	|pɪːlɪ|	[t̠ɪː**l̠**ɪ]	‘first’	3;05.13
nkapese	|ŋ̩kapeːse|	[n̩**t̠**iːl̠ɛ]	‘dress me’	3;05.13

B also realized target |p| in an accurate fashion in words which did not undergo the harmony process. We show examples of these non harmonizing words in (15) below. These words were mainly found in recorded data closer to the end of the observation period.

(15) B’s accurate production of |p| in non CH contexts

Orthography	Adult form	Child form	Gloss	Age
sepatshe	|sɪpaːt͡ʃʰɪ|	[dɪpaːt͡ʃʰɪ]	‘purse’	3;05.13
pudi	|puːdi|	[puːtɪ]/[pudi]	‘goat’	3;03.10-3-06.05
apole	|apʊːlɛ|	[ʔapʊːlɛ]	‘apple’	3;05.27
polone	|poloːnɪ|	[poloːnɪ]	‘polony’	3;06.05

Also central to our characterization of B’s CH pattern is the fact that he realized target |p| in an accurate fashion in words which do not display a coronal stop.[17] We show examples of this in (16) below.

17 B also produced labial assimilation for lateral affricates in his production of *tlhapa* |tɬha:pa| ‘bathe’, *ditlhako* |ditɬhaːkʊ| ‘shoes’ and *letlapa* |lɪtɬaːpa| ‘stone’ as [paːpa], [dipaːpʊ] and [lɪpaːpa] respectively. The same patterning was also found in W’s data. We discuss this pattern of substitution in section 3.3 below.

(16) B’s accurate production of |p|

Orthography	**Adult form**	**Child form**	**Gloss**	**Age**
popai	|pɔpaːɪ|	[pɔpaːjɪ]	‘cartoon’	3;05.06-3;06.05
papa	|paːpa|	[paːpa]	‘dad’	3;05.13
mpepu	|m̩peːpu|	[hapaːpu]	‘I want to hop on your back’	3;03.10

B’s pattern of CH is also found to optionally affect |b|, as in the following examples: *robetse* |robeːtsɪ|→[wet̠eː**ʧ**ɪ] ‘fast asleep’ (3;05.06), *kolobe* |kʊlʊːbɛ|→[tʊ**l̠**ʊːl̠ɛ] (3;06.05), *taboga* |tabʊːχa|→[**t̠**ʊl̠ʊːla] ‘run’ (3;05.13), and *ditsebe* |diʦɛːbɛ|→[di**t̠**ɛːl̠ɛ] ‘ears’ (3;05.21). However, this process was rather marginal in this context, given that most of B’s target |b| were produced accurately even in the presence of coronals within the words, as in the following examples: *bona* |bɔːna|→[bɔːna] ‘look’ (3;02.22-3;06.05); *batla* |baːt͡ɬa| →[baːt^ha]/[baːda] ‘search for something’ (3;03.22), and *base* |baːsɪ|→[baːsɪ] ‘bus’ (3;03.10).

1.1.2 W’s coronal substitution

W also produced some coronal substitutions for his target |p|, mainly to [t]. However, in contrast to B, W’s coronal substitutions were both random and marginal. For example, out of 574 attempts at |p|, W produced 38 coronal substitutions (7%). Further, W could routinely produce |p| accurately in words containing coronal consonants, as exemplified in (17). We can also see under the ‘frequency’ column in these examples the volatility of W’s coronal substitution.

(17) W's accurate production of |p|

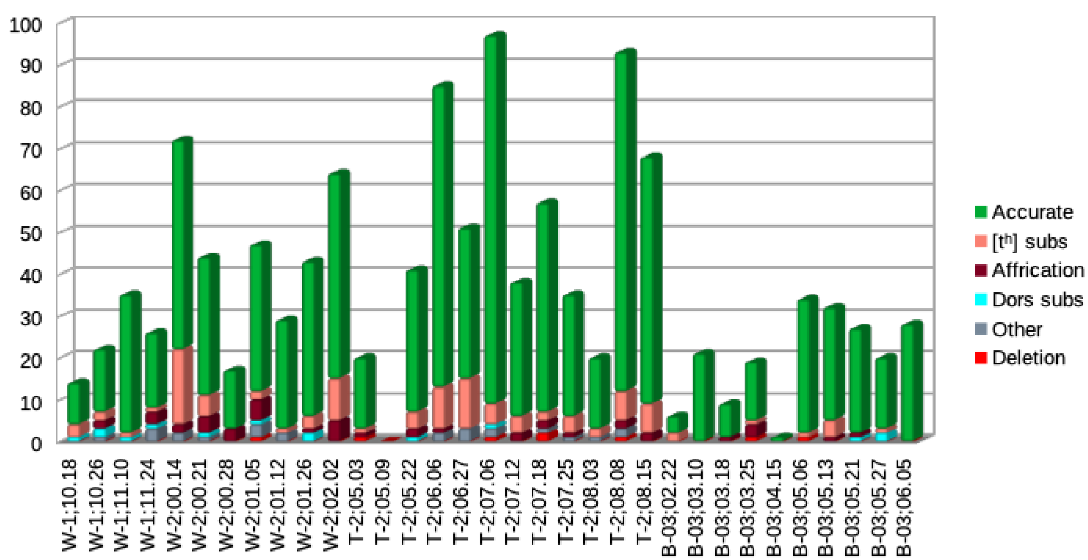
Orthography	Adult form	Child form	Gloss	Age	Frequency
pudi	|puːdi|	[puːdi]	'goat'	1;11-2;01	8/20
pene	|pɛːna|	[pɛːna]	'pen '	1;10-2;01	2/4
palama	|palaːma|	[palaːma]	'climb'	1;11-2;02	98/102
popae	|pɔpaːɪ|	[pɔpaːjɪ]	'cartoon'	1;10-1;11	55/66

In summary, only B exhibited a systematic pattern of coronal substitution for |p|, which itself was the result of consonant harmony.

1.2 Target |t| and |d|

Turning to target coronals, we can see in Figure 8 that WTB all produced coronal |t| with high rates of accuracy, alongside marginal cases of aspiration to [tʰ], affrication, dorsal substitutions and marginal processes.

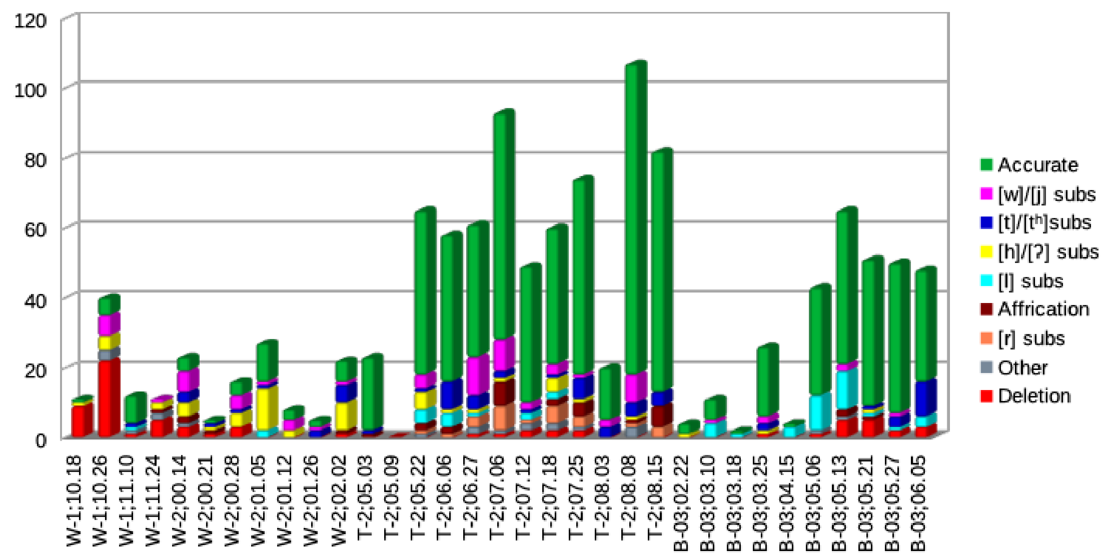
Figure 8: Target |t| for WTB



B produced the highest percentage of accurate |t| at 90% (n=177), followed by T at 85% (n= 515) and W at 78% (n=320).

WTB's productions for |d|, on the other hand, show more variability, represented in relative detail in Figure 9. Four substitution patterns are particularly noticeable in the chart. These are [w]/[j] substitution, devoicing to [t]/[tʰ], [h]/[ʔ] debuccalization, as well as [l] substitution. Deletion is also noticeable across the three datasets. However, these observations can be related to peculiar productions associated to a handful of relatively frequent word forms, some of which we discuss below.

Figure 9: Target |d| for WTB



Starting with W, his productions for target |d| mainly alternated between debuccalization to [ʔ] and substitution to [j]. W's [ʔ] productions for |d| prominently came from his production of non-human nouns with plural prefix, *di* |di| 'they' and its agreement marker, which is also *di*, as in |di|→[ʔi] (1;10 – 2;02). W also consistently produced |d| in the verb *dira* |dira| with either [ʔ] or [j] as in |dira|→[ʔiːja]; [jiːja] 'do' (1;10 – 2;02). Further, he appeared to employ the use of a proto-morpheme in his production of |d| in the same verb within a sequence, *e dira* 'it is doing' which he systematically produced as [ʔ], as in |ɪ dira|→[ʔiːja]. According to Peters (2001: 233) a proto-morpheme is an idiosyncratic free or bound morpheme or affix that can present itself phonologically as a full syllable, V or CV, in children's developmental speech. The children create and utilize this morpheme temporarily during their language development process until they have understood the morphological system at hand in more detail. Lastly, W displayed the same pattern in the sequence, *o dira* 'you'/'he/she is doing', which he produced in this fashion, |ʊ dira|→[wiːja]; [jiːja]; [ʔiːja], with [w]; [j] or [ʔ] substitution, respectively.

Just like W, T produced a noticeable amount of debuccalization and gliding, and both processes also involved the morpheme *di* (e.g. |di|→[ʔi] 'they'; 1;10.18 – 1;10.26 and the word *dira* (e.g. |diːra|→[jiːra] 'do'; 1;10.26-2;02.02). And also in line with B's pattern of gliding, T's [w] substitutions were mostly found within the sequence *o dira* |ʊ dira| 'you are or /he/she is doing' which she frequently produced as [wiːra].

T also devoiced |d| to [t]/[tʰ] in the following words, across different word positions: *ditlhako* |dit͡ɬʰaːkʊ|→[tit͡ɬʰaːkʊ] 'shoes'; *diatla* |diaːt͡ɬa|→[tiaːt͡ɬa] 'hands'; *rediwo* |rediːwɔ| →[retiːwɔ] 'radio', *dinawa* |dinaːwa|→[tinaːwa] 'beans', *diga* |diːχa|→[tʰiːχa] 'drop something', *pudi* |puːdi|→[puːtʰi] 'goat' (all produced at 2;06.06), *di* |di|→[ti] 'they' (2;06.06-2;08.08), *mosadi* |mʊsaːdi|→[mʊsaːtʰi] 'woman/lady' (2;06.06-2;08.03), *rakgadi* |raqʰaːdi|→[raqʰaːti] 'my aunt' (2;07.25), *dijo* |diːʤɔ|→[tʰiːʤɔ]/[tiːʤɔ] 'food' (2;08.03-2;08.08) and *didimatsa* |didimaːʦa|→[timeːʦa] 'quieten/calm someone down' (2;08.08). Lastly, she produced marginal cases of [r][18] and [l] substitution.

18 T's [r] substitution is only from the words *redio* |rediːɔ| and *khudu* |kʰuːdu|, which she consistently produced as [reriːwɔ] and [kʰuːru], respectively. However, she had no issues producing [r] aside from these two words.

Concerning B's cases of [l] substitution for |d|, these were mainly from his production of the word *khudu* |kʰuːdu| 'turtle' which he systematically produced as |kʰuːlu|. This word alone accounts for 28 out of B's 34 [l] substitutions for |d|. He also produced marginal devoicing in the last session.

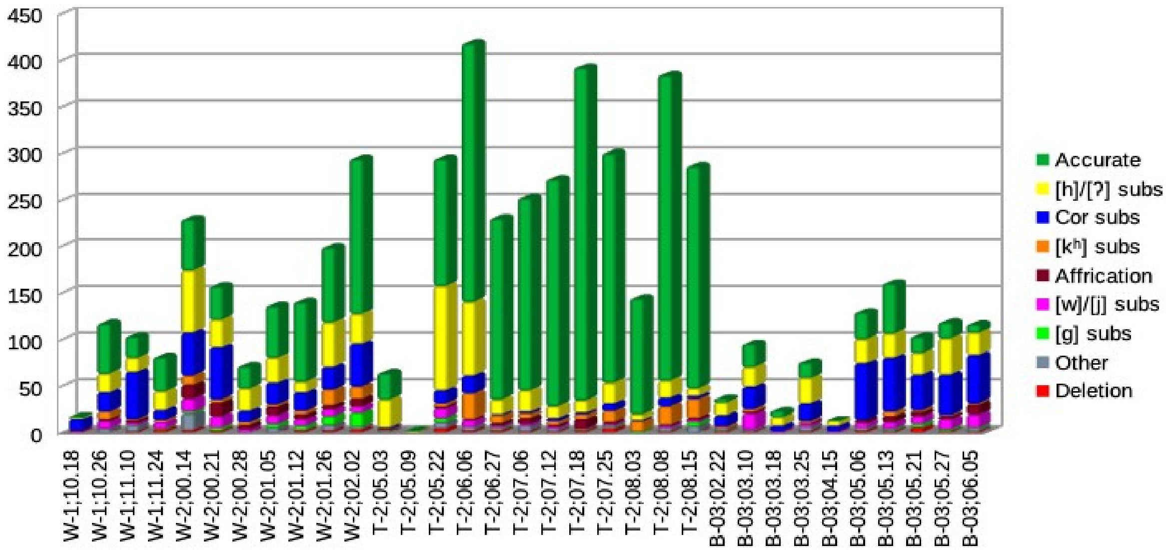
Finally, Figure 9 reveals a noticeable pattern of |d| deletion especially in the case of W. This pattern also prevalently comes from the verb *dira* |diːra|, often when it was preceded by [ʊ] or [ɪ] in a sequence (e.g. |ʊ diːra| 'you are doing; 'he or she is doing' and |ɪ diːra| 'it is doing') which all the three children produced as [wiːra] and [jiːra], respectively. This is pattern likely reflects the speech of adult speakers within these contexts. Aside from these words, WTB generally were able to produce |d| accurately at the time of their earliest recordings.

1.3 Target |k| and |qʰ|

1.3.1 General observations

Turning now to the dorsals |k| and |qʰ|, we can see first, in Figure 10, that |k| production was highly variable. The prominent substitution patterns are debuccalization to [h] or [ʔ] as well as coronal substitution, also with more marginal traces of [w]/[j] substitution.

Figure 10: Target |k| for WTB



Starting with W, he displayed coronal and laryngeal substitutions for |k| in relatively equal proportions. He also produced marginal [w]/[j] substitution. T prominently substituted her target |k| for [h] and [ʔ], in addition to marginal coronal substitution and [k] aspiration, while B prominently substituted |k| by coronals, in addition to some laryngeal substitutions and gliding to [w]/[j]. What is striking about WTB's [h]/[ʔ] substitutions is that they were found especially in the onset positions of the 1st person singular and 3rd person singular pronouns, *ke* |kɪ̀|[19] 'I' and *ke* [kɪ́] 'it is', respectively, which all three children produced interchangeably as [hɪ] or [ʔɪ]. They also produced [j] gliding in the same word position as in [jɪ] for *ke* |kɪ̀| 'I' and *ke* [kɪ́] 'it is'. This observation for [h]/[ʔ] and [j] gliding is especially true concerning W and B. Aside from this particular word, we revisit the issue of coronal substitution for W and B in the next section.

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19 *ke* |kɪ| is tonal in Setswana. It is [kɪ̀] when it means 'I' or 'I am' and [kɪ́] when it means 'he/she'.

1.3.2 W and B’s coronal substitution for target |k|

As noted above, both W and B displayed noticeable patterns of coronal substitution for |k|, exemplified by the words *tonki* |toŋ̩ː**k**i|→[toŋ̩ː**t**i] ‘donkey’, and *dikuta* |di**k**uːta| →[di**t**uːta]; [**t**uːta]. However, W’s pattern was generally random and volatile except for a few words such as the ones just mentioned.

In contrast to W, B’s coronal substitution was more robust. In fact, his patterns were two-fold: first they exhibit coronal substitution mainly to [t] in a vast majority of words systematically in CH contexts, as we show in the data in (18). Note as well that, just like B’s patterns of CH affecting |p| discussed in section 1.1.1, example (14), the harmony pattern for |k| also manifests itself in both progressive and regressive fashions.

(18) B’s |k|→[t] CH harmony

a. Single word

Orthography	**Adult form**	**Child form**	**Gloss**	**Age**
koloi	|koloːi|	[t̠o**l̠**oːji]	‘car’	3;02.22-3;05.06
reka	|rɛːka|	[**j̠**ɛːt̠a] [20]	‘buy’	3;03.10-3;05.27
jaaka	|jaːka|	[**j̠**aː**t**a]	‘mine’	3;03.10
tshoko	|ʧɔːkɔ|	[**ʧ̠**ɔːtɔ]	‘chalk’	3;03.10
yokate	|jɔkaːtɪ|	[**t̠**at̠aː**t̠**ɪ]	‘yogurt’	3;03.10
kokwanyana	|kʊkʷaɲaːna|	[t̠al̠aː**n̠**a]	‘chick’	3;04.15
khudu	|kʰuːdu|	[t̠uː**l̠**u]	‘tortoise’	3;04.15
dikuta	|dikuːta|	[**d̠**it̠uː**t̠**a]	‘motorbikes’	3;05.13-3;05.27
sekolo	|sɪkoːlo|	[t̠oː**l̠**o]	‘school’	3;05.13
kwale	|kʷaːlɛ|	[t̠aː**l̠**ɛ]	‘write’	3;05.27
tirekere	|tɪrɛkɛːrɛ|	[tɪ**j**ɛt̠ɛːlɛ]	‘tractor’	3;05.06
dikipa	|dikiːpa|	[**d̠**it̠iːtʰa]	‘t-shirts’	3;05.06

20 W’s coronal substitution for adult *reka* |rɛːka| ‘buy’ involved several coronal sounds such as in the following examples produced between age 2;05 and 2;07: [ʦɛːʦa]; [laːta];[taːtɛ]; [lɛːta]; [ʣɛːʦa]; [jɛːtɛ]; [tɛːða]. We discuss this substitution in detail later in section 6 when we discuss rhotics.

b. Two morphemes

Orthography	Adult form	Child form	Gloss	Age
ke e	|kɪːe|	[tɪːje]	‘here it is’	3;03.10-3;05.06
Ke ele	|kɪeːle|	[tɪ jeːle]	‘there it is’	3;03.10
ke a ja	|kɪaːʤa|	[taːʧa]	‘I’m eating’	3;03.25
ke jo	|kɪːjo|	[tɪːjo]	‘here he/she is’	3;05.06-3;05.27
ke je	|kɪːje|	[tɪːje]	‘here it is’	3;05.13-3;05.06
ke le	|kɪːle|	[tiːle]	‘here it is’	3;05.21

It is important to note that the adult forms in (b) are widely understood and orthographically written as disjunctive, however, Cole (1955: 160) represents them as one entity, as we show them in the examples.

Other CH contexts in B’s data involve affricates, as exemplified by the words *katse* |kaːʦɪ|→[t̠aː**ʦ̠**ɪ] *‘cat’ (3;05.27-3;06.05);* ke tse |kɪːʦe|→[ʦ̠ɪː**ʦ̠**e] ‘here they are’ (3;03); *ga keitse* |χa kɪːʦɪ|→[ʦ̠iː**ʦ̠**i] ‘I don’t know’ (3;03.10). CH is also apparent in B’s nasal consonant (ṆC) structures, as shown by the following examples*: tirinki* |*tiriŋ̩ːk*i|→[diṇːt^{h}i] ‘soda’ (3;05.21); *tonki* |toŋ̩ːki|→[**t̠**oṇːti] ‘donkey’ (3;02.22-3;06.05); *senka* |sɪŋ̩ːka|→[**t̠**ɪːt̠a] ‘search for something’ (3;05.06).

Secondly, B exhibited optional coronal substitution outside of CH contexts, hence its occurrence is not conditioned by the presence of another coronal consonant. This optional |k|→[t] alternation is exemplified by the data in example (19). The first word is a first person singular pronoun and the second one is a regular noun.

(19) Coronal substitution without CH

Orthography	Adult form	Child form	Gloss	Age
ke	|kɪ|	[dɪ]	‘it is’	3;02.22-3;06.05
buka	|buːka|	[buːta]	‘book’	3;03.18-3;06.05

It is important to note that B was also able to produce |k| accurately during the observation period both in the context of labials and coronals as examples in (20) illustrate.

(20) B's accurate production of |k|

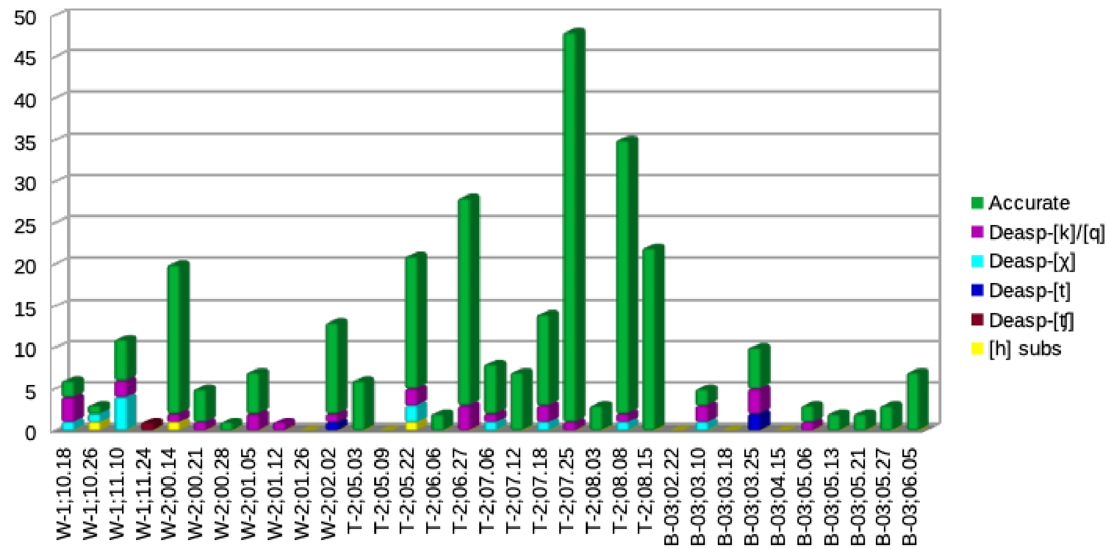
Orthography	Adult form	Child form	Gloss	Age
kae	|kaːɪ|	[kaːjɪ]	'where'	3;02.22-3;06.05
jaaka	|jaːka|	[jaːka]	'mine[21]'	3;02.22-3;06.05
koko	|kʊːkʊ|	[kʊːkʊ]	'hen'	3;02.22-3;06.05
gaaka	|χaːka|	[waːka]	'mine'	3;03.10
sekolo	|sɪkoːlo|	[sɪkoːwo]	'school'	3;03.18
koloi	|koloːi|	[koloːji]	'car'	3;03.25-3;05.06
kobo	|kʊːbɔ|	[kʊːla]	'blanket'	3;03.10

We can say that considering the data we have seen thus far for B's substitutions, [t] appears to act as B's default consonant as we have already seen in his |p| productions in Figure 6 and example (14).

Turning to |q^h|, we can see in the chart in Figure 11 below that, comparatively, this consonant was produced accurately in the vast majority of its attempts by all the children, even though it involved fewer tokens. All children also produced marginal cases of deaspiration to stops (mainly [k] and [t]) as well as [χ] for this consonant.

21 B produced |k| accurately in the following possessive pronouns: *yaaka* |jaːka|→[jaːka]; *gaaka* |χaːka| →[waːka]; *laaka* |laːka|→[laːka]; *saaka* |saːka|→|ʦaːka|; *waaka* |waːka|→[waːka]; *tsaaka* |ʦaːka| →[taːka], which all mean 'mine'. However, they are differentiated by their different concords which refer to different noun prefixes.

Figure 11: Target |qʰ| for WTB



In the next section, we summarize the general observations regarding the children's phonological development of all obstruent stops.

1.4 Summary of obstruent development

This summary, as well as all similar summaries to follow in subsequent sections, compiles the information above to the exclusion of all patterns associated with specific lexical items, in order to arrive at a working estimate of the children's patterns of phonological development. Starting with target labials |p| and |b|, all three children produced |b| with accuracy. However, the production of target |p| was more variable, especially for B, whose productions were affected by a virtually systematic pattern of coronal harmony.

Concerning the coronal stops, |t| was produced with higher accuracy by all the children, also with a mix of affrication and other marginal processes.

Lastly, concerning the dorsals, again here the only dominant pattern of substitution we found outside of idiosyncratic word forms comes from B, who displayed a systematic pattern of coronal substitution involving CH triggered by a coronal consonant already present in an adjacent syllable within the word or phrase. Aside from this, the two dorsal consonants appeared to pose little difficulties to the children.

Table 7 provides a summary of the children's significant error patterns for each sound.

Table 7: Summary of obstruent stop patterning by WTB

Phone	Main patterns	Notes
/p/	Acquired early	Consonant harmony in B's productions, caused by another coronal in the word
/b/	Acquired early	
/t/	Acquired early	
/d/	Acquired early	
/k/	Acquired early	Consonant harmony in B's productions
/qʰ/	Acquired early	

We now turn to the development of WTB's fricative productions.

2. Fricatives

In comparison to the stops above, WTB produced many variable patterns in their attempts at target fricatives. The following fricatives were attempted as part of the children's productions: /f, s, ʃ, χ, h/. The discussion of these consonants follows this order. For all current intents and purposes, the patterns we observed for target |s| and |ʃ| were comparable. As a result we merged their description in our report.[22] As we will see,

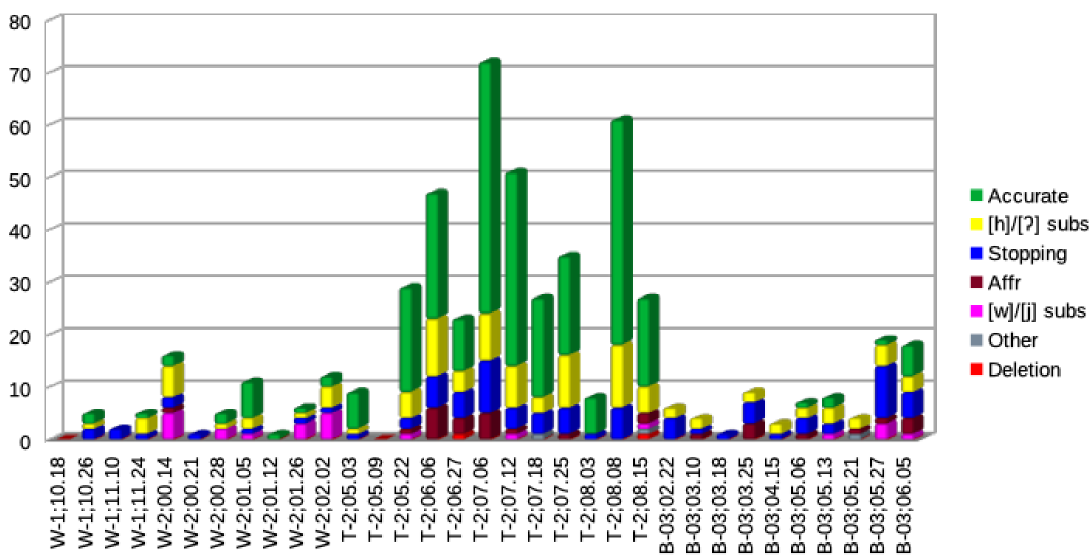
22 As highlighted in the review of the initial draft of this thesis, it would have been more useful to many readers to have kept the data separate, in particular to observe potential issues in coronal contrast

the productions of these target consonants and that of |f| yielded the largest amount of variation. |χ| and |h| were, in comparison, the least challenging fricatives.

2.1 Target |f|

We can see in Figure 12 that WTB displayed variable productions for their target |f|. W and B displayed variable and unstable patterns in their productions. T displayed more accurate productions despite her noticeable patterns of [h]/[ʔ] substitution, stopping (mainly to labial stops) and marginal affrication.

Figure 12: Target |f| for WTB



Starting with W, he produced [h]/[ʔ] and [w]/[j] substitutions as well as marginal stopping, all of which are randomly distributed in the data. We show his realizations of |f| using *futshi* |fuːtsʰɪ| and *fa* |fa| as examples in the data below in (21).

development. We agree with this statement and invite the interested reader to the original dataset, available through PhonBank (https://phon.talkbank.org/access/Other/Setswana/Matlhaku.html), from which such additional inquiries can easily be performed.

(21) W's variable attempts at target |f|

a. *futshi* |fuːtsʰɪ| 'hat'

|f| productions	Child form	Age
[f]	[vuːtsʰɪ]	2;01
[h]	[huːʧʰi]	2;01-2;02
[ʔ]	[ʔiːʧʰi]	1;11-2;01
[w]	[wuːtʰi]	1;11.24 – 2;02
[j]	[jiːʧʰi]	01;11-2;00
[t]	[tiːʧʰi]	1;11 & 2;02
[ʤ]	[ʤuːtsɪ]	2;00

b. *fa* |fa| 'here'

|f| productions	Child form	Age
[f]	[fa]	1;10.26-2;01.06
[h]	[ha]	2;00.14-2;01.05
[χ]	[χa]	2;00.14-2;01
[d]	[da]	2;00.14
[qʰ]	[qʰa]	2;00.14

Concerning the data in (21a), W made 28 attempts at *futshi* |fuːtsʰɪ|, out of which he only made one accurate production. In fact, in one of his sessions, 02;00.14, his nine attempts at target |f| variably shifted between gliding (4 [w] and 1 [j]), [ʔ] debuccalization (4) and affrication (1) whereas at age 2;02.02, he produced the same phone with [h], [w], [j] and [t] substitutions. He only made one successful accurate attempt at age 2;01.05. Concerning his production of his target |f| in the word *fa* |fa| 'here/give' in (21b), W produced |f| accurately in 3 out of his 16 attempts. The latter resulted in stopping and debuccalization.

B's productions were also variable with only a few accurate productions recorded. His productions for |f| were prominently to stops. However, this stopping was random particularly in terms of place of articulation and voicing. Firstly, B produced labial stops for |f| in the following fashion, using the word *fatshe* |faːʦʰɪ| as an example: *fatshe* |faːʦʰɪ|→[paːʦʰɪ] /[baːʦʰɪ] /[paːtɪ]/[baːdɪ] 'down' (2;05-2;08). Secondly, he produced velar stops for |f| in the following patterns: *founu* |fo.uːnu|→[kowuːnu], [koːnu], [kʰuːni], [qʰoːnu] and [qʰoːŋ̍] ‘phone’ (3;02.22-3;06.05). B also produced [h]/[ʔ] substitutions, marginal [w]/[j] gliding and affrication. Just like W, B’s [h]/[ʔ] substitutions display this variable pattern, *fa* |fa|→[ha]/[ʔa] ‘here’/‘give’ (3;02.22-3;06.05).

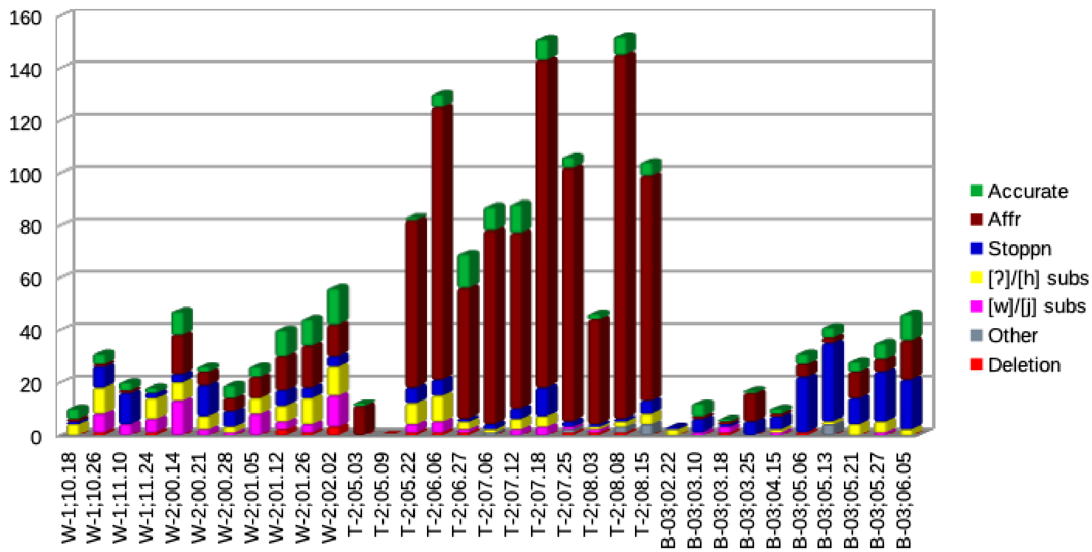
Lastly turning to T, as already established, she is the only child in the group displaying more accurate productions. Out of 389 attempts at her target |f|, she produced 251 accurate productions, or 65% of all her attempts. Her substitutions mainly involved debuccalization to [h] and her stopping was mainly to labial stops. Furthermore, T produced [ts] affrication, prevalent only in her production of the word *founu* |fouːnu| ‘phone’ displaying the following pattern: *founu* |fouːnu|→[ʦo.wuːnu] (2;05-2;07). This occurred in 15 out of her 18 attempts at this word, a lexical exception, in the sense that this is only context in which |f|→[ts] substitution is found in T’s data.

We discuss the production of target |s| next in section 2.2 below.

2.2 Target |s| and |ʃ|

Recall that the data for |s| and |ʃ| are merged. As we can see in Figure 13, these consonants were produced with the most variability in comparison to the rest of the fricatives. All the three children individually produced more errors than accurate productions: W: 20% (67 out of 337) accurate productions, B: 16% (37 out of 229), and T: 6% (66 out of 1028). The remainder of these data consists of a number of marginal substitutions.

Figure 13: Target |s| and |ʃ| for WTB



Affrication was the most prominent substitution pattern for |s| and |ʃ|, especially for T, who affricated 83% (n=857) of these consonants during the observation period, mostly to non-aspirated affricates (mainly [ʦ]) at a rate of 83%, as well as aspirated affricates at a rate of 17% (n=149). She also produced marginal stopping as well as [h]/[ʔ] substitutions.

Also relatively stable is B's patterns of substitutions, through a combination of stopping (51%; n=116), mainly to [t] and [d], and affrication (22%; n=51), mainly to [ʦ]. The remainder of his productions for |s| and |ʃ| consist of [h]/[ʔ] substitutions and gliding.

Concerning B's stopping substitutions, the majority of cases involve the coronal stops [t] and [tʰ], also in the context of another coronal consonant. We show this in the dataset in example (22).

(22) B's stopping for |s| in coronal CH contexts

Orthography	Adult form	Child form	Gloss	Age
sebene	|sɛbɛːnɛ|	[tɛlɛːnɛ]	'seven'	3;03.10
sepe	|sɪːpɛ|	[tɪːtɛ]	'nothing'	3;03.10-3;05.06
dipilisi	|dipiliːsi|	[ditiliːti]	'tablets'	3;03.25
suphu	|suːpʰu|	[tuːtʰu]	'soup'	3;03.25
sekuta	|sɪkuːta|	[ditiːta]	'motorbike'	3;03.10-3;06.05
mosadi	|mʊsaːdi|	[n̩taːdi]	'woman'	3;05.06
mosimane	|mʊsimaːnɪ|	[mitanaːnɪ]	'boy'	3;05.06-3.05.27
sele	|seːle|	[teːle]	'those'	3;05.06-3.05.27
setlhare	|sɪt͡ɬʰaːrɪ|	[ditaːla]	'tree'	3;05.06-3;06.05
sese	|sɪːsɪ|	[tʰɪːtʰɪ]	'pee'	3;03.25
sekipa	|sɪkiːpa|	[ditʰiːtʰa]	't-shirt'	3;06.05

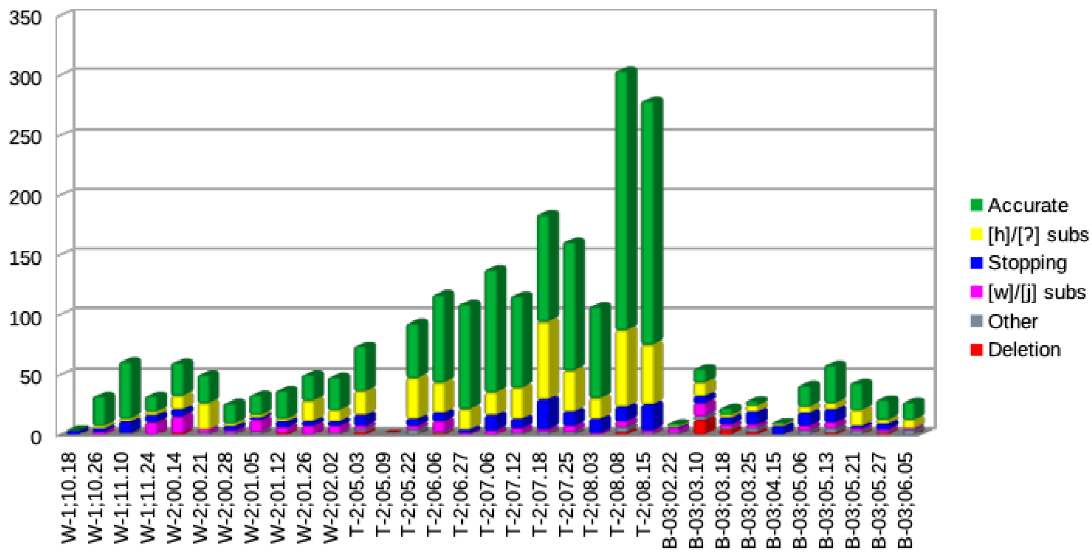
Lastly, W's productions were the most variable of all the three children. These include a mix of debuccalization to [h]/[ʔ] (21%); affrication (23%), [w]/[j] substitution (17%) and stopping (17%). His affrication was mainly to a palatal, unlike B and T.

We discuss target |χ| in the next section.

2.3 Target |χ|

The data for |χ| are presented in Figure 14 below and display a higher percentage of accurate productions than |f|, |s| and |ʃ|.

Figure 14: Target |χ| for WTB



As we can see, [h]/[ʔ] substitution was the most common substitution pattern, displayed most prominently by W and T throughout the observation period. B's attempts were the most variable, especially between ages of 3;03.10 and 3;05.13.

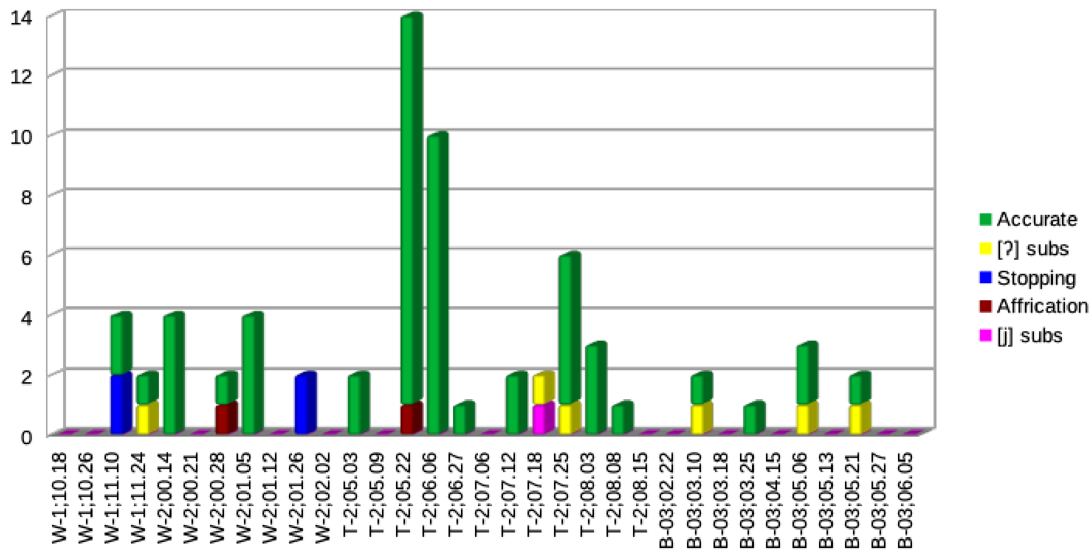
Finally, the stopping pattern displayed by WTB involved different places of articulation. For example, W and T mainly stopped |χ| to uvular [qʰ] and velar [k], while B engaged mostly in coronal and labial stopping.

2.4 Target |h|

Turning finally to |h|, this consonant just like |χ|, was produced with relatively higher accuracy than |f|, |s| and |ʃ|. Based on the few datapoints we have for this consonant, W displayed cases of stopping and his affrication was to palatal [ʧ], similar to his productions for target |s| and |ʃ| production. B and T, on the other hand, were generally accurate in producing their target |h|, with B also displaying [ʔ] substitution.[23]

23 Note that these data exclude all examples of one word used by the children to imitate a barking dog (e.g. *houhouhou* |ho.u.ho.u.ho.u|→[wo.wu.wo.wu.wo.wu]). Because this substitution is unique to this

Figure 15: Target |h| for WTB



It is important to note that none of the children substituted target |h| with [f], as opposed to what we saw in Figure 12 where |f|→[h] is one of the processes observed in the children's data.

2.5 Summary

In summary, target |f|, |s| and |ʃ| were produced with high levels of variation. Stopping was prominent in |f| production, and affrication was common for |s| and |ʃ|, specifically for T, whose affrication pattern was more stable than that of the boys. B displayed stable stopping as well as coronal harmony, mostly to [t] and [tʰ], while W was the most variable. Concerning |χ| and |h|, the children displayed laryngeal substitutions alongside marginal stopping, gliding and affrication.

Table 8 provides a summary of the children's most noticeable error patterns for each fricative.

word, and given its onomatopoeic nature, we excluded it from our results.

Table 8: Summary of fricatives patterning by WTB

Phone	Main patterns	Notes
/f/	Acquired later	[h]/[ʔ] substitutions and stopping
/s/	Acquired late	Stable affrication for T Stable stopping for B Coronal CH for target |s| by B
/χ/	Acquired early	
/h/	Acquired early	

I move the description to affricates, in the next section.

3. Affricates

Affricates consist of a combination a stop closure and a fricative release at the same place of articulation (Ladefoged & Maddieson 1996). As already established in Chapter 1, section 2.1.2, Setswana displays several affricates, including both non-lateral affricates /ʦ, ʦʰ, ʤ, ʧ, ʧʰ/ and lateral affricates /tɬʰ, tɬ/. We begin our description with the non-lateral affricates, followed by the lateral ones. As we will see, deafffrication is prominent for all the affricates in WTB's data. In order to further specify this general observation, we begin each section below with an overview of deaffrication patterns for each target phone.

3.1 Non-lateral affricates

In the description to follow, we omit the data for the production of |ʧ|, due to the fact that WTB only produced it within the context of a nasal+consonant sequence (/N̩C/) where is was preceded by a syllabic homorganic nasal predominantly within a single word, *ntsa* |ɲ̩ʧa| 'dog'.

3.1.1 Overview of deaffrication for target |ʦ, ʦ^{h}, ʤ, ʧ^{h}|

We begin with an overview of the rates of deaffrication for each child. Deaffrication implies that the target affricate is produced as something other than an affricate, while accurate production in this section generally refers to an "affricate" production, even if it is not produced with its exact place of articulation or voicing features.

We can see in Figure 16 that W produced aspirated affricates, |ʧ^{h}| and |ʦ^{h}|, with higher accuracy rates than the unaspirated ones. His pattern of deaffrication is most prominent for the plain affricate |ʤ|, with a 69% (n=40) deaffrication rate, while his production of |ʦ| displayed a 48% (n=183) deaffrication rate. Just like W, B prominently deaffricated both |ʦ| and |ʤ|, with 62% (n=126) and 42 % (n=31) deaffrication rates, respectively.

Figure 16: |ʦ, ʦ^{h}, ʧ^{h}, ʤ| deaffrication by W

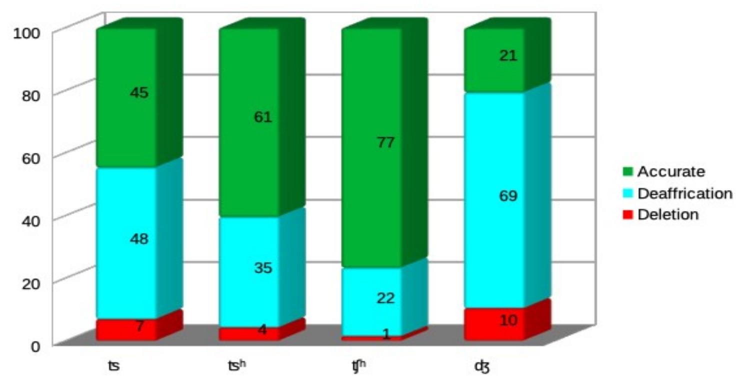
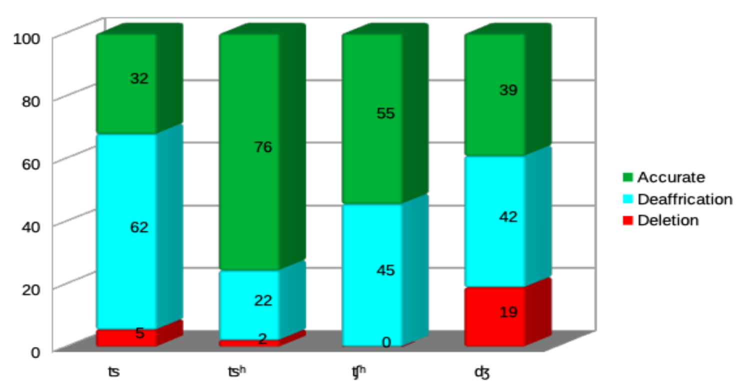
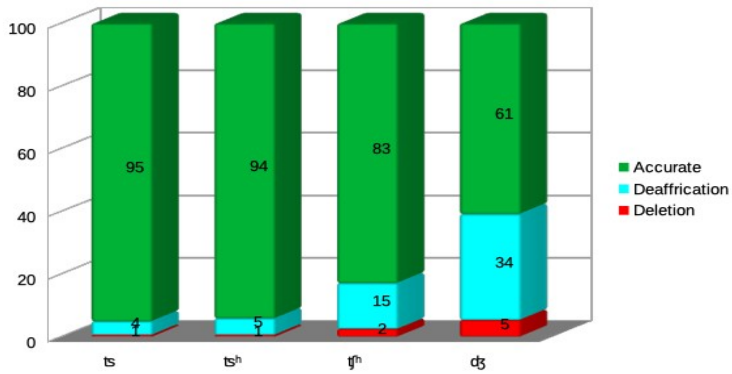


Figure 17: |ʦ, ʦ^{h}, ʧ^{h}, ʤ| deaffrication by B



In comparison to W and B, T more consistently produced affricates. This is shown in Figure 18. She deaffricated |ʤ| the most, compared to the remainder of the affricates.

Figure 18: |ʦ, ʦʰ, ʧʰ, ʤ| deaffrication by T

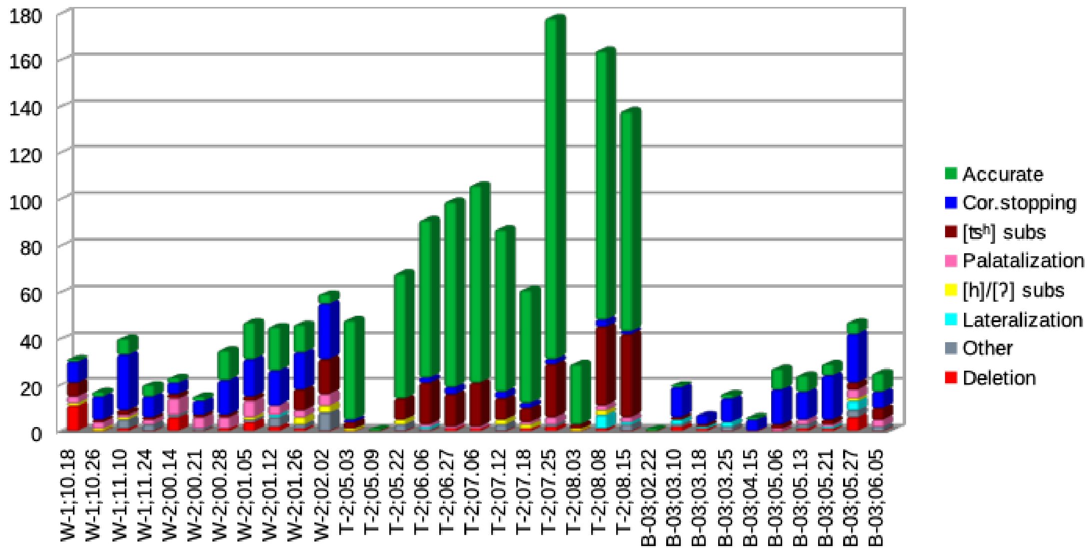


As we can see from these comparisons, no clear trend emerges concerning what affricates the children were more or less proficient with. In light of this variation, we now turn to a consideration of other patterns in more detail.

3.1.2 Target |ʦ|

We can see in Figure 19 that deaffrication to mainly coronal stops is prominent for target |ʦ|. The chart also highlights other processes, such as aspiration and palatalization, which are not related to deaffrication. T displayed the highest accuracy for |ʦ|, at a 78% rate (n=834), while W and B displayed accuracy rates of only 19% (n=39) and 22% (n=83), respectively.

Figure 19: Target |ʦ| for WTB



Alveolar stopping, mainly to [t] and [tʰ], was prominent in W's and B's productions. B displayed an 84% deaffrication rate (n= 91). We illustrate B's |ʦ| productions as coronal stops in (23) below.

(23) B's |ʦ| deaffricated to [t]

Orthography	**Adult form**	**Child form**	**Gloss**	**Age**
tsere	|ʦeːrɪ|	[teːðɪ]	'took'	3;03.10
tsaya	|ʦaːja|	[taː]/[taːja]	'take'	3;03.10-3;05.27
tsena	|ʦɛːna|	[tɛːna]	'come in'	3;03.18
tsaga	|ʦaːχa|	[taː]/[taːha]	'belong to'	3;03.10-3;05.27
reetsa	|reːʦa|	[taːta]	'listen'	3.03.25
tsele	|ʦeːle|	[teːle]	'those ones'	3;05.06-3;05.27
tsee	|ʦɛː|	[tɛː]	'take'	3;05.06-3;06.05
metsi	|meːʦi|	[meːti]/[meːtʰi]	'water'	3;03.25-3;05.27
tsene	|ʦɛːnɪ|	[tɛːnɪ]	'arrived'	3;05.06-3;05.27
tsaaka	|ʦaːka|	[taːka]	'mine'	3.05.25

Similarly, W, in comparison, deaffricated |ʦ| to [t] at a rate of 72%(n=111), as shown in (24). He also palatalized |ʦ| during the observation period, as he produced 20 of the 21 cases of palatalization to |ʧ| found in the overall corpus.

(24) W's |ʦ| deaffricated to [t]

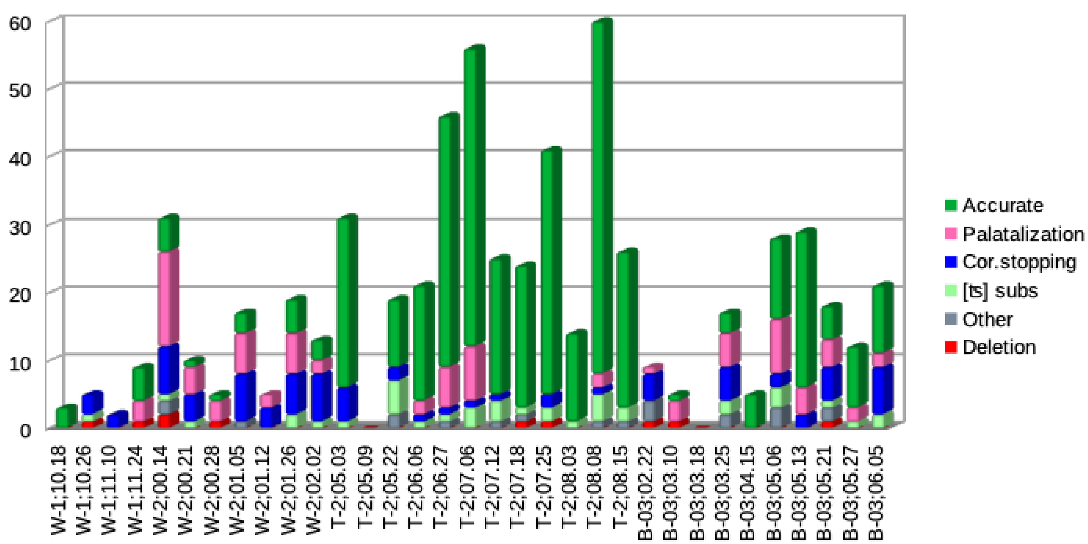
Orthography	Adult form	Child form	Gloss	Age
robetse	|robeːʦɪ|	[jeːtʰɪ]/[jojeːtɪ]	'asleep'	1;10-2;01.26
tsamaya	|ʦamaːja|	[tamaː]	'leave/go'	1;10-2;02.02
tsena	|ʦɛːna|	[tɪːna]/[tɛːja]	'enter'	1;10-2;01.05
metsing	|meʦiːŋ|	[netiːŋ]/[jetiːŋ]	'in the water'	1;10-2;01.26
tsaya	|ʦaːja|	[taː]	'take'	1;10-2;02.02
tsame	|ʦaːme|	[taːme]/[taːnʊ]	'mine'	1;11- 2;02.02
pitsi	|piːʦɪ|	[tiːti]	'horse'	1;11.10
katse	|kaːʦɪ|	[taːti]	'cat'	1;11-2;01.26
tsoga	|ʦʊːχa|	[tʊːχa]	'wake up'	1;11.24
tsile	|ʦiːle|	[tiːje]	'came'	2;00.14
bitsa	|biːʦa|	[jiːta]	'call someone'	2;00-2;02.02
tsaaka	|ʦaːka|	[taːka]	'mine'	2;01.26
kgweetsa	|qʰʷeːʦa|	[geːta]/[veːta]	'drive'	2;02.02
tsididi	|ʦidiːdi|	[teːtʰi]	'cold'	2;02.02

Lastly, T produced target |ʦ| with the highest level of accuracy with aspiration to [ʦʰ] as a noticeable process.

3.1.3 Target |ʦʰ|

The children's productions of target |ʦʰ| are shown in Figure 20.

Figure 20: Target |ʦʰ| for WTB



W was the least accurate in his productions of target |ʦʰ|, at 22% (n=26). He displayed coronal stopping (i.e., [t] and [tʰ]) at a rate of 33% (n=39) and palatalization at a rate of 34% (n=40). He also displays marginal substitution to [ʦ].

B’s attempts at target |ʦʰ| also fluctuated between coronal stopping (i.e., [t], [tʰ] and [d]), palatalization as well as substitution to [ʦ]. B was however more accurate than W, at 47% (n=68). B’s stopping[24] is exemplified in (25).

(25) B’s deaffrication of |ʦʰ|

Orthography	**Adult form**	**Child form**	**Gloss**	**Age**
fatshe	|faːʦʰɪ|	[baːdɪ]/[paːtɪ]	‘down’	3;02.22-3;06.05
tshaba	|ʦʰaːba|	[taːna]	‘be scared’	3;02.22-3.03.25
ditsha	|diːʦʰa|	[diːta]	‘plots of land’	3.03.25
tshega	|ʦʰɛːχa	[tʰaːla]	‘laugh’	3;05.06
tshuba	|ʦʰuːba|	[tiːle]	‘switch on something’	3;05.25
tshameka	|ʦʰamɪːka|	[taːda]	‘play’	3;06.05
tshuswane	|ʦʰʊsʷaːnɪ|	[tʰaʃaːnɪ]	‘ant’	3;06.05

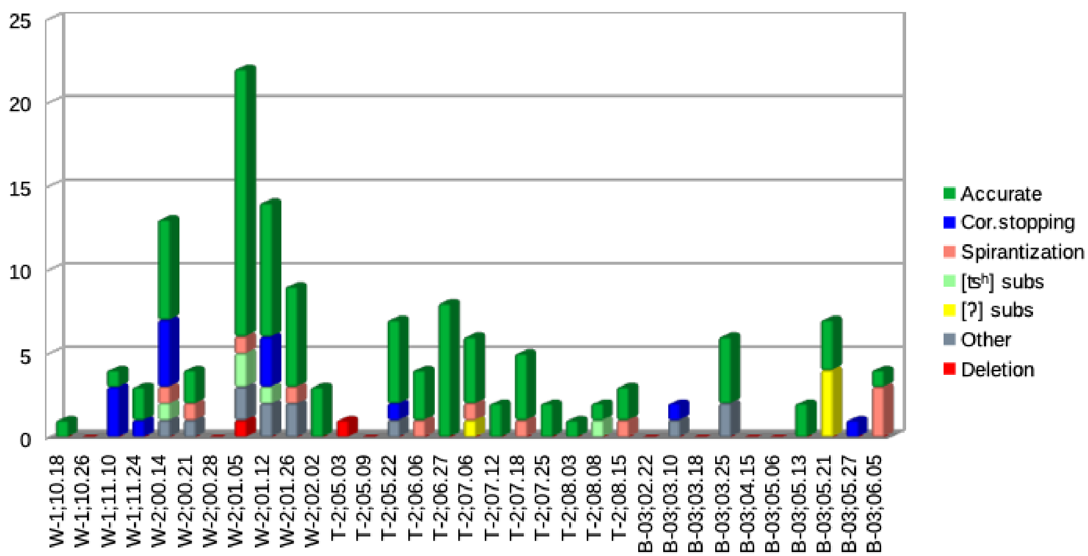
Lastly, T produced /ʦʰ/ more accurately than W and B at 82% (n=298). She displayed marginal cases of palatalization, deaspiration and stopping.

3.1.4 Target |ʧʰ|

WTB attempted fewer cases of |ʧʰ| in comparison to the other affricates we have described so far. This is shown in Figure 21 where gaps, especially for B and W, imply that the sound was not attempted during those recording sessions.

24 B’s coronal stopping also extends to his production of N̩C sequences in words such as *ntshutlhe* |n̩tsʰutɬʰɛ|→[n̩tiːða]/[n̩tiːla] ‘wipe me’; *bontsha* |bɔn̩ːtsʰa|→[baːda]/[baːta] ‘show someone something’; *mpontshe* |m̩pɔn̩ːtsʰɛ|→[ʔɪbɔːtʰa] ‘show me’.

Figure 21: Target |ʧ^{h}| for WTB



In spite of this relative dearth of data, we can make the following observations: W produced |ʧ^{h}| with an accuracy rate of 54% (n=73). He displayed coronal stopping, mainly to [t^{h}], between 1;11.10 and 2;01.12. We also note a palatalization versus depalatalization asymmetry in W's data: his palatalization of |ʦ^{h}| and |ʦ|, noted in the preceding sections, was more prevalent than his depalatalization of |ʧ^{h}|.

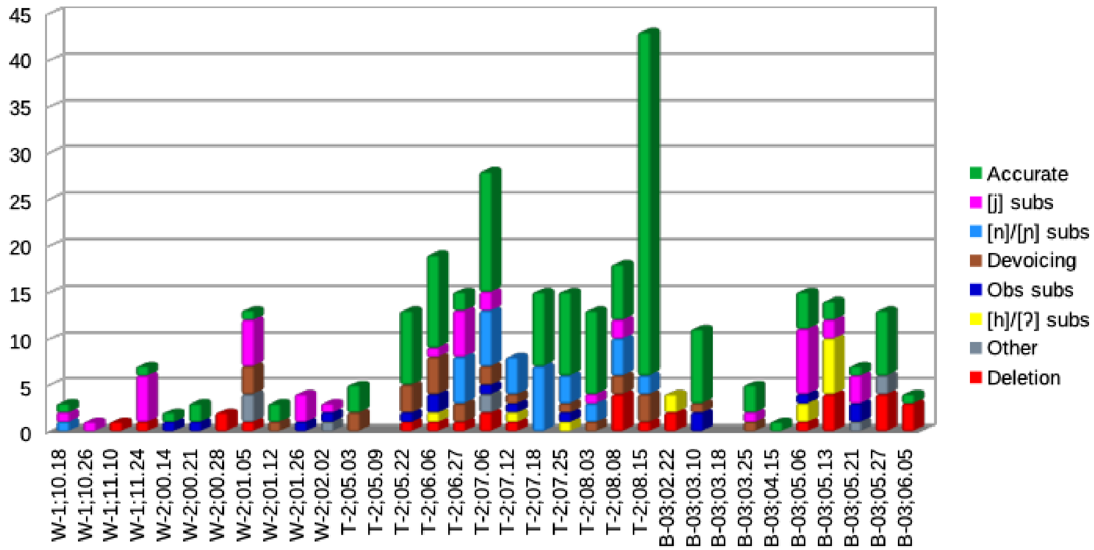
B attempted the fewest number of |ʧ^{h}|, with 22 tokens in total, out of which he achieved 10 accurate productions. Errors included debuccalization to a glottal stop as well as depalatalization to [ʦ], stopping and spirantization.

T also attempted few cases of |ʧ^{h}|, however with the highest percentage of accurate productions (78%; n=32) in comparison to W and B.

3.1.5 Target |ʤ|

As we can see in Figure 22, WTB as a group produced the voiced affricate |ʤ| very variably. The prominent patterns are of nasal substitution, more specific to T, as well as gliding to [j] and devoicing. Devoicing was to [ʧ], [ʦ] or [ʦ^h]. The children also produced marginal stopping, debuccalization to [h]/[ʔ] and other random processes, in addition to a few cases of deletion.

Figure 22: Target |ʤ| for WTB



W and B were most variable in their productions of target |ʤ|. W displayed a combination of gliding to [j], devoicing and stopping while B's substitution patterns included gliding to [j], debuccalization to [h]/[ʔ] and marginal stopping. Gliding to [j] was commonly found in the initial position of the following words: *jaanong* |ʤanʊːŋ̩|→[janʊːŋ̩] 'now/and then', *jaana* |ʤaːna|→[jaːna] 'like this', *jang* |ʤaːŋ̩|→[jaːŋ̩] 'how'.

T, on the other hand, displayed substantial nasal substitution, followed by gliding to [j] and devoicing. Her pattern of nasal substitution took place in the context of nasal harmony: *jaanong* |ʤanʊːŋ̩|→[nanʊːŋ̩]/[ɲanʊːŋ̩] 'now/and then' (2;06.27- 2;08.15) and *jaana* |ʤaːna|→[naːna] 'like this' (2;06.27 – 2;08.15). T also produced random cases of devoicing of |ʤ| to [ʧ^h].

3.2 Summary

In summary, the non-lateral affricates were produced with less accuracy than the obstruent stops. The most prominent substitution pattern was deaffrication, mostly in the form of stopping. WTB produced the alveo-palatal |ʧʰ| and |ʤ| with more variability than the alveolar |ʦ| and |ʦʰ|. |ʤ| was produced with the least accuracy.

Table 9 summarizes the prominent patterns for each affricate sound discussed.

Table 9: Prominent processes for affricates

Phone	Main patterns	Notes
/ʦ/	Acquired early	Deaffrication for W and B Alveolar stopping for B and W Aspiration for T
/ʦʰ/	Acquired early	Deaffrication for W and B Palatalization and stopping for W Stopping for B
/ʧʰ/	Acquired early	Deaffrication for B
/ʤ/	Acquired later	Deaffrication for WTB Nasal substitution for T Gliding to [j] for W and B Devoicing for W and T

We now move on to the target lateral affricates /t͡ɬ/ and /t͡ɬʰ/.

3.3 Lateral affricates

Similar to what we saw with the non-lateral affricates, WTB displayed substantial deaffrication of their target lateral affricates. They also displayed marginal patterns of debuccalization. Following the presentation of our data for the non-lateral affricates, we begin with a general overview of the children's deaffrication patterns before we detail the productions of each affricate.

3.3.1 Overview of deaffrication for target |t͡ɬ| and |t͡ɬʰ|

As shown in Figure 23 and Figure 24, W and B deaffricated |t͡ɬ| and |t͡ɬʰ| at generally similar rates. W displayed a 78% deaffrication rate for both |t͡ɬ| (n=66) and |t͡ɬʰ| (n=200). B, on the other hand, produced |t͡ɬ| at 79% rate (n=129), and at a 90% rate for |t͡ɬʰ| (n=45).

Figure 23: Target |t͡ɬ| and |t͡ɬʰ| for W

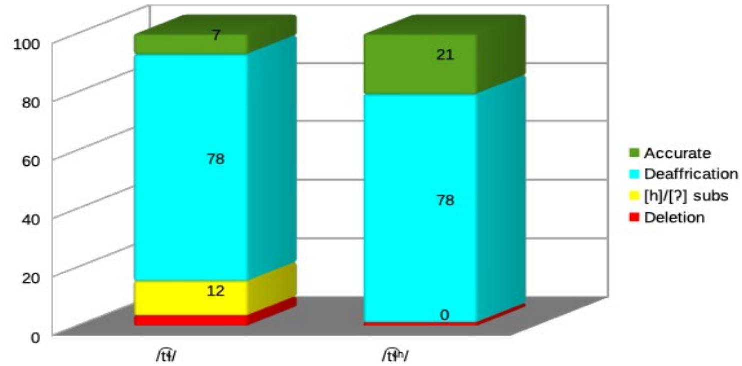
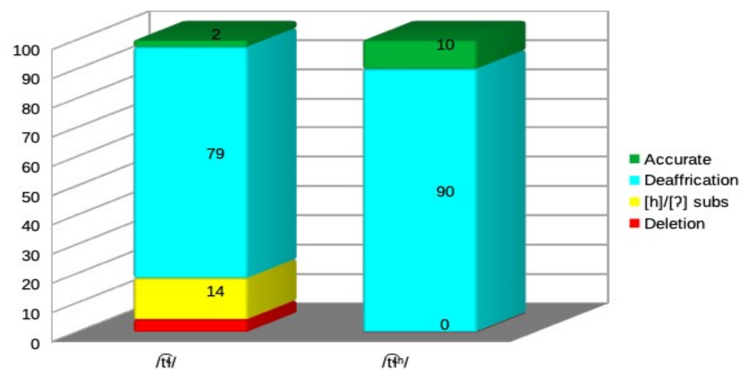
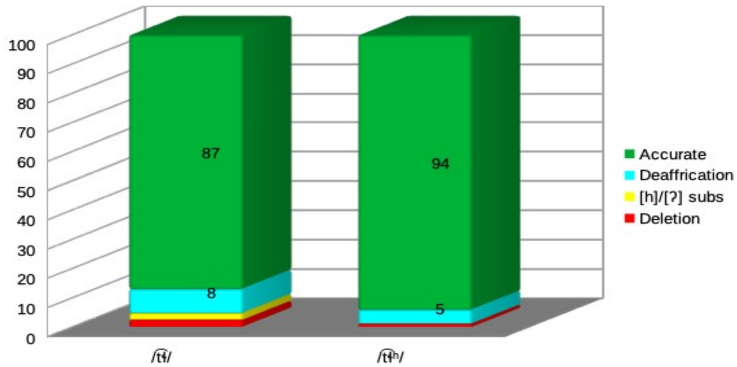


Figure 24: Target |t͡ɬ| and |t͡ɬʰ| for B



In comparison, T produced target |t͡ɬ| in 87% (n=476) and |t͡ɬʰ| in 94% (n=337) of her attempts, as we can see in Figure 23.

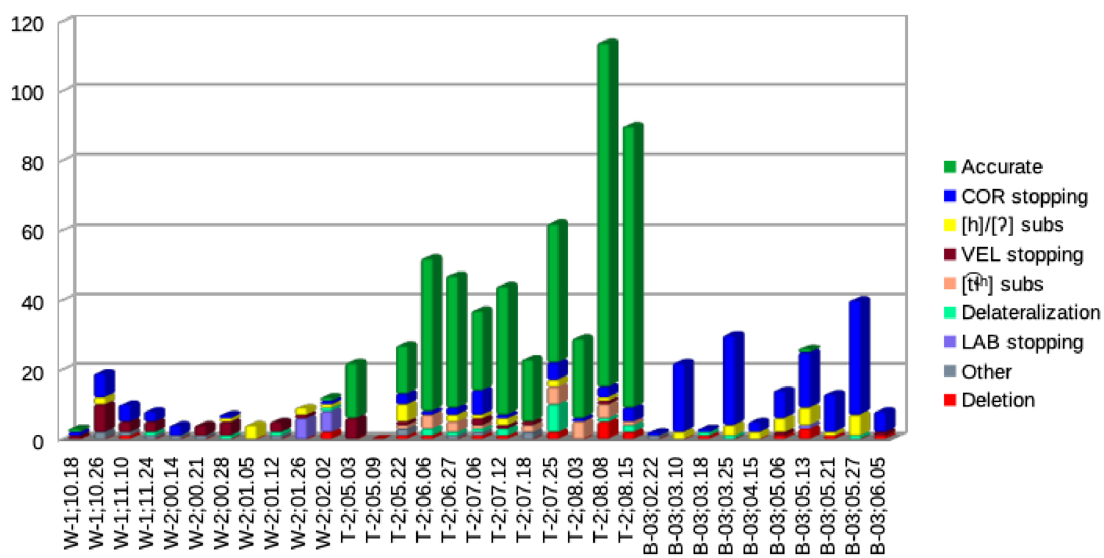
Figure 25: Target |t͡ɬ| and |t͡ɬʰ| for T (general picture)



3.3.2 Target |t͡ɬ|

As we can see in Figure 26, WTB produced their target |t͡ɬ| very variably, especially in the case of W and B. Delateralization in these data implies the production of a non-lateral affricate.

Figure 26: Target |t͡ɬ| for WTB (detailed picture)



Starting with W, he only made a few attempts at |t͡ɬ|, with a total of 85 productions. In spite of the small amount of data, we can see that W displayed prominent stopping of this affricate, at a rate of 73% (n=62), across various places of articulation. This includes velar stopping (i.e., /t͡ɬ/→[k]), the majority outcome, at 31% (n=26), which he produced independent of any other consonant within the word in these words (e.g. *tlaya* |t͡ɬaːja| →[kàːja] 'come', *tlola* |t͡ɬʊːla|→[kʊːla] 'jump', |t͡ɬaːla|→[káːja] 'hunger'). W also deaffricated target |t͡ɬ| to coronal stops in the context of other coronal stops in the words (e.g. *mmutla* |m̩muːt͡ɬa|→[n̩nɛːta] 'rabbit', *tlogela* |t͡ɬʊχɛːla|→[tʊχɛːla] 'let go', and *tliliniking* |t͡ɬilinikiːŋ̩| →[tikiːŋ̩] 'to/at the clinic'). His deaffrication of |t͡ɬ| in the context of a labial stop involved a single word: *letlapa* |lɪt͡ɬaːpa|→[taːba] 'stone'.

B produced |t͡ɬ| accurately only once out of 163 attempts. In contrast to W, however, his stopping was stable and predominantly to coronal stops, at 77% (n=125). He also produced [h]/[ʔ] substitution and marginal delateralization. The data in (26) shows B's coronal stopping for target |t͡ɬ|.

(26) B's |t͡ɬ| substitutions to coronal stops in both coronal and non-coronal contexts

Orthography	**Adult form**	**Child form**	**Gloss**	**Age**
batla	|baːt͡ɬa|	[baːta]/[baːda]	'search for something'	3;02.22-3;06.05
lebotlolo	|lɪbɔt͡ɬɔːlɔ|	[lɪbɔtɪːlɪ]	'bottle'	3;05.06-3;05.27
mmutla	|m̩muːt͡ɬa|	[m̩muːtʰa]	'rabbit'	3;05.13-3;06.05
batle	|baːt͡ɬɪ|	[baːdɪ]	'don't want'	3;05.25-3;06.05
tlela	|t͡ɬɛːla|	[tɪːla]	'deliver something for someone'	3;05.27

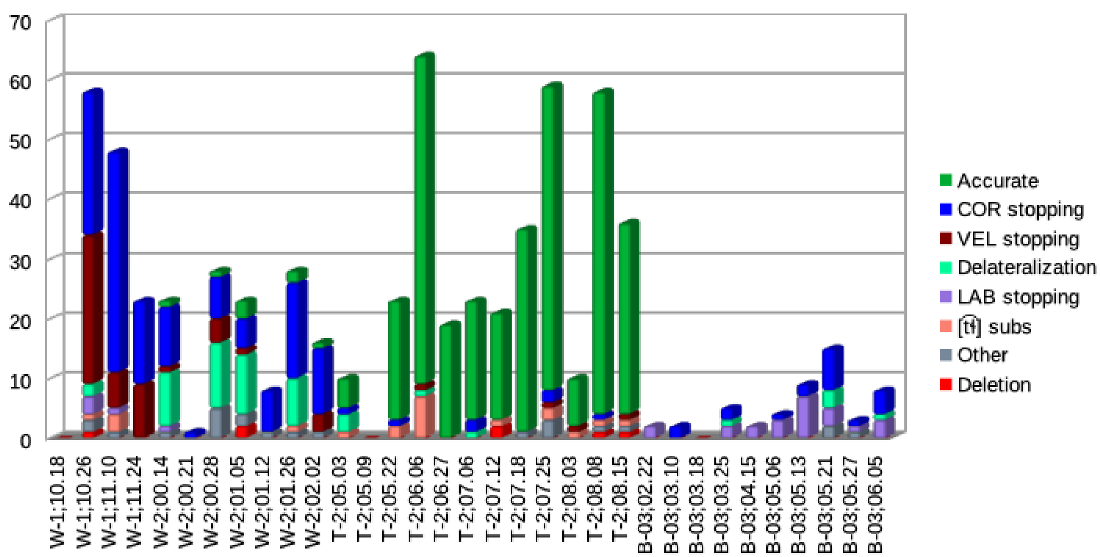
Note that the lack of velar outcomes is in line with B's overall tendency to avoid producing consonants at that place of articulation, as we saw already in sections 1.1.1, 1.3 and 3.1.2.

Lastly, T's production of /t͡ɬ/ showed the highest degree of accuracy at 79% (n=433). She also displayed marginal coronal stopping, aspiration and delateralization, especially to [t͡s].

3.3.3 Target |t͡ɬ^{h}|

We illustrate the productions of WTB's |t͡ɬ^{h}| in Figure 27 below. As we can see, the children's patterns are generally similar to that for target |t͡ɬ|, some of which in higher proportions.

Figure 27: Target |t͡ɬ^{h}| for WTB



W prominently displayed deaffrication to a combination of coronal stop substitutions (i.e., [t], [t^{h}] and [d]) at a 52% rate (n=152) as well as a 19% rate (n=49) velar stopping (i.e., [k] and [t^{h}]), a pattern which evolved into mostly coronal stopping later during the observation period. Examples are provided in (27); note that the two substitutions appear to take place independent of the other consonants present within the word.

(27) W's deaffrication patterns for |t͡ɬʰ|

a. To coronal stops

Orthography	**Adult form**	**Child form**	**Gloss**	**Age**
tlhapa	|t͡ɬʰaːpa|	[tʰaːpa]	'bathe'	1;10-1;11
botlhoko	|bʊt͡ɬʰʊːkʊ|	[tʊːkʊ]	'painful'	1;11
tlhogo	|t͡ɬʰɔːχɔ|	[tʰɔːχɔ]	'head'	2;02
setlhako	|sɪt͡ɬʰaːkʊ|	[tʰaːkʊ]	'shoe'	2;02

b. To velar stops

Orthography	**Adult form**	**Child form**	**Gloss**	**Age**
setlhare	|sɪt͡ɬʰaːrɪ|	[kʰaːjɪ];[kaːlɪ]	'tree'	1;10
tlhapa	|t͡ɬʰaːpa|	[kʰaːpa]/[kaːpa]	'bathe'	1;10-1;11
setlhako	|sɪt͡ɬʰaːkʊ|	[kaːkʊ]	'shoe'	1;10-2;01
tlhogo	|t͡ɬʰɔːχɔ|	[kʰɔːχɔ]	'head'	2;02

Note as well that W's delateralized affricates were produced mostly as alveo-palatals in line with his tendency towards posterior palatal affricates noted in sections 3.1.2 and 3.1.3 above.

Concerning B, we can see that he substituted his target |t͡ɬʰ| substantially with labial stops at a 46% (n=23) rate. B's labial stopping[25] was mainly to [p], and took place exclusively as a result of consonant harmony in the following words: *ditlhako* |dit͡ɬʰaːkʊ| →[dipaːpʊ]/[dipʰaːpʰʊ] 'shoes' (3;03.22-3;06.05) and *tlhapa* |t͡ɬʰaːpa|→[paːpa] 'bathe' (3;03.25-3;06.05). Note that this particular harmony pattern is exclusive only to these words in B's data. However, we already know B's tendency to assimilate target consonants with places of articulation other than alveolar to the place of articulation of a surrounding consonant within the word. In contexts involving other consonants, B substituted |t͡ɬʰ| for a coronal stop, as exemplified in (28). This accounts for 38% (n=19) of B's attempts at |t͡ɬʰ|.

25 B also displayed labial consonant harmony in his production of *letlapa* |lɪt͡ɬaːpa|→[lɪpaːpa] 'stone'.

(28) B's |t͡ɬʰ| substitutions to coronal stops

Orthography	Adult form	Child form	Gloss	Age
fitlha	|fiːt͡ɬʰa|	[ʧiːta]/[hiːtʰa]	'hide something'	3;03.10-3;02.25
tlhe	|t͡ɬʰɛ|	[tɛ]	'please'	3;03.10-3.05.25
setlhare	|sɪt͡ɬʰaːrɪ|	[ditaːla]	'tree'	3;05.06-3.06.05
latlha	|laːt͡ɬʰa|	[haːta]	'throw away'	3;05.13
leitlho	|le.iːt͡ɬʰɔ|	[diːtʰɔ]	'eye'	3.05.25
ditlhogo	|dit͡ɬʰɔːχɔ|	[ditɔːlɔ]	'heads'	3;05.27

3.4 Summary

To summarize our description of lateral affricates, we have seen that WTB produced both |t͡ɬ| and |t͡ɬʰ| with deaffrication, similar to the non-lateral affricates. W's productions evolved from velar to coronal stopping. B's substitutions were mainly to coronals or influenced by consonant harmony. T mostly displayed accurate |t͡ɬ| and |t͡ɬʰ| productions.

Table 10 summarizes the prominent patterns for each lateral affricate sound discussed.

Table 10: Prominent processes for |t͡ɬ| and |t͡ɬʰ|

Phone	Main patterns	Notes
/t͡ɬ/	Acquired later	Deaffrication Coronal stopping for B Velar stopping for W
/t͡ɬʰ/	Acquired later	Deaffrication Coronal stopping for W Labial CH harmony for B Delateralization for W

In the next section we discuss the children's development of nasal stops.

4. Nasal stops

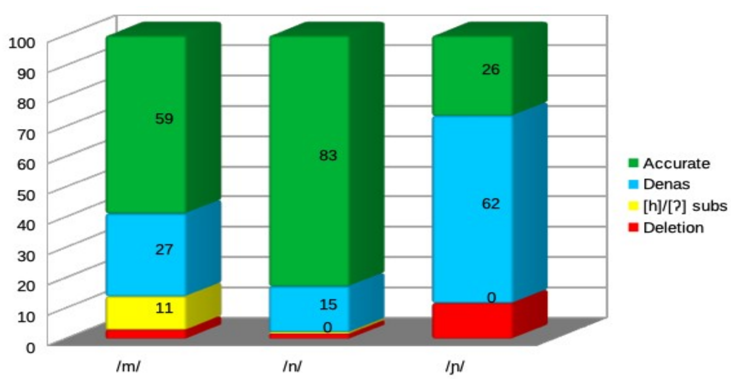
As stated earlier, the Setswana nasals comprise the /m, n, ɲ, ŋ/ series of consonants. Note that /ŋ/ is excluded from this discussion due to the fact that it is represented in very little data, with a total of 13 tokens for all three children combined. As we will see in this section, all nasals were generally produced large degrees of accuracy by WTB. We begin with an overview of the rates of denasalization for each child.

4.1.1 Overview of denasalization for target |m, n, ɲ|

In this section, denasalization implies that the target nasal is produced as something other than a nasal, while accurate production means that the sound is either produced accurately or as another nasal (i.e., /m/→[nasal]).

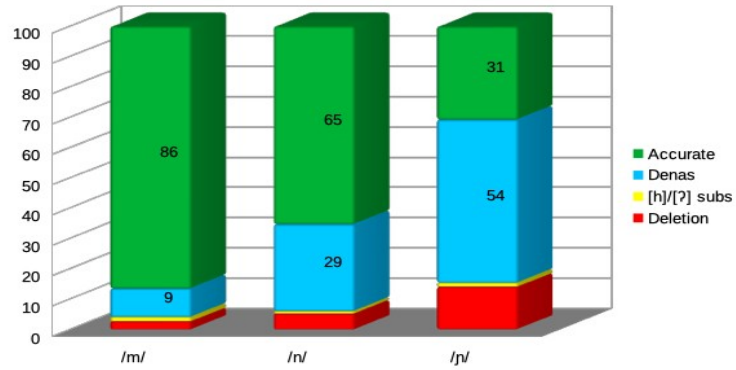
As we can see in Figure 28 and Figure 29 below, W and B display higher denasalization rates for /ɲ/, at 62% (21 out of 34 attempts) for W, and 54% (42 out of 78 attempts) for B. Concerning target |m| and |n|, W denasalized |m| in 212 out of 780 attempts (27%), and denasalized |n| in 218 out of 1142 attempts (15%).

Figure 28: |m, n, ɲ| denasalization by W



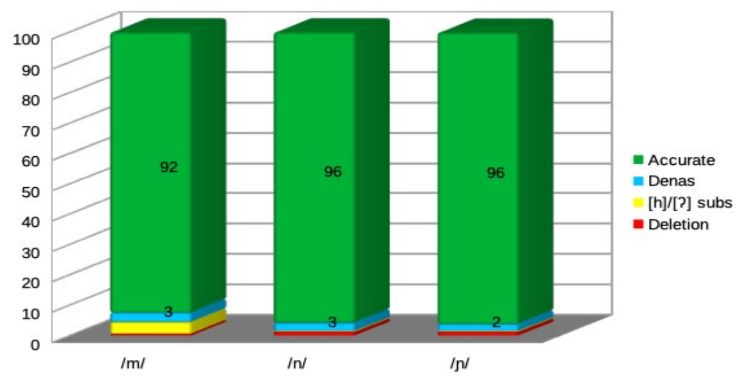
Similarly, B displayed lower rates of |m| and |n| denasalization, at 29% (180 out of 628 tokens) for |m| and 9% (57 out of 606 attempts) for |n|.

Figure 29:Target |m, n, ɲ| denasalization for B



In comparison, T's denasalization, seen in Figure 30, was much less prominent. Out of a total of 4537 attempts at target |m, n, ɲ|, she displayed denasalization rates of less than 10% overall.

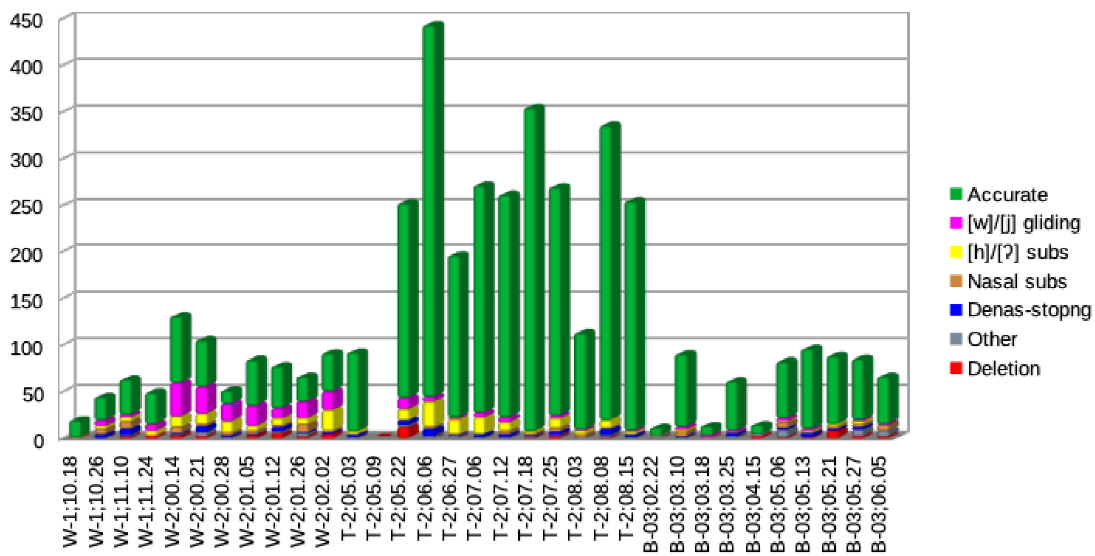
Figure 30: Target |m, n, ɲ| denasalization for T



4.2 Target |m|

As already stated, WTB displayed high levels of accuracy for target |m|. We see in Figure 31 that T produced the highest number of accurate outcomes for |m| at 92% (n=2840), followed by B's outcomes at 82% (n=496) and W at 53% (n=413).

Figure 31: Target |m| for WTB

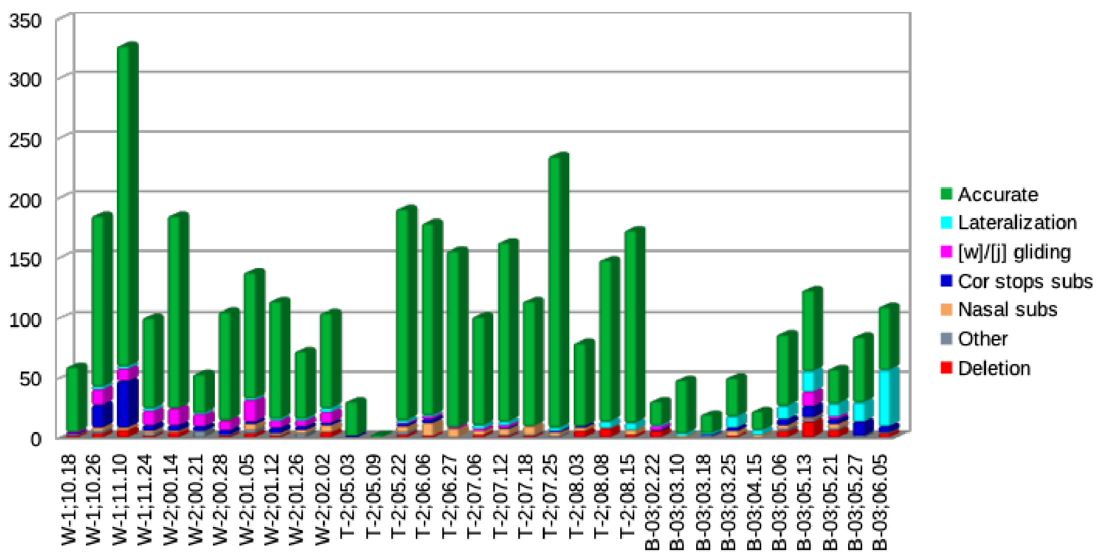


W glided his |m| mostly to [j] in 22% (n=171) of his attempts. This gliding pattern, which tended to occur in consonant harmony contexts, was found prominently in the following words: *mosimane* |**m**ʊsimaːnɪ|→[**j**iʧi.aːnɪ] 'boy'; *mosese* |**m**ʊsɪːsɪ|→[**j**ɪʃɪʃɪ] 'dress'; *metsing* |meʦiːŋ̩|→[**j**iʧiŋ̩] 'in the water'; *palama* |palama|→[pana**j**a]/[paja**j**a] 'climb onto something' and *tshameka* |ʦʰa**m**ɪka|→[tɪ**j**ɪka] 'play'.

4.3 Target |n|

WTB also produced target |n| with high accuracy, as can be seen in Figure 32. T displayed higher accuracy rates of 93% (n=1456), followed by W and B, who displayed accuracy rates of 81% (n=1169) and 63% (n=395), respectively. W displayed marginal denasalization to coronal stops (mainly to [d]) and also produced |n| as [j].

Figure 32: Target |n| for WTB

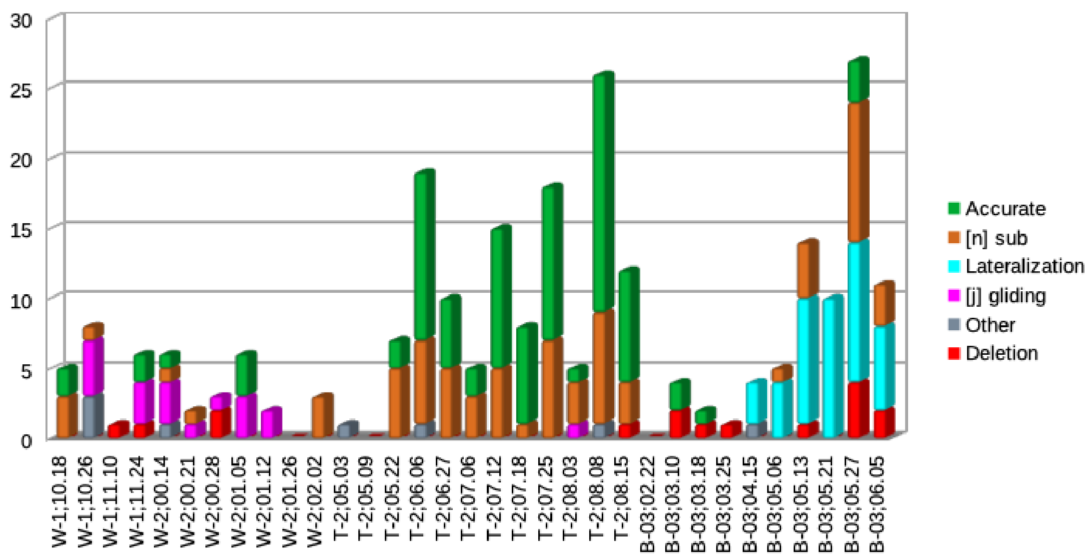


B denasalized |n| to [l] in 119 out of 628 attempts (19%). The majority of these substitutions come from attempts at the words *pene* |pɛnɛ|→[tɛːlɛ] 'pen' (3;03.22-3;06.05), *bona* |bɔːna|→[bɔːla] 'see/look' (3;02.22-3;06.05) and *ntsanyana* |ɲ̩ʧaɲaːna| →[n̩talaːla] 'puppy' (3;04.15-3;06.05), where the first and the third examples suggest an interaction with consonant harmony.

4.4 Target |ɲ|

In contrast to |m| and |n|, we observe in Figure 33 that WTB produced target |ɲ| with more variation. B displayed the lowest accuracy rate for |ɲ| at 8% (6 out 78 attempts), followed by W at 19% (8 out of 42 attempts). T produced |ɲ| with a 60% (75 out of 126) accuracy rate. The generally low accuracy rates for |ɲ|, as we can see, especially relates to inaccuracies in place of articulation (PoA), with all the children showing substantial substitutions to [n]. W had 9 (21%) substitutions to [n]. B had 18 (23%) and T had 46 (37%).

Figure 33: Target |ɲ| for WTB



W produced a higher rate of gliding to [j], at 40% (17 out of 40 attempts). The majority of his gliding occurred in three words, *ntsanyana* |ɲ̩ʧaɲaːna| ‘puppy’ (19 times), *nonyane* |nɔɲaːnɪ| ‘bird’ (15 times) and *senya* |sɪːɲa| ‘destroy’ (three times). *Nonyane* and *senya* were produced as [najaːnɪ] at 1;11-2;01 and [ʦɪːja] at 2;01, independent of other glides in the word. However, [j] also harmonized in *ntsanyana* |ɲ̩ʧaɲaːna|→[ɲ̩ʧajaːja] ‘puppy’ (2;00-2;01) and *nonyane* |nɔɲaːnɪ|→[jajaːnɪ]/[jajaːjɪ] ‘bird’ (2;00-2;01).

Concerning B, he displayed lateral substitution for |ɲ| at a rate of 54% (42 out of 78). This pattern was mainly found in the words *ntsanyana* |ɲ̩ʧaɲaːna|→[n̩talaːla] ‘puppy’ (3;03.25-3;05.06) and *kukwanyana* |kʊkʷaɲaːna|→[ʔitalaːla]/[ditalaːla] ‘chick’ (3;05.25), in which the lateral participates in a harmony pattern. The production of *ntsanyana* comprise the highest number of B’s alveolar substitutions for target |ɲ|. For example, out of his 86 attempts at target |ɲ|, he produced this word in this fashion 41 times.

4.5 Summary

In summary, WTB generally produced target nasals with high accuracy, except for /ɲ/. Lateralization, commonly observed for targets |n| and |ɲ|, occurred within a select number of words often in the context of consonant harmony effects. Gliding was common for all the target nasals, while [n] substitution was common for /ɲ/.

Table 11 summarizes the prominent patterns for each obstruent nasal discussed in this section.

Table 11: Prominent processes for |m, n, ɲ|

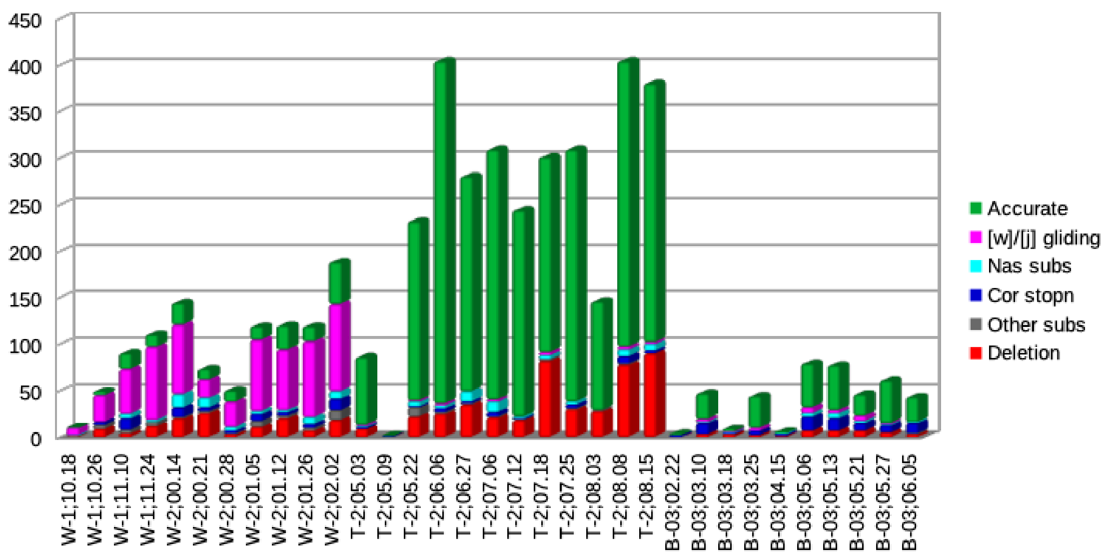
Phone	Main patterns	Notes
/m/	Acquired early	Gliding for W (CH)
/n/	Acquired early	Gliding for W CH for B
/ɲ/	Acquired later	Gliding for W Substitution to [n] for T

This completes our description of target nasals. We now move on to the description of lateral /l/ in section 5.

5. Lateral |l|

Figure 34 shows that T had the highest proportion of accurate productions for target |l|, at 81% (n=2540). B produced accurate |l| at a rate of 60% (n=260) as well as marginal coronal stop substitutions, at 18% (n=77). W, on the other hand, produced the least accurate rate at 17% (n=182). He prominently displayed gliding substitutions of |l| at a rate of 55% (n=604). He also produced marginal stopping and nasal substitution.

Figure 34: Target |l| for WTB



W thus displayed the most variation. He generally substituted |l| by [j] across all contexts. This substitution prevalently involved non-coronal contexts (i.e. labials and dorsals). This is shown in (29).

(29) W's [j] substitution for |l| in non-coronal contexts

Orthography	**Adult form**	**Child form**	**Gloss**	**Age**
bale	|baːle|	[baːje]	'those ones'	1;11.10
malome	|malʊːmɛ|	[jɪːmɛ]	'my uncle'	1;10
palama	|palaːma|	[pajaːma]	'climb'	1;11.11-2;01.26
rwala	|rʷaːla|	[waːja]	'put on'	1;10-2;01.26
robala	|rɔbaːla|	[wɔbaːja]/ [bɔbaːja]	'sleep'	1;10-2;01
kwala	|kʷaːla|	[kʷaːja]	'write'	1;10.26-2;01.12
golo	|χʊːlɔ|	[χʊːjɔ]	'thing'	2;00.14

The same sound also participated in harmony relations with other surrounding phones, especially the phones that he produced variably, as seen in previous sections. The harmony relations were found to be sporadically coincidental, as illustrated in (30).

(30) W's [j] in harmonizing contexts

Orthography	Adult form	Child form	Gloss	Age
setilo	|sɪtiːlɔ|	[tiːjɔ]	'chair'	1;10-2;02
kgagola	|qʰaχʊːla|	[qʰajɪːja]	'tear something up'	2;00
ele	|eːle|	[jeːje]	'that one'	2;01-2;02
apeile	|a.peiːle|	[pejiːje]	'cooking'	2;02
sele	|seːle|	[jeːje]	'that one'	2;02

Lastly, WTB, and especially W and T, also deleted |l| marginally (i.e., rate of 14% for T (n=438 out of 3097); 12% rate for W (n=131 out of 1073). Their deletions commonly involved target |l| in the final (post-tonic) syllable of the words, *tlile* |t͡ɬiːle|→[t͡ɬoː] 'I am going to', *dilo* |diːlɔ|→[dɔː] 'things', and *golo* |χʊːlɔ|→[χɔː] and *selo* |sɪːlɔ|→[sɔː], the latter three mean 'thing'. It is important to note that this process of post-tonic deletion mimics adult language.[26] This pattern thus likely reflects a property of the linguistic input to the children.

5.1 Summary

Generally, WTB produced |l| variably, particularly W. The most common process observed is gliding to [j]. All children also generally maintained accurate alveolar place of articulation in spite of the manner substitutions they displayed.

Table 12 highlights the only prominent pattern observed for lateral |l|.

26 Post-tonic deletion in adult language commonly involves, the uvular fricative /χ/ in words such as, *waga* |waχa|→[waː], *yaga* |jaːχa|→[jaː], *laga* |laːχa|→[laː], which all mean 'of'/belongs to'. It is also involves the lateral /l/ attested in the words, *selo* |sɪːlɔ|→[sɔː] and *golo* |χʊːlɔ|→[χɔː], both of which meaning, 'thing'. Lastly, it involves, the glide /j/, as we briefly discuss in section 7.2 of Chapter 4.

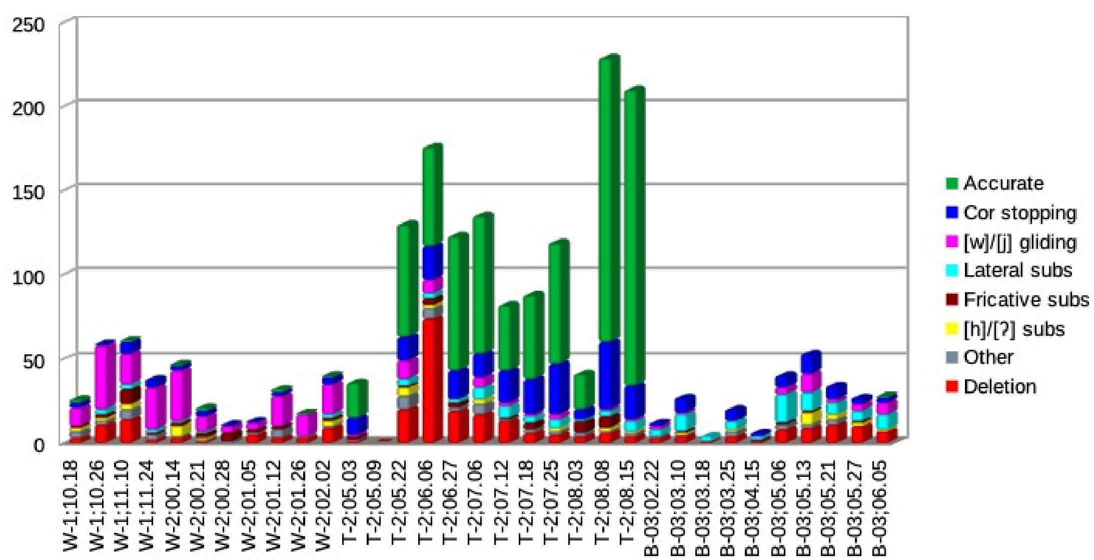
Table 12: Prominent processes for |l|

Phone	Main patterns	Notes
/l/	Acquired early	Gliding by W

6. Rhotic |r|

Figure 35 presents WTB’s productions for target rhotic |r|. As we can see in the chart, all children produced |r| with significant levels of variation, including deletion patterns.[27] T produced the highest proportion of accurate productions at 61% (n=836). She however displayed a prominent pattern of stopping, mainly to [d], in addition to marginal substitution and deletion patterns. This variability becomes less prominent towards the end of the observation period.

Figure 35: Target |r| for WTB



27 Deletions for all three children commonly affect the following contexts: (1) final syllables, involving the words *are* /aːrɪ/→[ʔaː] ‘let us’; *tshwara* |ʦ^{hw}aːra|→[ʦ^{hw}aː] ‘touch/hold’, and (2) entire words, containing |r|, especially in connected speech in words, *gore* |gʊːrɪ|→[∅] ‘that’, *dira* [diːra]→[∅] ‘do’ and *riana* |ri.aːna|→[∅] ‘do like this’. These deletions may thus relate to issues in morphological or syntactic development.

W and B barely produced accurate forms for |r|, with less than 5% accuracy in each case. W displayed a substantial rate of gliding, mainly to [j], at 51% (188 of 366 attempts). This pattern was sporadic, similar to what we have already seen for substituted nasals and laterals whereby [j] exhibited harmony relations. This was particularly visible in the words *dira* |diːra|→[jiːja] 'do' at 1;10– 02;02; *borokgwe* |bʊrʊːkʰʷɪ|→[jijʊːkʰʷɪ] 'pants' at 1;10-2;02; *robetse* |robeːʦɪ|→[jojeːtʰɪ] 'asleep' at 1;10-2;00; *moriri* |mʊriːri|→[mʊjiːji] 'hair' and *raese* |ra.ɪːsɪ|→[jajɪːsɪ] 'rice' at 2;01.

B's productions of target |r| were also variable. He substituted |r| by [l] and coronal stops, in addition to marginal gliding and debuccalization to [h] and [ʔ]. In fact, B only produced a single accurate |r| during the last session, at age 3;06.05. Similar to W, his substitutions to [l] were sporadic but tended to involve harmony effects with consonants in adjacent syllables, such as in the words *emere* |ɛmɛːrɛ|→[ʔalaːlɛ] 'bucket'; *garawe* |χaraːwe|→[ʔalaːla] 'spade'; *moriri* |mʊriːri|→[mʊjiːji] 'hair'; *tshwarelela* |ʦʰʷarɛlɛːla| →[tal̩laːla] 'hold on'; *rra* |r̩ːra|→[l̩ːla] 'sir'; *raga* |raːχa|→[laːla] 'kick' and *robala* |rɔbaːla| →[lalaːla] 'sleep'.

6.1 Summary

In summary, target |r| was produced very variably by the three children. The common processes for |r| are gliding, stopping and lateral substitution. W's gliding and B's lateral substitution tended to also involve harmony with consonants in the adjacent syllables.

Table 13 summarizes the prominent patterns for rhotic /r/ discussed in this section.

Table 13: Prominent processes for |r| production

Phone	Main patterns	Notes
/r/	Acquired later	Gliding to [j] by W (CH) Lateral substitution by B (CH) Coronal stopping by T

7. Glides

In this section, we focus on WTB's development of glides. As we will see, they exhibited fewer difficulties with the production of |w| than with |j|.

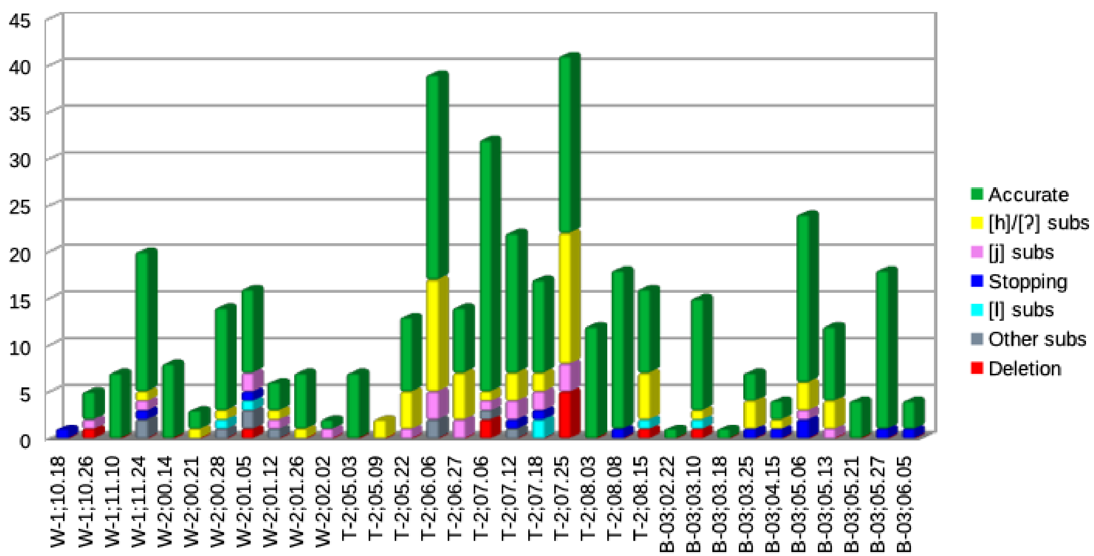
7.1 Target |w|

We can see in Figure 36 that WTB displayed high accuracy rates for target |w|. For example, B displayed the highest accuracy rate at 77% (n=69), followed by W at 73% (n=65) and, T at 66% (n=153). T displayed a prominent pattern of [h]/[ʔ] substitution (mostly to [h]) at 21% (n=48), which spiked especially around 2;06 and 2;07. This substitution is prevalent in the production of the words *wame* |waːme|[28]→[haːme] 'mine' and *wa* |wa|[29]→[ha] 'of'. Further, T displayed substitution to [j] also involving the same words (*wame* |waːme|→[jaːme] 'mine'; *wa* |wa|→[ja] 'of').

28 *wame* |waːme| is the 1st person possessive pronoun (Cole 1955).

29 *wa* |wa| and *ya* |ja| are possessive concords for noun classes 1 and 9 beginning with prefixes /mo-/ and /N-/ respectively. The latter is silent in many words as we saw in earlier in section Chapter 1, section 2.3.1, example (7). See Mogapi (1984) for a comprehensive discussion of Setswana noun classes.

Figure 36: Target |w| for WTB

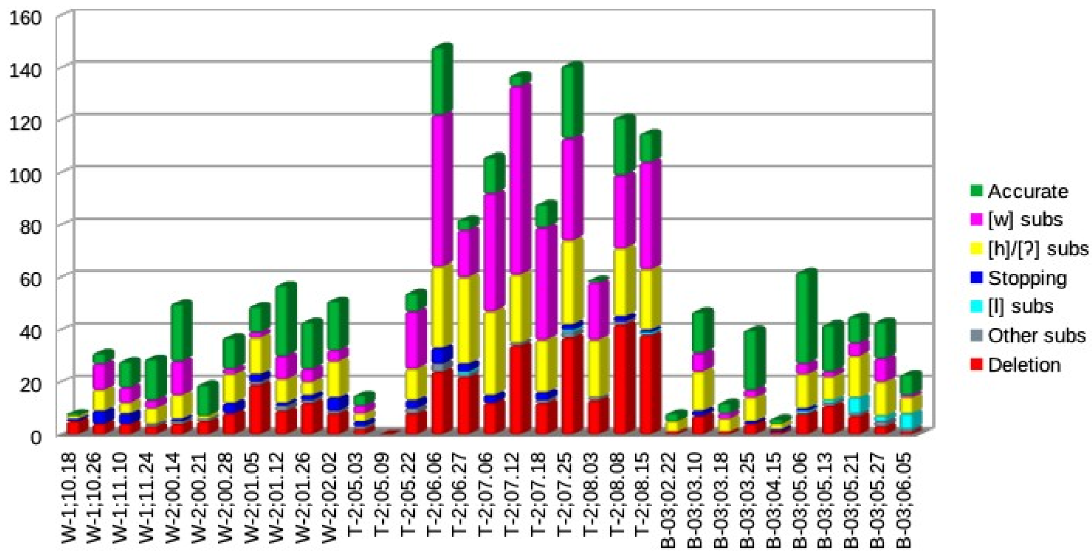


In contrast to T, W produced both gliding and stopping, while B displayed marginal [h]/[ʔ] substitution.

7.2 Target |j|

We can see in Figure 37 that target |j| was produced with more variability than what we described for |w|. The children commonly produced substitutions to [w] and [h]/[ʔ] as well as marginal stopping. T produced the highest rate of variation, with only 12% (n=130) accurate productions. B produced the highest rate of accurate productions for |j| at 41% (n=133), followed by W, at 38% (n=151).

Figure 37: Target |j| for WTB



T variably produced |j| as [w] or [h]/[ʔ]. She produced |w| solely in the word *yo* |jo| →[wo][30] 'this one' while [h]/[ʔ] substitutions, mainly involving [h], commonly occurred with the word *ya* |ja|→[ha] 'of', which she used in the context of the phrase *ya ga* |jaːχa|[31] 'an object belonging to a specified person'.

Also seen in the chart are spikes of deletions affecting target |j|, amounting to 542 cases in total in the three children's corpus. From the 542 cases, T deleted |j| 324 times (58% rate), W deleted it 138 times (25% rate) while B deleted it 80 times (15% rate). This type of deletion specifically involved the final post-tonic syllable *ja* |ja| across the following words: *tsamaya* |ʦamaːja| 'walk/go', *tsaya* |ʦaːja| 'take', *tlaya* |tɬaːja| 'come/let me', *bolaya* |bʊlaːja| 'hurt/kill', *mpolaya* |m̩pʊlaːja| 'hurting/killing me', *raya* |raːja| 'tell someone', *itaya* |i.taːja| 'hit/beat', *apaya* |a.paːja| 'cook', *tseye* |ʦɛːjɛ|[32] 'take'.

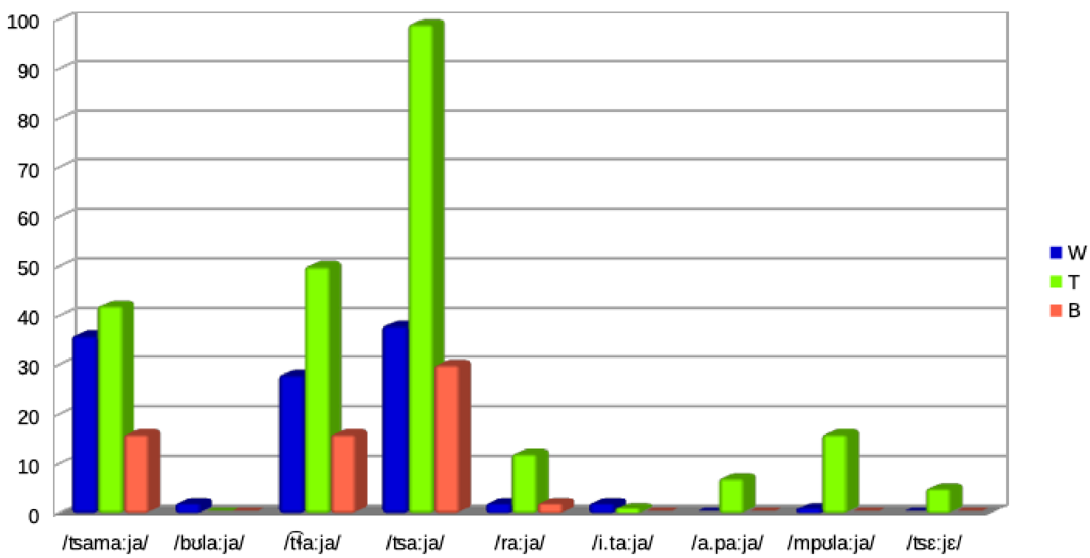
30 *yo* |jo| 'this one' is produced within the context of the phrase *motho yo* |mʊtʰʊ jo| 'this person' and it morphologically denotes class 1 noun or any noun beginning with /mo-/ prefix.

31 This form specifically refers to nouns from class 9.

32 *tseye* |ʦɛːjɛ| denotes 'take' in the present continuous tense'.

Figure 38 shows the rates of deletion of this post tonic |j| in percentages (presented on the lefthand side) for each word attempted. The target words are presented on the x-axis. Blue represents W's deletions, green represents T's deletions while B's deletions are presented in orange.

Figure 38: WTB's rates of |j| deletion within the final post-tonic syllable |ja|



As we can see, the children displayed differing rates of post tonic [ja] deletions in these words. T showed the highest rates of this type of deletion in the following words: *tsaya* |ʦaːja|→[ʦaː] 'take' (n=99), *tlaya* |tɬaːja|→[tɬaː] 'come' (n=50), and *tsamaya* |ʦamaːja| →[ʦamaː] 'walk/go' (n=42). She displayed marginal productions of less than 20 attempts each, for *mpolaya* |m̩pʊlaːja| 'hurting/killing me', *raya* |raːja| 'tell', *apaya* |apaːja| 'cook' and *tseye* |ʦɛːjɛ| 'take'.

W also displayed high rates of [j] deletions in the following words: *tsaya* |ʦaːja|→[taː] 'take' (n=38), *tsamaya* |ʦamaːja|→[tamaː] 'walk/go' (n=36), *tlaya* |tɬaːja|→[baː]/[kaː]/[ʔaː] 'come/let me' (n=28), while displaying marginal rates for the following words: *bolaya*

|bʊlaːja|→[bʊjaː] ‘hurt/kill’, *itaya* |i.taːja|→[ʔi.taː] ‘hit/beat’, *mpolaya* |m̩pʊlaːja|→[pʊlaː] ‘hurting/killing me’ and *raya* |raːja|→[ðaː] ‘tell someone’. The latter was also produced as [jaːja], without deletion. It is noteworthy that the children also tended to retain the length of the penultimate syllable even in words for which they were deleting the post tonics.

Lastly, B’s deletions display the following deletion patterns: *tsaya* |ʦaːja|→[taː] ‘take’ (n=30), *raya* |raːja|→[ʔaː] ‘tell someone’ (n=16) and *tlaya* |tɬaːja|→[ʔaː] ‘come/let me’ (n=16). Note that B had the fewest examples with post tonic [ja], hence the gaps in the chart.

However, it is important to note that these noticeable patterns of deletion in post-tonic contexts can be globally understood as input effects, given the behaviours of adult speakers within these contexts. Therefore it is not a development process unlike the processes for segmental development.

7.3 Summary

In summary, WTB generally produced |w| with more accuracy than |j|. The variability of |j| was however specific to two words which occurred at a high frequency within the dataset. Lastly, |j| also underwent deletion as part of a more general pattern of final syllable deletion.

Table 14 summarizes the prominent patterns for the glides |w| and |j| discussed in this section.

Table 14: Prominent processes for |w| and |j| production

Phone	Main patterns	Notes
/w/	Acquired earlier	[h] substitutions for T
/j/	Acquired later	[w] and [h] substitutions for T Deletions for W and T

This concludes our description of target glides. We now turn to a discussion of the production of sounds involving laryngeal features, mainly the aspiration phenomenon in WTB's data.

8. Aspiration

As already established in Chapter 1, in addition to the consonants realized with secondary place articulation, Setswana presents a relatively complex system of laryngeal contrasts: (1) three-way laryngeal contrasts for labial stops (i.e., /b/, /p/, /pʰ/) and non-lateral affricates (i.e., /ʤ/, /ʦ/, /ʦʰ/); and (2) two-way laryngeal contrasts for coronal and velar stops (i.e., /t/, /tʰ/ and /k/, /kʰ/) as well as lateral affricates (i.e., /tɬ/ and /tɬʰ/). Each of these contrasts can manifest itself in both word initial and medial positions.

The general observation emerging from WTB's data is that the aspiration errors observed, by way of either aspiration or deaspiration, affect different consonants in different ways. Our discussion below mainly focuses on patterns of deaspiration affecting voiceless obstruents and affricates. We note as well more minor patterns of devoicing which mainly affect target voiced obstruents, as we have seen already in section 1 of this chapter.

Our results in this section should ideally be based on VOT (Voice Onset Time) acoustic measurements. However, the current results are merely built on the researcher's own perceptions as a native (adult) speaker of the language. The measurement of VOT, defined as the time interval between the release of a stop and the onset of vocal-fold vibration (Lisker and Abramson 1964), is a widely used method to study laryngeal contrasts among obstruent stops, including in acquisition data (e.g. Macken & Barton 1980). According to Lisker & Abramson (1964), the VOT continuum comprises three main categories: long lag voicing lead (<0ms), corresponding to fully voiced sounds; short voice lag (0-20 ms), corresponding to voiceless unaspirated stops, and long voice lag (>40ms), which corresponds to aspirated stops. These VOT measurements are applicable cross-linguistically, while the phonetic requirements for each contrast may vary between languages. According to Macken & Barton (1980), there are three stages which children go through in their VOT development of stop consonants in English. The initial stage involves children primarily producing voiced short lag stops of 0-20ms VOT. This is followed by the production of voiceless stops, which children initially produce with longer VOT values than adults. The last to emerge is the production of aspirated stops (i.e., long lag VOT). This tendency has led to Macken & Barton's (1980) suggestion that aspiration[33] is the most difficult laryngeal cue to acquire in children's language development. The origin of this difficulty, according to Lowenstein & Nittrouer (2008), lies in children's initial inability to coordinate laryngeal and supralaryngeal gestures. This limitation is therefore primarily rooted in children's productive abilities, rather than in their perceptual abilities.

We start our discussion with the production of aspirated stops (/p^h/ and /t^h/) in section 8.1, followed by aspirated non-lateral affricates (/ʦ^h/ and /ʧ^h/) in section 8.2 and, finally,

33 Yang (2018) also notes aspiration to be a difficult cue to acquire for Mandarin-speaking children.

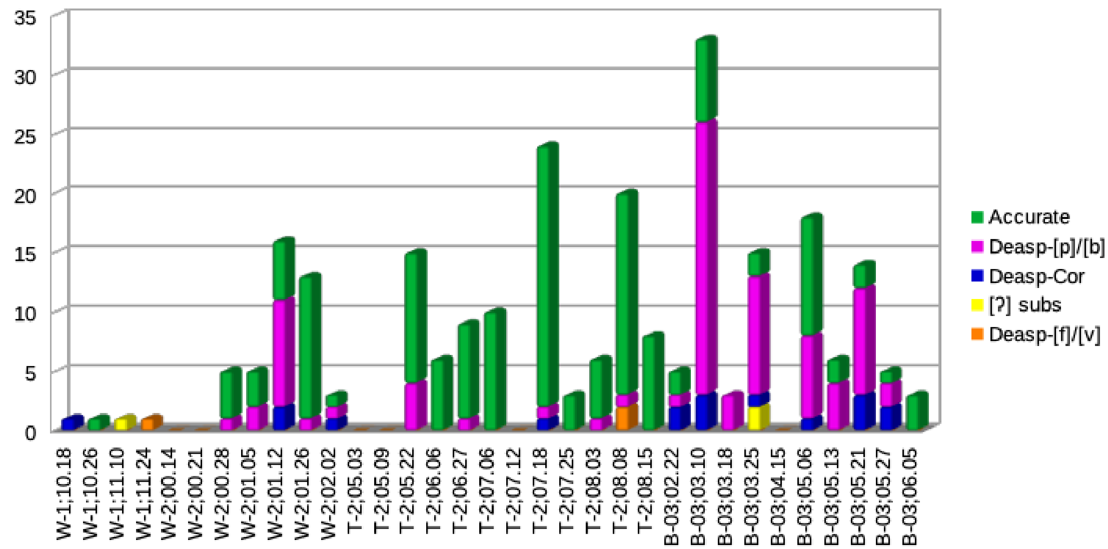
the aspirated lateral affricate (/t͡ɬʰ/) in 8.3. Recall that the production of these affricates has already been discussed earlier in sections 3.1.3 for /ʦʰ/, 3.1.4 for /ʧʰ/ and 3.3.3 for /t͡ɬʰ/, where our primary focus was on deaffrication patterns. We now turn to a consideration of noticeable patterns of deaspiration.

Overall, the children did not attempt as many tokens of aspirated targets as they did for the plain counterparts. We omit the discussion of /qʰ/ here because it has already been discussed earlier, in section 1.3 of this chapter. We also ignore /kʰ/ due to the fact that its production is limited, for all children, to the single word *khudu* |kʰuːdu| ‘turtle/tortoise’, frequently produced by one child, B, and constituting 70% of all his cases of deaspiration. Concerning aspiration, we note that T tended to display this pattern in an overgeneralized manner, across all categories, including /N̩C/ sequences, described with the relevant level of detail in section 10 below.

8.1 Aspirated stops |pʰ, tʰ|

As can be seen in Figure 39 for target |pʰ|, a number of gaps affect our current assessment, especially for W and T. Out of a total of 249 tokens, W displayed the lowest numbers of target |pʰ| with 46 attempts, while T and B made 101 and 102 attempts, respectively. Note as well that deaspiration, for all the children, commonly involved one word with an |N̩C| sequence, *mpha* |m̩pʰa| ‘give me’, in addition to a few other words, as we make explicit below.

Figure 39: Target |pʰ| for WTB



We can also see from the graph that T attempted target |pʰ| with a higher number of tokens than W and B, for which she displayed marginal deaspiration to labials [b]/[p] (i.e., in the word *mpha* |ṃpʰa| 'give me', which she attempted 21 times and produced as [ṃba]/[ṃpa]). Target |pʰ| was also spirantized to [f] in the same word *mpha* |ṃːpʰa|, together with another word, *mphara* |ṃpʰaːra| 'sit on your lap', as the two words were produced as [ṃːfa] and [ṃfaːra], respectively, at 2;08.08. T's tendency towards deaspiration also involved the words *phenti* |pʰeṇti|→[piṇti] 'underwear' and *iphara* |ipʰaːra|→[jipaːda] 'sit on the floor'.

In comparison, B deaspirated |pʰ| the most, mainly to [p]/[b], at a rate of 58% (n=59). Like T, his deaspiration also was prominently found in *mpha* |ṃpʰa|→[ṃba]/[ṃpa], attested 54 times between 3;02.22 and 3;05.27. Other words include *mpontshe* |ṃpɔṇtsʰɛ|→[baːʦʰa] 'show me' and *lephoi* |lɪpʰoːi|→[lɪpoːji] 'dove/pigeon'. B's deaspiration of coronal outcomes for target |pʰ| was also attested in the words *mpha*

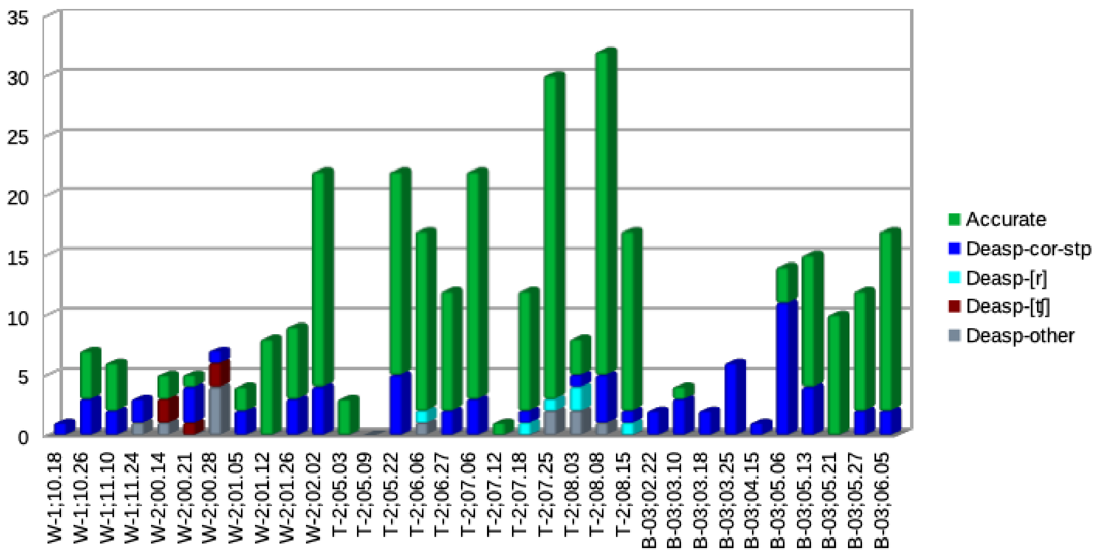
|m̩pʰa|→[n̩ta] ‘give me’ and *tshepile* |tsʰɛpiːle|→[tsitsiːle] ‘trusted’. Recall from section 1.1 that coronal substitution was also found in the context of B’s plain /p/ productions.

Similar to B, we can also see in Figure 39 that W deaspirated target |pʰ| to [b]/[p], especially at 2;01.12, also involving productions of *mpha* |m̩pʰa|→[m̩ba]/[m̩pa].

Moving to target |tʰ|, as shown in Figure 40, T produced the highest number of accurate forms of this consonant at a rate of 78% (n=151), with a few marginal cases of deaspiration. B and W, on the other hand, prominently displayed deaspiration to [t], at the rates of 37% (n=32) and 24% (n=21), respectively.

Concerning B, as we can see in the figure, his deaspiration pattern was most prominent in the earlier sessions but then decreased noticeably during the last four sessions. This observation is not surprising because, as we can recall from section 1.2, |t| is one of the speech sounds in which B displayed the majority of accurate productions, and tended to use it prominently as his substitute for labial and dorsal targets, as we saw also in sections 1.1 and 1.3, respectively.

Figure 40: Target |t^{h}| for WTB



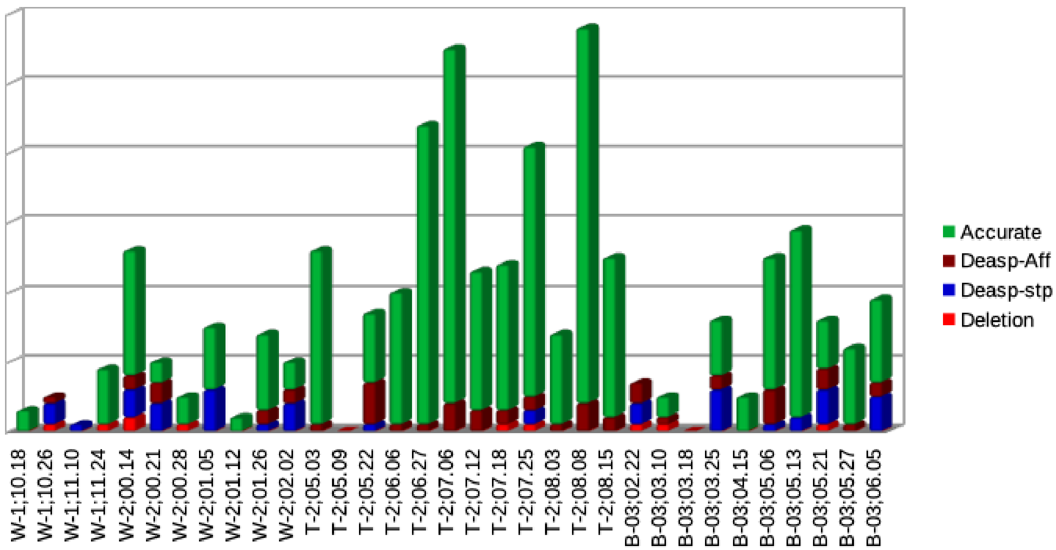
Note that, overall, B's attempts also displayed aspiration/deaspiration asymmetries for all of his obstruent stops, with a tendency for deaspiration over aspiration. This observation is in line with suggestions by Macken & Barton (1980) and Gandour et al. (2008) concerning the late mastery of aspiration for obstruent sounds. Similarly, W's deaspiration for target |t^{h}| also resulted in coronal stops, in addition to noticeable affrication to the plain alveo-palatal affricate [ʧ].

We now consider the production of non-lateral affricates /ʦ^{h}/ and /ʧ^{h}/, in the next section.

8.2 Non-lateral affricates |ʦ^{h}, ʧ^{h}|

Figure 41 illustrates WTB's production of target |ʦ^{h}|. All children displayed high rates of accuracy for this aspirated alveolar affricate. Two asymmetrical patterns of deaspiration are however prevalent in the data. T's deaspiration primarily resulted in plain affricates, whereas the boys commonly deaspirated to stops, mainly to [t].

Figure 41: Target aspirated |ʦʰ| for WTB

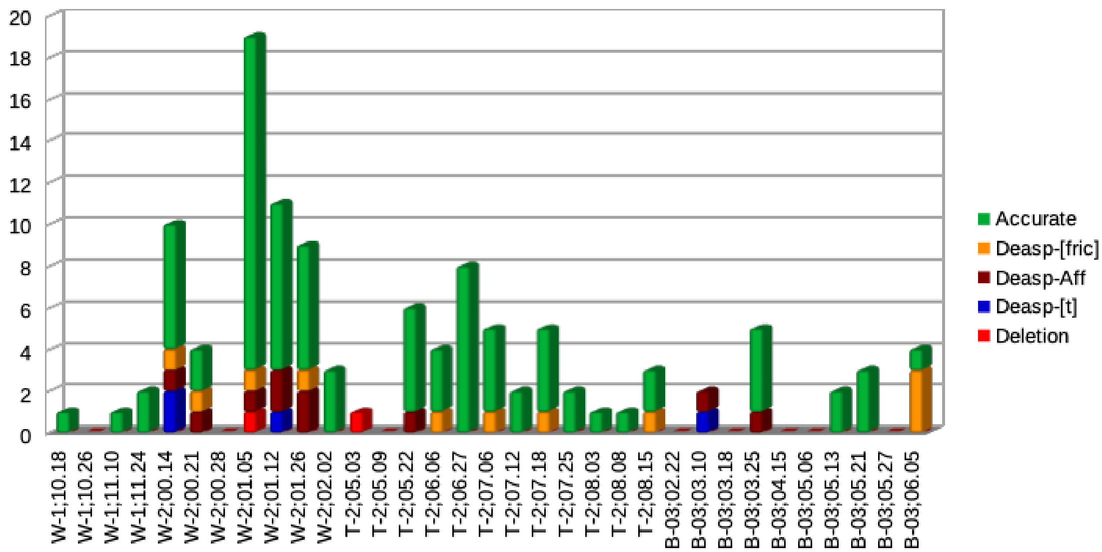


These substitution patterns should however not be confused with those seen earlier in section 3.1.3, Figure 20, in which WTB displayed substitutions to coronal stops and other affricates. The main difference between the data displayed in Figure 20 and Figure 41 is that the former showed deaffrication patterns, in which plain and aspirated sounds were treated as one unit, whereas the latter primarily focuses on aspiration. The same logic extends to our descriptions of /ʧʰ/ and lateral /t͡ɬʰ/ coming next.

As shown in Figure 42, just like they did for |ʦʰ|, the children produced the palato-alveolar |ʧʰ| accurately most of the time. W produced the highest number of accurate productions. His deaspiration patterns involved substitutions to fricatives,[34] plain affricates and the coronal stop [t].

34 The children's marginal deaspiration to fricatives involved the following words, starting with W: *thitsha* |tʰiːʧʰa|→[tʰiːʃa]/[tʰiːχʊ] 'teacher', *mmetshisi* |m̩metʃʰiːsi|→[mitiːʃi] 'match stick'; T: *phaletshe* |pʰalɪːʧʰɪ| →[pʰalɪːʃɪ] 'mealie-pap'; *boratshe* |bʊraːʧʰɪ|→[bʊlaːʃɪ] 'hair brush'; *watshe* |waːʧʰɪ|→[waːʃɪ] 'wrist watch'; B: *boratshe* |bʊraːʧʰɪ|→[baːʃɪ]/[baːsɪ] 'hair brush'.

Figure 42: Target |ʧʰ| for WTB



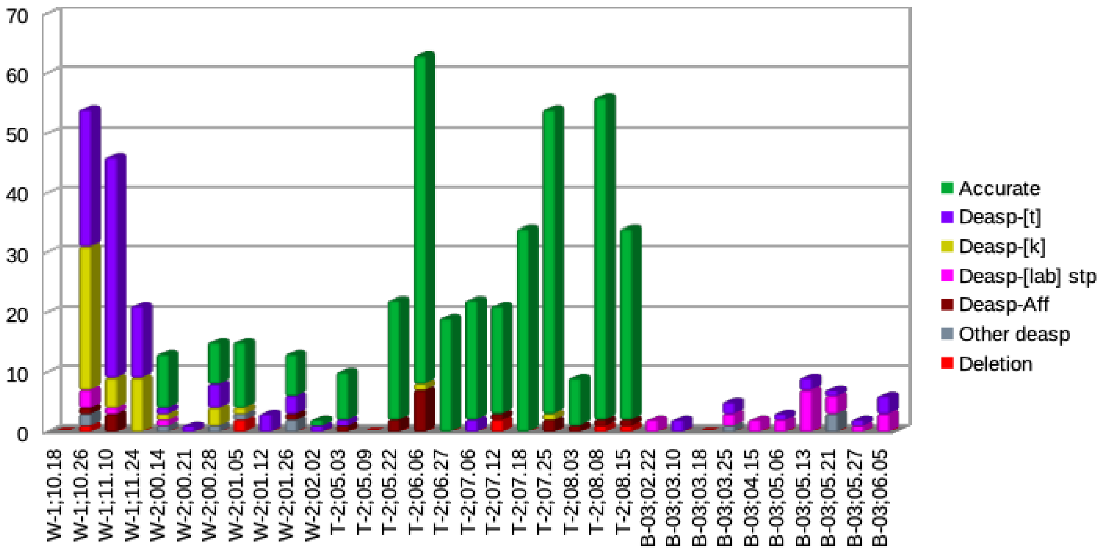
We can also see in the figure that, just like W, T displayed more accurate target |ʧʰ| productions and lower rates of deaspiration. Similarly, B produced /ʧʰ/ accurately in the majority of his attempts, despite a limited number of samples. He however rarely displayed coronal stop substitution as we would have expected, considering his preference for this pattern of substitution for all his affricates in general, as we previously saw earlier in section 3.

8.3 Lateral affricate |t͡ɬʰ|

We show the patterns of target |t͡ɬʰ| production in Figure 43. Recall from section 3.3 that W displayed the most deaffrications to plain and aspirated coronal and velar stops, while B deaspirated |t͡ɬʰ| prominently to labial stops,[35] at a rate of 46% (n=23) (this pattern resulting exclusively from consonant harmony effects), in addition to 38% (n=19) of the attempts resulting in coronal stopping.

35 The examples of words displaying B's labial stopping (i.e., to [p]) for target |t͡ɬʰ| are repeated here from section 3.3.3: *ditlhako* |dit͡ɬʰaːkʊ| → [dipaːpʊ]/[dipʰaːpʰʊ] 'shoes' (3;03.22-3;06.05) and *tlhapa* |t͡ɬʰaːpa| → [paːpa] 'bathe' (3;03.25-3;06.05).

Figure 43: Target |t͡ɬʰ| for WTB



The trends we see in the current data are that, for W, deaspiration affected lingual stops [t] and [k] and marginally affected [p]/[b] and plain affricates, mostly [t͡ɬ]. For B, deaspiration was categorically to labial stops and [t], attested in the same words for target |t͡ɬʰ| already seen in section 3.3.3. Lastly, T displayed by far the highest rate of accurate |t͡ɬʰ| productions.

8.4 Summary

In summary, deaspiration was prominent for all the sound classes discussed, with the children's substitution patterns generally displaying the same place effects for the aspirated targets as for their non-aspirated counterparts, except for the lateral affricate /tɬʰ/, whose deaspiration also resulted in velar stops.

Table 15 summarizes the prominent patterns for the target aspirated consonants |pʰ|, |tʰ|, |tsʰ|, |ʧʰ| and |tɬʰ| discussed in this section.

Table 15: Prominent processes affecting |pʰ|, |tʰ|, |ʦʰ|, |ʧʰ| and |tɬʰ| production

Phone	Main patterns	Notes
/pʰ/	Acquired later	Deaspiration by B and W
/tʰ/	Acquired early	Deaspiration by B
/ʦʰ/	Acquired early	Deaspiration to coronal stop for B and W Deaspiration by T
/ʧʰ/	Acquired early	Deaspiration to fricatives by WTB Deaspiration to affricates by W
/t͡ɬʰ/	Acquired later	Deaspiration to [t] and [k] by W Deaspiration to labials by B

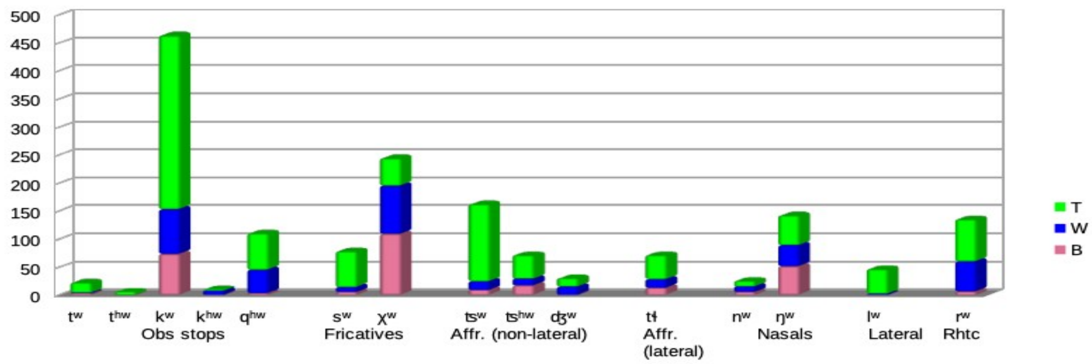
We now move to the description of consonants with secondary articulation, presented in the next section.

9. Labialized consonants

As stated in section 2.1.4 of Chapter 1, Setswana has a set of consonants with a secondary place of articulation which are realized with a labialized release on the base consonant (Ladefoged & Maddieson 1996: 354). Our corpus documenting the development of these consonants comprises the following /Cʷ/ contexts: obstruent stops /tʷ/, /tʰʷ/, /kʷ/, /tʰʷ/ and /qʰʷ/; fricatives /sʷ/ and /χʷ/; non-lateral affricates /ʦʷ/, /ʦʰʷ/, /ʤʷ/; lateral affricate /tɬʷ/; nasal stops /nʷ/ and /ŋʷ/; lateral /lʷ/ and rhotic /rʷ/.

We begin by reporting the children's overall productivity for these consonants, in Figure 44. As we can see, the labialized consonants were not equally represented in the children's datasets. T is the only child that attempted all the |Cʷ|s. She also displayed the highest number of attempts overall, with a total of 932, where the most productive targets are |kʷ| (n=310), |ʦʷ| (n=138), |rʷ| (n=75), |qʰʷ| (n=65) and |sʷ| (n=64).

Figure 44: WTB’s rate of productivity of |C^{w}|s



In comparison, W and B displayed lower numbers of attempts, at 379 and 294, respectively. We can also see from Figure 44 that velar |k^{w}| displayed the highest frequency of all the |C^{w}|s, with T attempting the most (n=311), followed by B (n=73) and W (n=72). In the description to follow, we omit the data for target |χ^{w}|, due to the fact that its production, which involved 244 attempts in total (i.e., W: 92, T: 34 and B: 118), comes from a single word: *segogwane* |sɪχɔχ^{w}anɪ| ‘frog’.

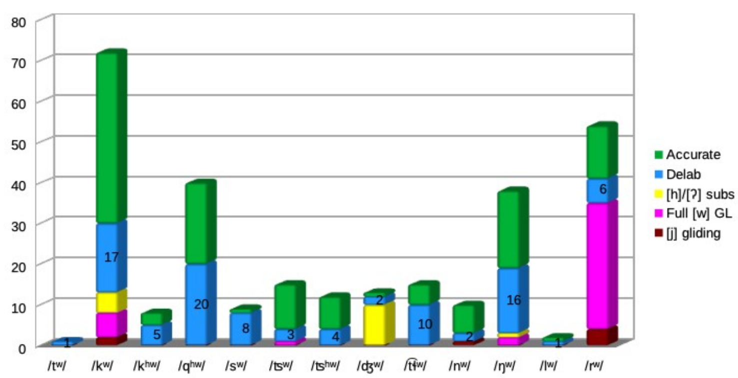
As we can also see in Figure 44, the two boys missed certain types of |C^{w}|s as part of their attempted words. For example, W produced no data for |t^{hw}| and showed very low numbers of attempts at |t^{w}|, |k^{hw}|, |s^{w}|, |l^{w}| and |tɬ^{w}|. Similarly, empirical gaps in B’s data are affecting our ability to characterize his development of |t^{hw}|, |k^{hw}|, |dʒ^{w}|and |l^{w}|. B also attempted very few tokens of the following |C^{w}|s: |t^{hw}|, |q^{hw}|, |s^{w}|, |n^{w}| and |r^{w}|. Because of this limitation, our discussion will focus mainly on phones for which there is enough evidence to allow for minimally robust generalizations.

9.1 Overview of delabialization affecting target |C^{w}|s

We begin with an overview of the rates of delabialization for each child. Delabialization implies that the target |C^{w}| was produced but without its labial release. Accurate production in this section generally refers to a labialized outcome, even if this outcome was not produced with the exact base target phone. As stated earlier, we make comparisons only on phones for which there is a sufficient number of attempts.

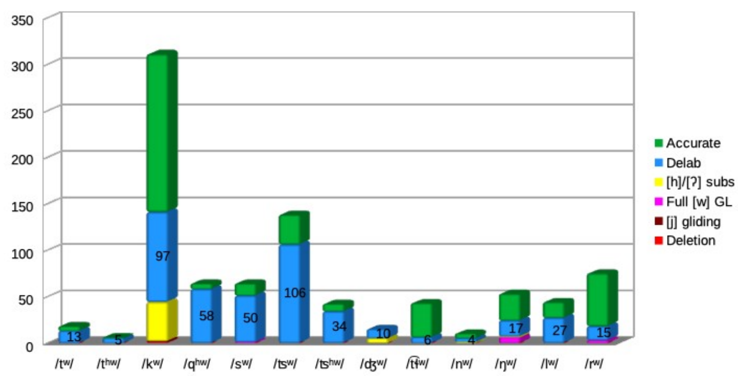
Overall, WTB displayed a relatively high rate of delabialization. We show this in Figure 45 for W, Figure 46 for T, and Figure 47 for B. As we can see in these figures, W produced the lowest rate of delabialization at 40% (n=127), followed by T at 51% (n=478) and B at 67% (n=185). As we can see in W's productions, illustrated in Figure 45, his delabialization mostly affected the uvular |q^{hw}|, followed by the velars |k^{w}| and |ŋ^{w}|. Concerning his coronals, although their tokens were among the fewest from the corpus, we can still see that W delabialized them at lower rates, especially for target |ʦ^{w}|, |ʦ^{hw}|, |n^{w}| and |r^{w}|. In comparison, |s^{w}| and |tɬ^{w}| displayed higher rates of delabialization, at 89% (n=8) and 67% (n=10), respectively, however, over relatively few tokens in total.

Figure 45: Delabialization for W



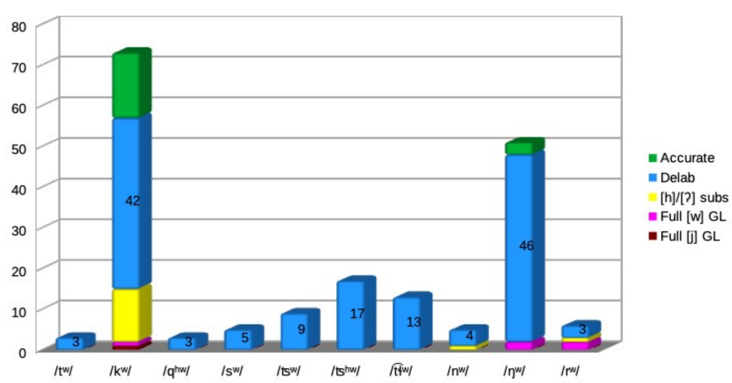
Concerning T, her delabialization proportionally affected more tokens of |ʦʷ| (106 attempts out of 138), and |kʷ| (97 out of 311).[36] She however attempted only a few tokens for the remainder of the sounds. Nonetheless, we can observe patterns in the data, such as higher rates of delabialization for |tʷ|, |qʰʷ|, |sʷ|, |χʷ|, |ʦʰʷ| and |ʤʷ|, and relatively higher accuracy rates for |tɬʷ|, |ŋʷ| and |rʷ|.

Figure 46: Delabialization for T



B's delabialization, as illustrated in Figure 47, generally affected all sounds, with /kʷ/ being the least affected. Those considerably affected, with no accurate productions, include |tʷ|, |qʰʷ|, |sʷ|, all affricates (|ʦʷ|, |ʦʰʷ|, |ʤʷ|, |tɬʷ|) and the nasal |nʷ|.

Figure 47: Delabialization for B



36 T debuccalized |kʷ| to [h]/[ʔ] marginally at a rate of 17% (42 out of 308) and this involved one word, *kwa* |kʷa| 'there' which she prominently produced as [ha].

Building on these observations, we now proceed with a more detailed discussion about the productions of target labialized consonants by each child. We discuss asymmetries observed between the |Cʷ|s and their corresponding non-labialized phones, in order to determine how the labial release present on these consonantal targets were affected across different consonant productions. We begin with W’s productions.

9.2 W's delabialization patterns

As we have already seen in Figure 45, W displayed the least amount of delabialization of the three children. His productions of fricative, nasal and lateral[37] |Cʷ|s generally displayed similarities with their simple |C| counterparts, except for the rhotic |rʷ|. In the lines below, we describe his productions of the velar stops |k| and |kʷ|, uvular stops |qʰ| and |qʰʷ|, the alveo-palatal affricates |ʤ| and |ʤʷ|, and the rhotics |r| and |rʷ|.

Starting with |kʷ| and |qʰʷ|, we observe that his delabialization was mostly to base velars and uvulars. Recall from section 1.3 of this chapter that W’s productions of |k| and |qʰ| were accurate for the most part. In this context, we can claim that W’s productions of |kʷ| and |qʰʷ| were only affected by the child’s still ongoing development of labialization as a secondary articulation. To this we add, for target |qʰ|, a marginal process of fronting and affrication, which however only involved a single word, *kgweetsa* |qʰʷeːʦa| →[tʰeːʦa]/[ʦeːʦʰa] ‘drive’.[38]

37 W’s production of /tɬʷ/ even though limited in number (e.g., n=15) resulted in delabialization, which predominantly involved backing (e.g. to [kʰ], the pattern also formed part of his accurate attempts (e.g. labialized velar stop [kʰʷ]).

38 W produced accurate |Cʷ| in word-final position of the word *borokgwe* |bʊrʊːqʰʷɪ|→[bʊjʊːkʰʷɪ]. However, there is limited data to confirm the representativity of this example.

Moving on to W's affricate productions, recall from Figure 47 that he generally displayed higher rates of delabialization for all his |C^{w}| affricates, with the exception of |ʤ^{w}|, for which he displayed debuccalization to [h], at a rate of 40% (n=6), and to [ʔ], at 27% (n=10). This debuccalization affected the words *jwaga* |ʤ^{w}aːχa|→[haːda] 'belonging to' (2;00.14) and *jwaaka* |ʤ^{w}aːka|→[ʔaːka] 'mine' (2;01.26). Contrary to his prominent debuccalization for |ʤ^{w}|, W's productions of |ʤ| involved prominent gliding as well as sporadic stopping, devoicing and nasal substitution, as reported already in section 3.1.5, Figure 22 of this chapter.

Finally, concerning W's production of target |r^{w}|, just like for target |r| already detailed in section 6, Figure 35, we note that he barely produced accurate rhotics in any of his attempts, instead displaying high amounts of variation. Concerning |r^{w}|, we note a prominent process of full gliding to [w], at a rate of 57% (n=31 out of 54), attested in two different words, *rwala* |r^{w}aːla|→[waːja]/[waːla] 'put on accessories' and *tshwerwe* |ʦ^{hw}eːr^{w}ɪ|→[ʣeːwɪ] 'touched/feeling of hunger'. Crucially, W did not display better performance on the base phone, but he managed to display labialization on a number of substituted base phones such as [j^{w}] (n=6), [k^{w}] (n=2), [ð^{w}] (n=2); [v^{w}] (n=1) and [d^{w}] (n=1).

9.3 T's delabialization patterns

Keeping our description to the most productive target |C^{w}|s, as we already established in Figure 46, T's delabialization was prominent for some targets: |t^{w}|, |q^{hw}|, |s^{w}|, |χ^{w}|; |ʦ^{hw}|, |ʤ^{w}|, while it was less prominent for others: |tɬ^{w}|, |ŋ^{w}| and |r^{w}|. For the majority of targets, delabialization was to their base phones. For example, recall T's production of |s| from section 2.2, for which she displayed considerable affrication to [ʦ]. She displayed the same affrication in 63% (40 out of 64) of her attempts at |sʷ|.

|ʤʷ| and |tɬʷ| are the only |Cʷ|s whose patterns deviated from those of their base consonants, |ʤ| and |tɬ|, respectively. Starting with the production of |ʤ|, as discussed in section 3.1.5, in addition to an accuracy rate of 55%, T produced [n] substitution for |ʤ| at a rate of 17%, followed by devoicing to [ʧ] at 11% and other marginal processes. In comparison, her production of |ʤʷ| did not yield any accurate outputs. She prominently produced [b] substitution, in 10 out of 15 tokens. This patterning, which suggests a labial effect of the secondary target articulation on her outputs, involved two words, *jwaga* |ʤʷaːχa|→[baːχa] 'belonging to' (2;06.06-2;07.06) and *jwame* |ʤʷaːme|→[baːme] 'mine' (2;07.06-2;07.12).

Turning to her production of the lateral affricate |tɬ|, we saw in section 3.3.2 that T displayed a high rate of accurate productions at 79% and marginally substituted |tɬ| to a number of phones such as coronal and velar stops. In contrast to this, she prominently realized |tɬʷ| with accurate labialization on velars [kʰʷ] (30 out of 43 tokens) and [kʷ] (n=1). This backing involved the words *utlwa* |uːtɬʷa|→[wuːkʰʷe]/[ʔaːkʰʷe] 'hear/understand' (2;07.12 -2;06.27) and *thutlwa* |tʰuːtɬʷa|→[kʰuːkʰa] 'giraffe' (2;06.06).

9.4 B's delabialization patterns

We saw in Figure 44 that B attempted the fewest tokens of |Cʷ/|s of all the three children. We also saw in Figure 47 that his delabialization affected all the |Cʷ| targets in his data. Further, the majority of B's delabializations also came with substitutions affecting the base phones at various rates, also in line with B's patterns of production for these base phones. Recall the prominence of coronal stops in his attempts at |k|, |ʦ|, |ʦʰ| and |tɬ| in sections 1.3, 3.1.2, 3.1.3, and 3.3.2, respectively. The same pattern was also prevalent for |kʷ|, |ʦʷ|, |ʦʰʷ| and |tɬʷ|.

In his attempts at fricative |s|, we saw in section 2.2 that B commonly produced both affrication and stopping. In comparison, for |sʷ|, he asymmetrically displayed more affrication and no stopping. Asymmetries in the rates of affrication are also seen between |ʦʰ| and |ʦʰʷ|. Concerning |ʦʰ|, B displayed a higher rate of accuracy and a lower rate of stopping (section 3.1.3). However, his attempts at |ʦʰʷ| presented with predominant substitution to [t], at the rate of 88% (n=15), involving the words *tshwarelela* |ʦʰʷarɛlɛːla|→[taḷlaːla] ‘hold on’, (3;03.10-3;05.27), *ntshwarelela* |ṇʦʰʷarɛlɛːla|→[ṇtalaːjɛ] ‘hold this for me’ (3;05.06) and *tshwara* |ʦʰʷaːra|→[taːda]/[taːla] ‘hold/touch’ (3;05.06-3;06.05).

In summary, delabialization was prominent for the |Cʷ|s we observed in sufficient numbers in the children’s data, the outcomes of which also generally followed the patterns observed with the non-labialized counterparts of these target phones.

Table 16 summarizes the prominent patterns for the |Cʷ|s discussed in this section. Recall that words containing some sounds either had limited numbers or were not attempted at all by the children. Empirical gaps are especially evident for W (affecting |tʰʷ|,|tʷ|, |kʰʷ|, |sʷ| and |lʷ|) and B (affecting |tʰʷ|, |kʰʷ|, |ʤʷ| and |lʷ|). Because of this limitation, our summary focuses only on phones for which we could attain minimal generalizations.

Table 16: Prominent processes for |C^{w}| production

Phone	Main patterns	Notes
/t^{w}/	Acquired later	Delabialization to simple C by WTB
/t^{hw}/	Acquired later	Delabialization to simple C by WTB
/k^{w}/	Acquired later	Delabialization to simple C by WTB
/q^{hw}/	Acquired later	Delabialization to simple C by WTB Additional fronting and affrication for B
/s^{w}/[39]	Acquired later	Delabialization to simple affricates by TB
/ʦ^{w}/	Acquired later	Delabialization to simple C by WTB
/ʦ^{hw}/	Acquired later	Delabialization to simple C by TB Additional coronal substitution for B
/ʤ^{w}/	Acquired later	Debuccalization by W [b] substitution by T Nasal substitution by B
/t͡ɬ^{w}/	Acquired later	Delabialization to velar consonant and velar Substitutions to non-lateral |C^{w}|s by W Substitutions to velar |C^{w}|s by T
/n^{w}/	Acquired later	Delabialization to simple C by WTB
/ŋ^{w}/	Acquired later	Delabialization to simple C by WTB
/l^{w}/	Acquired later	Delabialization to simple C by WTB
/r^{w}/[40]	Not acquired	Full labial gliding by W Substitutions to non-rhotic |C^{w}|s by W Fricative |C^{w}| substitutions by T

This section concludes our discussion of |C^{w}|s. We now move to the production of nasal-consonant sequences in the next section.

39 Due to low numbers (six attempts), W's production of |s^{w}| was excluded from the discussion hence its absence in the summary.

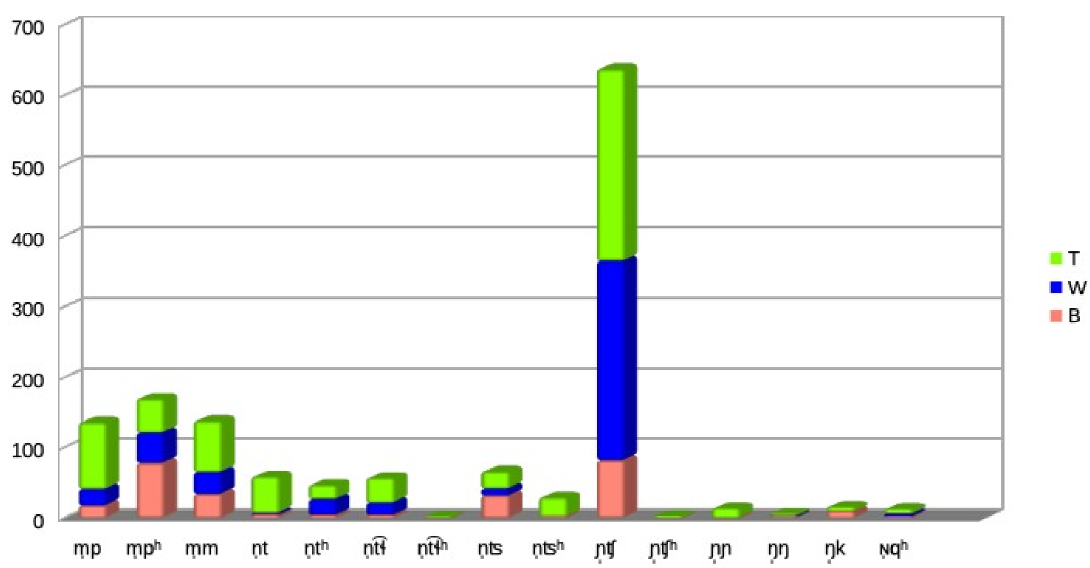
40 B's |r^{w}| production had only six tokens, therefore it was excluded from the discussion.

10. Nasal+consonant (|N̩C|) sequences

The main focus of this section is on the production of consonantal sequences involving the syllabic nasal /N̩/ followed by any syllable-initial consonant, which we refer to as nasal-consonant sequences (/N̩C/). Our corpus documents the acquisition of both the nasal+obstruent (/m̩p, m̩pʰ, n̩t, n̩tʰ, n̩t͡ɬ, n̩t͡ɬʰ, n̩ʦ, n̩ʦʰ, ɲ̩ʧ, ɲ̩ʧʰ, ŋ̩k, ɴ̩qʰ/), and nasal+nasal (/m̩m, n̩n, ɲ̩ɲ, ŋ̩ŋ/) contexts.

We begin by reporting on the children's overall productivity for target |N̩C|s in Figure 48. As we can see, the overall rates of production are generally marginal, while the children noticeably produced |ɲ̩ʧ| with the highest rates, with W making 283 attempts, T, 272 attempts, and B, 82 attempts in total.

Figure 48: WTB's productivity of |N̩C| sequences



These involved the following two closely related words: *ntsa* |ɲ̩ʧa| 'adult dog' and *ntsanyana* |ɲ̩ʧaɲana| 'puppy'. Finally, because of its lack of productivity in the children's overall corpus, we omit |ɲ̩ʧ| in the discussions to follow.

Overall, T made the highest number of attempts at |N̩C|s, with a total of 417, and her most productive targets were |m̩p| (n=95), |m̩m| (n=73), |n̩t| (n=52) and |m̩pʰ| (n=48). W followed with 149 attempts, including |m̩pʰ| (n=43), |m̩m| (n=31) as well as |m̩p| and |n̩t|, displaying 23 tokens each. B's most productive targets included |m̩pʰ| (n=78), |m̩m| (n=34) and, |n̩ʦ| (n=32).

As we can also see in Figure 48, the children made marginal or no attempts at a number of |N̩C|s. We have marginal data for |ɲ̩ʧʰ, ɲ̩ɲ, ŋ̩ŋ, ŋ̩k, ɴ̩qʰ|, with less than 50 tokens in total, virtually all of which were attempted by T only. For example, W showed no attempt at |n̩ʦʰ, ɲ̩ʧʰ, ɲ̩ɲ, ŋ̩ŋ, ŋ̩k| and B made no attempts at |ɲ̩ʧʰ, ɲ̩ɲ, ŋ̩k|. Our discussion below ignores |N̩C| data for which there is not enough evidence to allow for minimally robust generalizations, unless the few examples available do suggest some consistency in the production patterns they elicited.

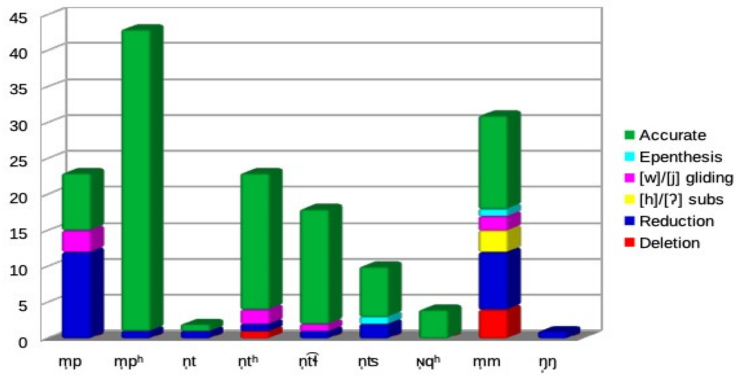
10.1 Overview of reduction rates for target IN̩CIs

We start with an overview of the rates of production of the target |N̩C|s. In this regard, we deem accurate a target |N̩C| produced with its two components (nasal and following consonant) even if these component sounds are not fully segmentally accurate. We also report on other relevant processes such as debuccalization and gliding. Where necessary, we report on segmental inconsistencies between the relevant segments within the sequence.

Overall, the children produced target |N̩C|s at relatively high rates and displayed few phonological processes, a general observation which suggests the early mastery of these sequences.

As we can see in Figure 49, W displayed noticeable patterns of sequence reduction to C, in particular for /m̩p/, which was reduced to [p] (n=6) and [n] (n=4) out of 23 attempts.

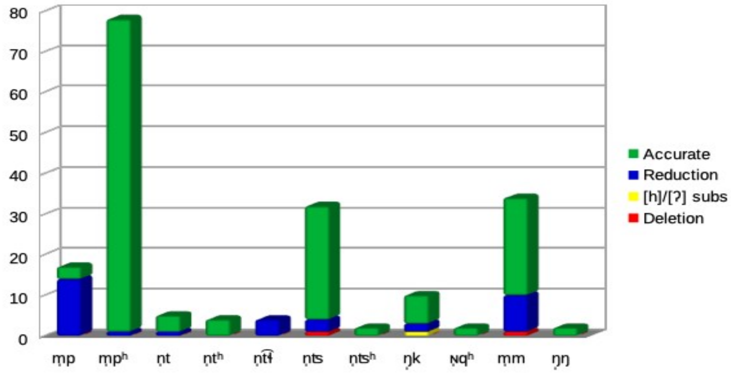
Figure 49: W's reduction rates for |N̩C|



We can also see that W's target |m̩m| production displayed more variation, with the |N̩C| sequence reduction as the most prominent pattern in eight out of 31 attempts (27%), resulting in [b] (n=3), [m] (n=2), [n] (n=1), [χ] (n=1) and [ʦ] (n=1). Other processes include debuccalization (n=3), gliding (n=2) and epenthesis (n=1). W's other attempts at |m̩m| resulted in deletion (n=4).

Similarly, |N̩C| reduction prominently affected B's attempts at |m̩p| (14 out of 17), |n̩t͡ɬ| (4 out of 4), and more marginally for |m̩m| (9 out of 34), as Figure 50 shows. The sequence |m̩p|, found in a single word, *mpontshe* |m̩pɔn̩ʦʰɛ| 'show me', was produced randomly as [ʔabaːʦʰa], [ʔibɔːdɛ], [ban̩ʦʰa], [bɔːʦʰɛ] at 3;06.05. The nasal + lateral sequence |n̩t͡ɬ|, was produced with both |N̩C|reduction and deaffrication of the lateral to [t], at a rate of 100%, involving a unique word: *ntlo* |n̩t͡ɬʊŋ̩|→[tʊŋ̩] 'in/at the house' (3;03.25 – 3;05.21), in four occurrences across all of the recording sessions.

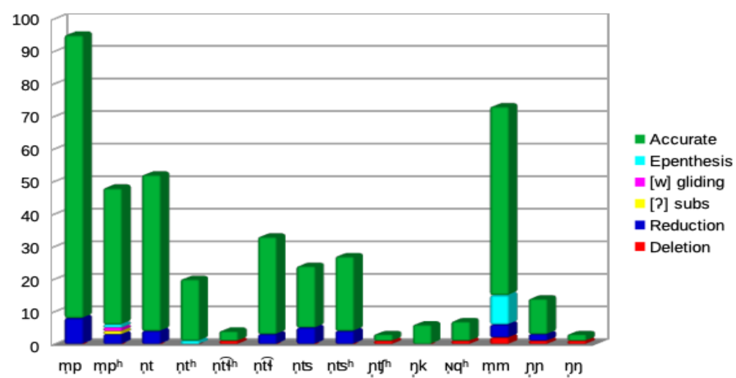
Figure 50: B's reduction rates for |N̩C|s



Recall from sections 1.1 and 4.2 that B displayed accuracy rates above 80% for singletons |b| and |m|. His preference for these sounds as substitutes for target |m̩p| and |m̩m| sequences is thus not surprising.

Finally, we can see in Figure 51 that T produced her target |N̩C| with the highest rates of accuracy and very little variation. Her reduction of |N̩C| sequences was marginal, at a rate of less than 5% for all her sequences combined. She also marginally displayed vowel epenthesis in a few attempts at |m̩m|.

Figure 51: T's reduction rates for |N̩C|



The trend emerging from these comparisons is that the children were generally as proficient in their productions of target |N̩C|s as they were in their productions of singleton obstruent stops and nasals. In light of this observation, we now turn to a consideration of the phonological processes that affected the children's productions of target |ṆC|s in more detail.

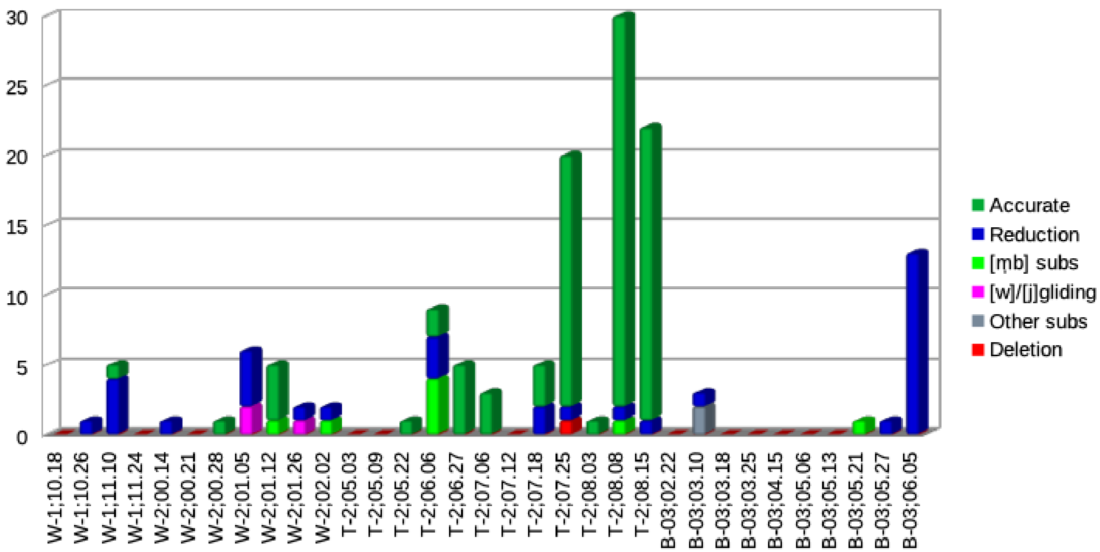
10.2 Phonological processes affecting |ṆC| sequences

Consistent with all other descriptions, we limit our discussion to the sequences that were attempted in sufficient numbers, namely, concerning nasal+non-affricate sequences, |m̩p|, |m̩pʰ|, |n̩t| and |n̩tʰ|, in section 10.2.1, and, concerning the nasal+affricate sequences, |n̩ʦ, n̩ʦʰ| and |n̩t͡ɬ|, in 10.2.2. (Target |n̩ʦ| and |n̩ʦʰ| are discussed as one unit because they displayed similar patterns.) Finally, section 10.2.3 completes our description with the nasal+nasal sequence |m̩m|.

10.2.1 Nasal+non-affricate sequences

We can see in Figure 52 that T displayed the highest accuracy rates of the three children. Aside from her |ṆC| reductions, she produced marginal voicing substitutions to |m̩b| at 2;06.06.

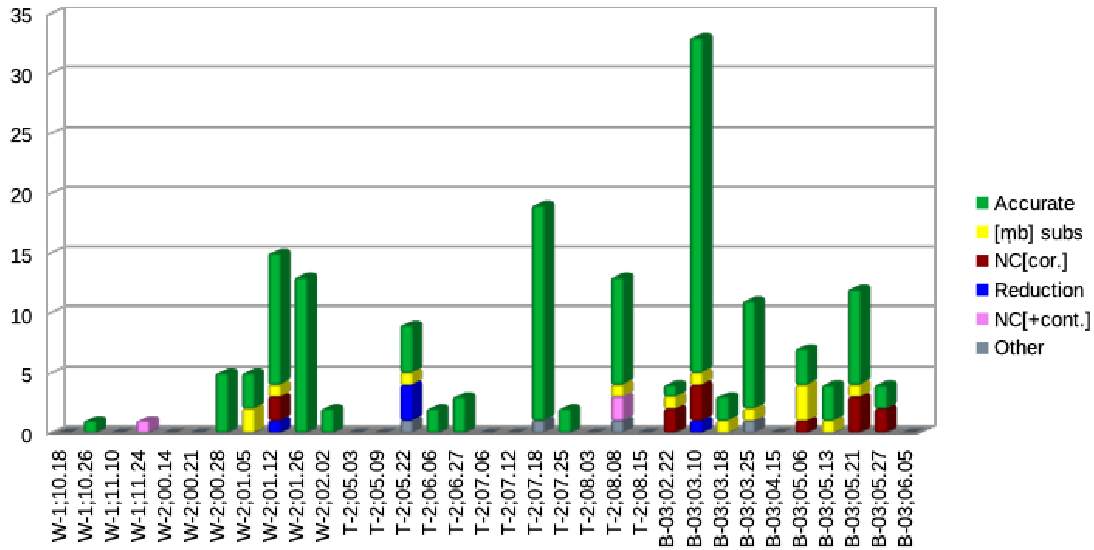
Figure 52: Target |m̩p| production for WTB



While W's and B's data are limited, they still reveal some trends. W produced |m̩p| sequences accurately in 6 out of 23 attempts (26%). His predominant pattern was |N̩C| sequence reduction, at a rate of 52% (12 out of 23 attempts). In comparison, B's attempts resulted in reduction to [b], which we already noted in Figure 50, hence he did not master target |m̩p|; he merely produced it three times, as [m̩b], [ɲ̩ʤ] and [ɲ̩ɲ].

The children's attempts at |m̩pʰ|, illustrated below in Figure 53, came in relatively low numbers for all the children. B had the highest number of tokens (n=78). The majority of his attempts at |m̩pʰ| resulted in deaspiration to [m̩p], at a rate of 60% (n=47). He also made noticeable coronal substitutions to [n̩t] in a single word, *mpha* |m̩pʰa| 'give me', which he produced between 3;02.22 and 3;05.27. The same word was produced with [m̩b] between 3;03.10 and 3;03.25. Recall in this context B's tendency to produce coronals for target |p|, as described in section 1.1 of this chapter, as well as his tendency to deaspirate target aspirated stops, as seen in section 8.

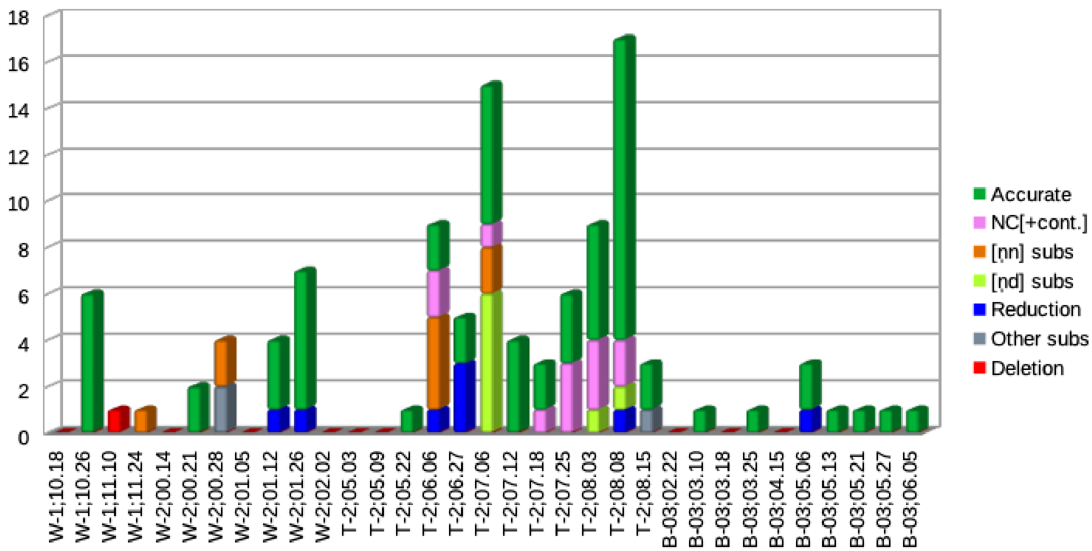
Figure 53: Target |m̩p^{h}| production for WTB



T, on the other hand, achieved the highest rate of accurate productions, at 79% (38 out of 48 attempts), in addition to a number of marginal processes. Lastly, W made the fewest attempts at target |m̩p^{h}| (n=42). Most of his productions were accurate, also with a few cases of deaspiration (10 out of 42 attempts).

We now turn to nasal+coronal sequences, which are illustrated in Figure 54 for target |n̩t| and |n̩t^{h}|. As stated earlier, these |N̩C|s are discussed as one unit because they displayed similar patterns. As we can see, these |N̩C|s were produced with higher accuracy rates than their nasal+labial sequences counterparts, by all the three children. Even though B displayed the fewest attempts at |n̩t| and |n̩t^{h}|, his productions were mostly accurate at 89% (n=9). This tendency to produce coronals with a high accuracy rate mirrors the productions of his singleton coronals |t| and |n| discussed earlier in this chapter in sections 1.2 and 4.3.

Figure 54: Target |ṇt| and |ṇtʰ| production for WTB



B's productions were also mostly accurate, at a rate of 89% (n=8), with marginal nasal assimilation and reduction. T, on the other hand, made the highest number of attempts at these consonants. She achieved 40 accurate productions out of 72 attempts (56%). She however displayed a high number of variable outcomes, with a noticeable pattern of lenition which yielded non-obstruent outcomes post-nasally (i.e., [ṇl, ṃv,[41] ṇr]), where [ṇt] and [ṇtʰ] were expected to surface. The data in (31) exemplifies this pattern.

(31) T's production of nasal+obstruent sequences: [ṇr], [ṃv], [ṇl] outcomes

Orthography	**Adult form**	**Child form**	**Gloss**	**Age**
nthaya	|ṇtʰaːja|	[ṇraː]/[ṇdaː]	'tell me'	2;06.06-2;07.06
nthekela	|ṇtʰɛkɛːla|	[ṇrɛkɛːla]	'buy me something'	2;06.06-2;08.15
nthotse/nthola	|ṇtʰʊːʦɛ|; |ṇtʰʊːla|	[ṃvʊːʦɛ]; [ṃvʊːla]	'took/taken off my accessories'	2;08.03
ntoga	|ṇtʊːχa|	[ṇlʊːχa]	'plait my hair'	2;06.06
ntapisitse	|ṇtapisiːʦe|	[ṇlapisiːʦe]	'made me tired'	2;07.06
ntoma	|ṇtʊːma|	[ṇlʊːma]/[ṇnʊːma]	'bite me'	2;08.08

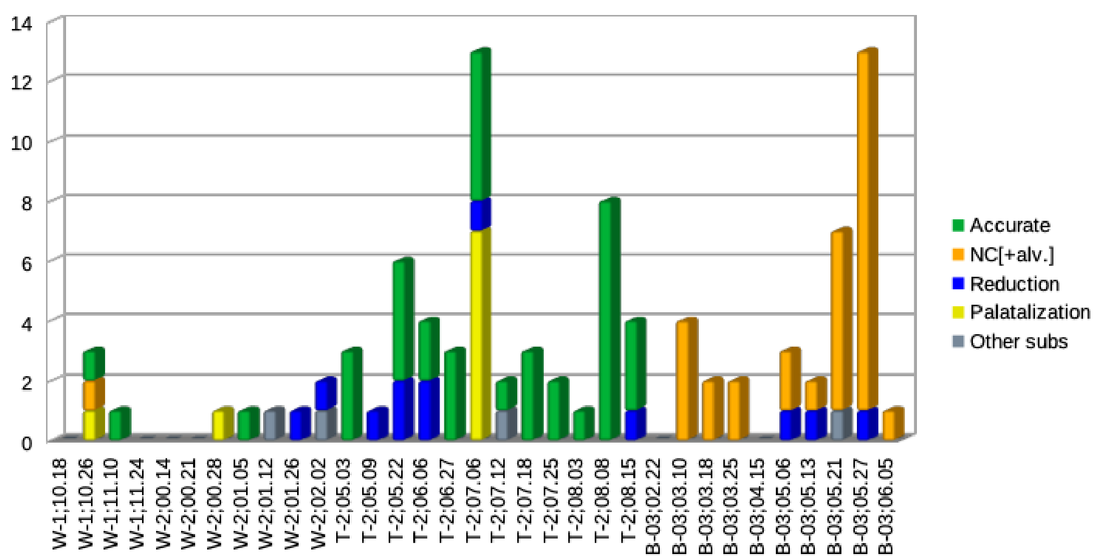
41 Note that T also displayed [ṃv] substitution patterns in her production of the word *nthwesa* |ṇtʰʷesa| with a labialized |ṆC| which she produced as [ṃvesa]/[ṃvʷesa]. This will not be discussed further because of limited data.

It appears that T displayed this behaviour only in the |N̩C| contexts. Recall from sections 1.2 and 8.1 that she did not substitute any of her singleton coronal obstruent stops with any of the continuant sounds.

10.2.2 Nasal+affricate sequences

Starting with |n̩ʦ| and |n̩ʦʰ|, illustrated in Figure 55, we see that T's productions displayed both structural and segmental accuracy in 35 out of 50 attempts (70%). Her spike in palatalization observed at 2;06.07 involved a single word, *ntshutela* |n̩ʦʰutɛːla| →[ɲ̩ʧʰutɛːla] 'make way for me'. W, on the other hand, displayed the fewest number of attempts. His tendency to randomly display palatalization in these data is also noted in his production of singleton affricates in earlier sections.

Figure 55: Target |n̩ʦ| and |n̩ʦʰ| for WTB

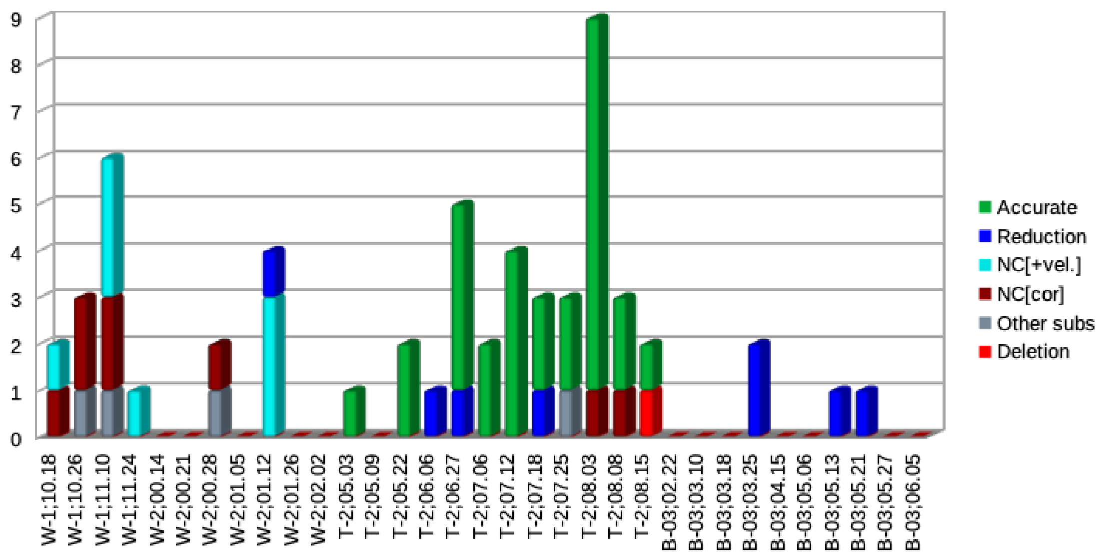


Lastly, B, whose productions of |N̩C| sequences were generally accurate from a structural standpoint, however displayed prominent alveolar stopping in his attempts at

|n̩ʦ| and |n̩ʦʰ|, in 30 out of 34 attempts (88%). This deaffrication pattern is in line with his production of singleton affricates, as we saw earlier in sections 3.1.2 and 3.1.3 for |ʦ| and |ʦʰ|, respectively.

Concerning target |n̩t͡ɬ|, illustrated in Figure 56 below, T was the only child to display accurate productions, in line with her productions of lateral |t͡ɬ|, described earlier in section 3.3.2.

Figure 56: Target |n̩t͡ɬ| production for WTB

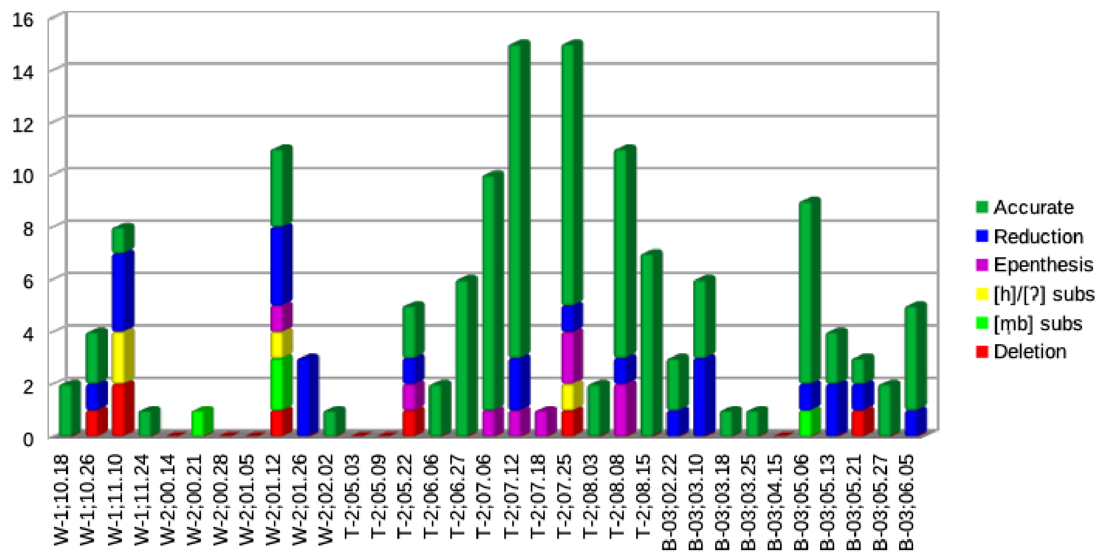


Concerning the boys, also in line with their performances on singleton |t͡ɬ|, their attempts at |n̩t͡ɬ| did not yield any accurate outcomes. For example, B's only four attempts all resulted in reduction to [t], while W substituted post-nasal |t͡ɬ| with mostly velar [k] and [kʰ] and coronal [t]. Recall from section 3.3.2 that B prominently displayed coronal substitution while velar and coronal substitutions were among W's patterns for target |t͡ɬ|. These patterns were attested in the following three words: *ntlo* |n̩t͡ɬʊ| 'house', *ntle* |n̩t͡ɬɛ̀| 'beautiful' and *ntle* |n̩t͡ɬɛ́| 'outside'.

10.2.3 Nasal+nasal sequences

Figure 57 shows WTB's production of target |m̩m|. Out of the 74 attempts made by T, 58 were accurate (78%), while the remainder involved vowel epenthesis, reduction to [b] and [m] as well as other more marginal processes.

Figure 57: Target |m̩m| production for WTB



B also displayed a relatively high rate of accurate productions for target |m̩m|, at 65% (22 out of 34). He however reduced |m̩m| to [m] seven times (24%) in three different words: *mma* |m̩ma|→[ma] 'ma'am' (3;02.22-3;06.05), *mmone* |m̩mɔːnɛ|→[mɔːnɛ] 'see him/her' (3;03.10-3;05.21) and *mmidi* |m̩miːdi|→[miːdi] 'corn' (3;06.05). Finally, W's productions displayed the lowest rate of accurate productions at 26% (8 out of 31). He randomly reduced target |m̩m| among cases of coronal substitution and debuccalization.

In summary, |N̩C|s were generally produced with high levels of structural accuracy while the component consonants underwent patterns similar to those observed in other sections. Therefore while the structure of an |N̩C| sequence might seem complex at first sight, none of its components truly is; the children, who had mastered each component independently in other contexts (e.g. able to produce nasals as well as obstruent stops), had no significant problem with the production of these sequences. This suggests that the acquisition of syllabic nasals of Setswana does not pose segment issues to child learners. In fact, the only areas of difficulties noted relate to segmental complexity, for example in the context of aspiration, already discussed above.

Table 17 summarizes the prominent patterns for |N̩C| sequences discussed in this sections.

Table 17: Prominent processes for |N̩C| sequence production

/N̩C/ sequence	Main patterns	Notes
/m̩p/	Acquired early	Limited data for W and B
/m̩pʰ/	Acquired early	Deaspiration for B
/n̩t/ and /n̩tʰ/	Acquired early	Post-nasal lenition for T
/n̩ʦ/ and /n̩ʦʰ/	Acquired early	Nasal+coronal stop substitution for B
/n̩t͡ɬ/	Not acquired	Velar |N̩C| substitution for W Reduction to [t] for B
/m̩m/	Acquired early	Reduction for WB

In the next section, we summarize the main observations gathered throughout the current chapter.

11. Chapter summary

In this chapter, we describe WTB's productions of obstruent stops, fricatives, affricates, nasal stops, laterals, rhotics, glides, labialized consonants as well as nasal-consonant sequences. Throughout these descriptions, our main interest was on the substitution patterns prevalent in the children's productions of these target speech sounds and sound combinations. The following trends emerged from the data.

- Obstruent stops were generally acquired early. One process however stood out, that of coronal substitution affecting labial and velar stops. While the process often occurred in consonant harmony contexts, it also took place independently of any other coronals within the words produced by the children, especially B and W.
- Obstruent fricatives presented with many errors and their mastery generally came later than for the obstruent stops. For example, target |s| was substituted the most through affrication and stopping. Common errors for target |f| production included [h]/[ʔ] debuccalization and stopping. On the other hand, target |h| and |χ| were produced accurately in a majority of the productions.
- Obstruent affricates commonly underwent deaffrication, mostly to stops, displaying the following tendencies: alveolar stopping for |ʦ| and |ʦʰ|, aspiration for |ʦ| in post-tonic syllables, palatalization of alveolar |ʦʰ|; nasal substitution, gliding as well as devoicing of |ʤ| to a number of affricates; and lastly, the tendency towards velar outcomes of lateral affricates |t͡ɬ, t͡ɬʰ| to result in velar consonants.
- Nasal stops |m, n, ɲ|, besides denasalization, were acquired early with marginal processes such as gliding by W, lateralization by B, and some palatalization by T.
- Lateral |l| was acquired early by B and T. W's attempts at |l| often resulted in gliding to [j].
- Rhotic |r| had the most variable productions in comparison to other segmental categories. Common processes included gliding by W, coronal stopping by T and lateral substitution by B.
- Glides
  - |j| was acquired later than |w| and it displayed frequent substitutions to [w] and [h].
  - |w| was acquired earlier in spite of noticeable debuccalization to [h] by T.
- |Cʷ|s were acquired later. The common errors affecting these consonants included delabialization to their base phones or to other non-labialized phones. Besides delabialization the base phones underwent substitutions similarly observed for their

non-labialized counterparts. However, |r^w| production noticeably resulted in full labial gliding (by W), something we did not observe with other base phones.

- |NC|s were acquired early and displayed very high accuracy rates. The post nasal consonants displayed similar substitution patterns observed for their singleton counterparts.
- Overarching phonological processes
  - Consonant harmony (progressive and regressive), was observed in the production of target stops |p| and |k|, fricative |s|, affricate |$\widehat{t\text{ɬ}}^h$| and glide |j|. This process was systematic for B, and more variable for W.
  - Post-tonic deletion was prevalent in the production of |j| by all children. The children mimicked the adult productions in their input therefore this pattern was not related to their segmental developmental.
- Table 18 presents a summary of the processes discussed in this chapter.

Table 18: Summary of phonological processes

Phone class	Sub-class	Processes	Overarching processes
Obstruent stops	Plain		Consonant harmony: coronal substitution for B
	Aspirated	Deaspiration	
Fricatives		Affrication and coronal stopping (for |s|): Debuccalization (for |f| and |χ|)	
Affricates	Non-lateral	Deaffrication Palatalization Nasal substitution and devoicing (for |ʤ|)	
	Lateral	Deaffrication	Consonant harmony: labial stopping for B
Nasals		Denasalization	
Laterals		Gliding	
Rhotics		Gliding, stopping and lateralization	
Glides	/j/	Substitution to [w] Debuccalization to [h]/[ʔ]	
	/w/	Debuccalization to [h]/[ʔ] Substitution to [j]	
/C^w/s		Delabialization	
	Stops and nasals	Delabialization	
	Fricatives	Stopping and affrication (Manner effects)	
	Lateral affricate	Backing (place effects) Stopping (manner effects)	
	Rhotics	Full labial gliding, lateralization, stopping Substitutions to non-rhotic |C^w|s	
/N̩C/s		Reduction Backing for |n̩t͡ɬ|	

Chapter 5: Data Analysis

As stated in the introduction chapter, the goals of the current study are, first, to identify patterns of segmental development in the speech of Setswana learning children and, second, to understand the origins of these developmental patterns. In this chapter, we discuss the phonological processes that have emerged in the speech productions of the three Setswana learning children under investigation. Given the relatively small sample size that the current descriptions rely upon, our analysis does not focus on developmental norms; the discussion to follow addresses the patterns observed from an essentially qualitative standpoint, with the aim of providing an understanding of the facts observed. As we will see, many of the patterns observed can be traced back to acoustic and articulatory properties of the Setswana language.

In Chapter 2, sections 1.4 and 2.7, we established the following foundational facts: (1) early on, children do not speak like adults do, yet their speech differs from adult speech in systematic, rather than haphazard ways; (2) there are phonological processes that are specific to child speech, in that they find no direct correlates in adult phonological systems, either that of Setswana or beyond. As established in the previous literature on the topic, phonological processes observed in child language are at times a by-product of children's own limitations in speech-motor control (Pater 1997; Inkelas & Rose 2003; McAllister Byun 2009; 2011; Rose & Inkelas 2011; Combiths et al. 2021) and with children's motor control maturation over a period of time, these processes ultimately get resolved (Inkelas & Rose 2007). As such, processes such as velar fronting, fricative gliding and consonant harmony involving major places of articulation, which lack counterparts in adult languages, can be best explained as limitations of children's speech developing systems (Inkelas & Rose 2007; McAllister Byun 2011), as opposed to be seen as unnatural or crazy phonological rules (Priestly 1977; Buckley 2003). We pursue this issue in section 1 below.

1. Segmental processes in the acquisition of Setswana phonology

Recall from the summary presented in Table 18, at the end of the previous chapter, that WTB's data displayed a number of production patterns affecting either the place, manner, or voicing dimensions of the different consonant classes which form the Setswana phonological inventory. Our aim in this section to attempt to uncover the factors which may have yielded the emergence of these patterns of segmental substitutions in the children's speech productions.

Following the outline of our data description presented in the previous chapter, we organize the present discussion by phonological classes, from obstruents to approximants, and then discuss issues affecting aspiration as well as secondarily articulated consonants. In this regard, because all target plosives (obstruents and nasals[42]) and |N̩C|s were generally acquired early by all the children, in spite of the production of the former being affected sporadically by the independent process of consonant harmony, our discussion begins with target fricatives in the following subsection, and ends with target $|C^w|$s in section 1.6.

1.1 Substitutions affecting target fricatives

Recall from section 2 of Chapter 4 that fricatives were one of the most variably produced sound categories in WTB's data. Recall also from Table 18 the asymmetries in

42 Despite their early acquisition, the production of nasal stops was also sporadically affected by consonant harmony.

production between coronal and non-coronal fricatives: attempts at the coronal fricatives |s| and |ʃ|[43] often resulted in (mainly alveolar) stops and affricates, while attempts at the non-coronal fricatives |f| and |χ| often resulted in debuccalization, mainly to [h] and more marginally to [ʔ].

From an acoustic point of view, fricative consonants are characterized by turbulent noise created by the partially obstructed airstream at the point of constriction. Across languages, the overall level of noise can be generally classified into two categories: louder, or strident, versus weaker, or non-strident. Between these two categories of fricatives, as these labels imply, the former involves noticeably higher sound energy (Stevens 1983: 251). According to Kim, Clements & Toda (2015), fricatives articulated within the alveolar and alveo-palatal places of articulation (e.g. [s, z, ʃ, ʒ, ʂ, ʐ, ʑ, ɕ]) and corresponding affricates can thus be assigned the phonological feature [+strident], while fricatives articulated in labial, interdental or palatal regions (e.g. [θ, ɸ, ð, ç, ʝ]) are featurally [-strident].

As established earlier in section 2.7 of Chapter 1, the substantial and systematic variability observed in the acquisition of fricatives is largely due to the fact that these consonants belong to the motorically more challenging category of controlled gestures (Kent 1992). As such their production requires highly controlled gestures and timing of tongue movement at the point of articulation (Kent 1992; Green, Moore & Reilly 2002). Among other details, strident fricatives involve controlling the airstream against the teeth (incisors), while the airstream inherent to the non-strident fricatives is generally more

43 Recall from section 2 of Chapter 4 that the fricatives |s| and |ʃ| were merged due to the fact that they displayed similar patterns.

distributed, following different articulatory configurations across different points of constriction (Kim, Clements & Toda 2015).

From an auditory perspective, as documented in Maddieson (1984: 50-51) and Ladefoged & Maddieson (1996: 175-176), one key difference between strident and non-strident fricatives indeed concerns the quality of the cues to place of articulation that these consonants carry within the speech signal (see, also, Jakobson, Fant & Halle 1952: 24, for an early discussion of this distinction). We attribute the asymmetry observed in the children's data, between |s, ʃ|, on the one hand, and |f, χ|, on the other, to this general difference between strident and non-strident fricatives, in particular concerning the types of cues to place of articulation that are auditorily carried by each type of fricatives (Maddieson 1984: 50-51; Ladefoged & Maddieson 1996: 175-176).

Under the emergentist approach to segmental development adopted in this dissertation, we argue that the auditory distinction between strident and non-strident fricatives has implications for the child learner, whose task requires, in part, to interpret the speech signal in order to map it into windows of articulatory implementation (McAllister Byun, Inkelas & Rose 2016: 147). In a nutshell, non-strident fricatives, due to their generally weaker auditory cues, are not as easy to interpret as strident fricatives. We claim that, consequently, while the children had no sizeable difficulty assigning a place of articulation to the strident (coronal) fricatives, they encountered more difficulty with the non-strident fricatives. In the absence of well-defined cues to place of articulation for these latter consonants, it took the children longer to sort through the cues carried by the non-strident fricatives; it is during this period that debuccalization to laryngeal consonants resulted in their productions.

In addition to issues in assigning place of articulation to the different consonants, the data also reveal patterns of stopping, which were more prominent in the coronal place of articulation than for the debuccalized consonants. We attribute this difference in the data to speech-motor articulatory constraints affecting the production of fricatives in the coronal versus laryngeal places of articulation. Indeed, the production of fricative continuancy in the coronal area requires a high level of control of the articulatory gestures and configurations. This is especially true considering the level of control involved in both tongue positioning and apex configuration to generate the fine constriction that generates turbulence within the airflow of a consonant like [s]. Achieving frication through laryngeal opening is arguably simpler, as it merely involves control of the glottal opening.

In sum, the asymmetrical patterns observed between coronal vs. non-coronal fricatives were primarily driven by the stridency distinction that characterize these different classes of phones. While the children had no difficulty assigning a place of articulation to the strident fricatives, they took longer to achieve the same with the non-strident fricatives. Concerning the substitution patterns observed at each relevant place of articulation attained by the child, issues in articulatory complexity enable an account for the fact that stopping was more frequent in coronal productions but less frequent in debuccalized outcomes.

Returning to the coronal place of articulation, as also noted in Table 18 of the preceding chapter, a portion of the target coronal fricatives were produced as affricates. As noted in the more detailed descriptions in section 2.2 of Chapter 4, the data also suggest that affrication represents a period of development closer to the mastery of fricative production than stopping does, in that whenever stopping and affrication are observed as two separate stages of development, stopping generally precedes affrication. Again, we adopt an articulatory stance in order to capture this observation. Note, first, that affricates are phonetically characterized by an initial stopping or constriction of air in the vocal tract followed by the release of the constriction after which a more prolonged period of frication is heard following the release (Ladefoged & Maddieson 1996: 90-91). Further, Stevens (1993) asserts that from an aerodynamic starting point, the production of affricates entails a two-stage constriction and release mechanism. The initial stage involves a transient rapid release following the closure usually executed at the anterior section of the vocal tract (i.e., corresponding to the stop portion of the affricate), while the second stage involves an interval of frication noise (i.e., corresponding to the fricative part of the affricate). Taking a more phonological stance, Chomsky & Halle (1968: 322) describe affricates as stops followed by delayed releases. Kim, Clements & Toda (2015) state that a stop is distinguished from an affricate by the fact that the former is simple while the latter is complex.

We argue that what can be described in terms of articulatory complexity can also be interpreted as a bridge between the more ballistic (less controlled) gestures involved in stop constrictions and the more controlled ones involved in fricative production, within each relevant place of articulation (Rose 2018b). This outlook on affricates offers a logical explanation for the patterns of affrication affecting target fricatives, given that affricates stand, in terms of manner or articulation, in between stops and fricatives. As the children were not initially able to fully reach the fine level of articulatory control involved in fricative production and, as such, would overshoot their lingual constriction in ways that were temporarily obstructing the airflow, this offered something comparable to an articulatory prop from which the constriction could be rapidly readjusted to obtain the target frication. In sum, we can interpret the rapid succession of fricative stopping and release typical of an affricate as a logical step toward control of the fine constrictions involved in the production of coronal fricatives. This analysis also captures the fact that while affrication commonly affected the children's target coronal fricatives, the same was not observed in the context of fricatives at other places of articulation. This analysis also sets the stage for our discussion of WTB's acquisition of affricates, in the next section.

1.2 Substitutions affecting target affricates

Recall from the section just above that affricates are generally analyzed as segments involving a complex manner of articulation, because of the quick transition they involve between stop closure and fricative release (Ladefoged & Maddieson 1996: 90-91). Perhaps in a paradoxical way, however, while the affricate release for target fricatives we discussed in the section just above may offer a transitory stage toward the attainment of fricative constrictions, the production of affricates still involves degrees of articulatory complexity which make these consonants difficult to realize in a consistent fashion in early speech production.

As we will see below, the complexity inherent to target affricates manifests itself in different ways across different affricates, depending among other factors on the particular type of affricate release, with a crucial distinction between non-lateral and lateral releases. We also saw throughout the data descriptions that, in their attempts at non-lateral affricates, the children displayed place behaviours generally in line with what we observed for fricatives in alveolar vs. alveo-palatal places of articulation. We discuss these observations in turn below.

1.2.1 Non-lateral affricates

We begin our discussion of the children's productions of affricates by focusing on non-lateral affricates, noting first that the fricative release of these consonants is phonetically strident (Stevens 1983). This implies that, from an auditory standpoint, these consonants offer relatively robust cues to the learner concerning their places of articulation. Recall from Table 18 that WTB all displayed some difficulties in their productions of non-lateral affricates (e.g. |ʦ|, |ʦʰ| and |ʧʰ|), which resulted in variable patterns of deaffrication, especially for W and B, as we saw in detail in section 3 of Chapter 4. The voiced affricate |ʤ| (described in sub-section 3.1.5 of that chapter) was the only affricate which WTB produced with gliding, among other processes generally implying lenition or weakening of the affricate. However, this process is arguably not developmental, in that lenition of voiced affricates is attested as a common process in adult languages (Recasens & Espinosa 2007), which is also the case in Setswana. Recasens & Espinosa (2007) state that, generally this process is phonetically motivated by the short duration of the closure phase typical of these affricates, in comparison to that of their voiceless counterparts, whose closure generally involves longer duration. While we are not aware of any scientific publication on the topic, we can attest that lenition does affect /ʤ/ in Setswana, in ways similar to that described by Recasens & Espinosa (2007). It is thus possible that the children had not identified these phonological targets as affricates in all cases, but rather interpreted the lenited form as their input. Independent of this issue is the more central observation that deaffrication of non-lateral affricates resulted in the vast majority of cases in coronal stops. We attribute the children's correct realization of the target place of articulation to the auditory salience (stridency) of these affricates.

Focusing now on manner of articulation, we claim that W's and B's stopping patterns resulted from their inability to execute the more complex stopping+fricative release sequence required in affricate production, which resulted in an articulatory simplification to the stopping gesture only. This is logical in that while affrication of target fricatives was a by-product of issues in gesture control, the children were not yet able to fully control the stop-fricative sequences of target affricates, arguably more complex, both phonologically and phonetically, as discussed above. In turn, this asymmetry in the children's patternings further reinforces our analysis of the target fricatives and the articulatory issues they involve.

We also observed that all the children generally displayed more palatalization for the aspirated targets than for the non-aspirated ones (i.e., |ʦ^{h}|~[ʧ^{h}]). According to Goldstein & Browman (1986); Maddieson and Ladefoged (1996) aspiration essentially entails timing between two types of speech movements, namely those controlling laryngeal settings and those controlling oral articulations, whose combination incorporates glottal abduction (opening) gestures. Consequently, the children had to learn to precisely coordinate these controlled gestures, which crucially do not correspond to basic or default articulations involved in obstruent production; voiced or plain voiceless consonants in fact come closer to these defaults, as documented in independent studies (Macken & Barton 1980; Lowenstein & Nittrouer 2008). This observation led Lowenstein & Nittrouer (2008) to state that difficulties in the production of aspiration are primarily rooted in children's productive abilities, rather than in their perceptual abilities, a position that we embrace fully in this current discussion (see also section 2.7 of Chapter 2). This is particularly true in the context of affricates, whose inherent complexity in terms of manner of articulation (i.e., stopping + fricative release) adds another layer of articulatory complexity. In light of this, we hypothesize that the children's preference for palatalization in their attempts at producing aspirated affricates was driven by an elevation of the tongue body (Ma et al. 2022). This can be interpreted as a consequence of the children's attempts to match the auditory cues corresponding to aspiration although we do not have independent evidence to support this hypothesis further. This additional hypothesis can only be verified through additional phonetic analysis, for example using palatographic (e.g. Gibbon 1999) or ultrasound imagery (e.g. Gick 2002), which transcend the scope of the current work. At a more basic level, this distinction also provided the children with a way to differentiate their productions of aspirated affricates from that of plain ones.

1.2.2 Lateral affricates

Turning now to the target lateral affricates |t͡ɬ| and |t͡ɬʰ|, we begin with the expectation that the auditory properties of these non-strident affricates should yield more difficulty for the children's perceptual identification of the consonants' place of articulation. This is particularly true for lateral release of these affricates, characterized by a generally low amplitude second formant (F2) (Ladefoged & Maddieson 1996: 206), which is the formant that plays a central role in the auditory identification of place of articulation. These phonetic facts alone likely explain the typological observation that lateral affricates are cross-linguistically rather uncommon (Maddieson 2005: 39). Indeed, as

Maddieson (2005:39) reports, out of the 567 languages of the World Atlas of Language Structures (WALS) online database (https://wals.info/chapter/8), the languages with lateral affricates present in their phonemic inventories only represent a marginal 4.4% (n=25). Further, we note that coronal+lateral sequences of speech articulations generally display a blurry contrast with similar velar+lateral sequences (Hallé et al. 1998; Hallé & Best 2007; Davidson & Shaw 2012).

In spite of this, recall from section 3 that T was generally proficient at producing target lateral affricates. In this respect, T displayed a higher level of phonological productive abilities than B or W, also in line with most other observations noted throughout Chapter 4 about T's more advanced level of phonological development, compared to the two boys, during the period of observation. On the other hand, B's and W's attempts at lateral affricates generally resulted in deaffricated outcomes, most commonly to coronal stops.[44] In addition, W displayed optional substitutions to velar [k].

While the coronal deaffricated outcomes are in line with the children's overall patterns of articulatory simplification for target affricates already discussed, we argue that the optional velar substitutions observed in the data must instead be captured in terms of auditory cues. First, as reported above, cues to place of articulation displayed through non-strident frication are generally more diffuse than those displayed through strident frication. Second, as mentioned in the previous paragraph, coronal stop+lateral sequences may also yield perceptual cues confusable with that of velar stop+lateral sequences. Indeed, experimental evidence suggests that these two sequences are

44 Recall from the same section that in addition to coronal stopping, B also produced labial stopping for the lateral affricates, which was triggered by consonant harmony.

highly confusable in perception (Davidson & Shaw 2012). For example, Hallé et al. (1998), Pitt (1998) and Hallé & Best (2007) show that /tl/ and /dl/ sequences, which are phonotactically impermissible in word-initial positions in languages such as French or English, generally tend to be perceived by speakers of these languages as /kl/ and /gl/, respectively. Note that these scholars state that the speakers' misperceptions must relate at least in part to the fact that French and English listeners are phonotactically biased against /tl/ and /dl/ clusters, given the absence of such sequences in their languages. However, these speakers never associate individual alveolar stops or laterals to velar segments. The perception of /tl/ and /dl/ sequences as involving a velar place of articulation is thus crucially a result of these sounds (coronal stop+lateral) being strictly adjacent within the string.

While Setswana learners are evidently exposed to different speech phonotactics than are English or French speakers, and in particular to the presence of genuine lateral affricates in Setswana, these learners nonetheless face the challenge to auditorily interpret the lateral affricates as truly coronal, especially given the presence of actual velar consonants within the language. In light of the relative confusability of coronal stop+lateral sequences, it is thus not surprising that at least a portion of the target lateral affricates present in the input were misinterpreted by the children as involving a velar place of articulation. Indeed, as stated by Davidson & Shaw (2012), the phonotactics of a language are not the only triggers of perceptual illusion; other triggers which are not language specific, such as acoustic similarity, may also yield perceptual confusion. For example, fricative-initial sequences may lead to prothesis illusions; stop-nasal sequence may lead to the illusion that the initial consonant is either not present in the string or is present in some modified form, while stop-stop sequences may lead to vowel epenthesis. Building on the research above based on adult speakers of French and English as well as on our own observations from the acquisition of Setswana lateral affricates, we add to this list alveolar stop+lateral sequences as potential triggers of velar place perception. This hypothesis also dovetails with the typological observation reported above that /tl/ and /dl/ sequences, either as consonant clusters or, in the case of Setswana, as lateral affricates, are hardly attested in the phonological inventories of the world's languages (Hallé et al. 1998; Maddieson 2005).

This concludes our discussion of target affricates. We discuss substitutions affecting target laterals in the next section.

1.3 Substitutions affecting target laterals

Laterals are sounds whose production is characterized by "lingual contact (made with the anterior tongue tip or blade in the anterior region of the oral cavity) along the midsagittal line such that air flows along one or both sides of the tongue" (Narayanan, Alwan & Haker 1997:1064). In addition to the lateral airflow, the production of these sounds entails simultaneous constriction or retraction of both the tongue tip and tongue body/dorsum during the production of the lateral (Sproat & Fujimura 1993; Narayanan, Alwan & Haker 1997). The lateral of Setswana can be described in relatively lay terms as a 'clear' /l/, similar to that found in languages such as French, German or Spanish, also in comparison to the 'darker' lateral allophone of English. The production of the Setswana lateral thus involves a less retracted part of the tongue body making the apical contact (Giles & Moll 1975) if compared to the darker flavours of /l/, whose production involves a more retracted tongue body, at times with no apical contact (Giles & Moll 1975; Sproat & Fujimura 1993).

Given the lingual properties of Setswana /l/, it is not surprising that attempts at this consonant prominently resulted in gliding to [j]. As we can recall from Table 18 of Chapter 4, this gliding pattern was the only prominent pattern affecting /l/ production independently of consonant harmony. This gliding pattern for target laterals is also attested widely in the acquisition of laterals in other languages (e.g. Acevedo 1993; Goldstein 2007; Jiménez 1987; Macken 1978; Perez et al. 2018; Rose & Wauquier-Gravelines 2007; Rose, Almeida & Freitas 2022; Yamaguchi 2012). As discussed in Rose, Almeida & Freitas (2022: 22), /l/-to-[j] substitutions enable the child to maintain the coronality and voiced approximant nature of the target consonant during the stage when the arguably more intricate lateral articulation has not yet been mastered. Indeed, as stated by Gick et al. (2007:2-4), children tend to use simplification strategies for lingually complex sounds such as the liquids /r/ and /l/, resulting in gestural omission whereby one (or more) gesture(s) involved in the production of the target phone is (are) omitted during production. For example, the production of clear /l/ entails simultaneous positioning of the tongue-tip behind the alveolar ridge as well as the retraction and dropping of the tongue dorsum inside the oral cavity. On this basis, gliding to [j] simply implies an incomplete tongue apex gesture toward the alveo-dental point of articulation, the outcome of which also yields continuous airflow around the tongue body, however without the lateral resonance.

As we will see in the next section, articulatory simplification is also involved in the case of the other liquid of Setswana, the rhotic trill /r/. However, due to the phonetic differences that this consonant presents, for example in comparison to the lateral just described, the substitutions affecting the rhotic follow a range of different patterns.

1.4 Substitutions affecting target rhotics

Rhotics, just like laterals, are characterized by complex speech articulations. According to Ladefoged & Maddieson (1996: 216), rhotics are classified according to the following manners of articulation: trill (e.g. [r] and [ʀ]), tap or flap (e.g., [ɾ], [ɽ], [ɺ]), fricative (e.g. [ʁ]), approximant (e.g. [ɹ], [ɻ]) (Ladefoged & Maddieson 1986; 1996: 216). Skipping over the fine details differentiating these various rhotics, one key observation is that the production of these consonants requires high levels of articulatory precision and timing, including the manipulation of tongue body configurations required for bending, rolling or vibrating (Kent 1992: 57), as we describe further below. As established earlier in Chapter 1, section 2.1.2, the rhotic of Setswana is an apical trill, a consonant whose articulation it characterized by the precise fine-tuning of the tongue tip articulation (Ladefoged & Maddieson 1996; Barry 1997). As discussed in Ladefoged & Maddieson (1986: 217):

> The primary characteristic of a trill is that it is the vibration of one speech organ against another, driven by the aerodynamic conditions. One of the soft moveable parts of the vocal tract is placed close enough to another surface, so that when a current of air of the right strength passes through the aperture created by this configuration, a repeating pattern of closing and opening of the flow channel occurs. [...] In its essentials this is very similar to the vibration of the vocal folds during voicing; in both cases there is no muscular action that controls each single vibration, but a sufficiently narrow aperture must be created and an adequate airflow through the aperture must occur. The aperture size and airflow must fall within critical limits for trilling to occur, and quite small deviations mean that it will fail. [See also Sole, Ohala & Ying (1998: 2923) and Solé (2002).]

The articulatory complexity inherent to apical trills, and the many pitfalls it implies, as highlighted through this long quote, offer an explanatory basis to the variability in trill production observed not only in WTB's data but cross-linguistically as well.[45] According to Jiménez (1987) and Vihman (1996), apical trills are cross-linguistically known to be difficult to produce not only for children, who master them late, but also for adult second language learners.[46] As stated in Solé (2002: 656), this entails performing "muscle contraction of the tongue to assume the position, shape and elasticity requirements, and a sufficient pressure difference across the lingual constriction". Aerodynamic conditions are indeed crucial in the production of trills, in addition to placing the relaxed tongue tip such that it critically touches the alveolar zone (e.g., Sole, Ohala & Ying 1998: 2923; Solé 2002: 656). While the child should be able to attain the coronal place of articulation without obvious problems, failure to meet one or many of the tongue configurations described above may variably result in approximant, fricative or even stop productions. These three outcomes are indeed robustly attested in WTB's data. Recall from Table 18 of Chapter 4 that WTB's production of |r| variably resulted in gliding, coronal stopping and lateral substitution.[47] Gliding to [j] was prevalent for W; coronal stopping was commonly observed in T's productions, while B displayed a sizeable proportion of lateral substitutions in his attempts at |r|. These patterns are also in line with cross-linguistic observations of child language productions: Gliding to [j] is also noted for Swedish and

45 Interestingly, despite these difficulties, dental and alveolar trills are among the commonest sounds observed cross-linguistically. They also constitute 99.1% of all the trills attested in the world's languages (Maddieson 1984).

46 Of all the trills, dental/alveolar trills are the only ones which are generally missing from children's babbles (Stark 1980; as cited by Sole, Ohala & Ying 1998: 2923).

47 Recall also from Chapter 4, section 6, that some of W's and B's patterns also involved consonant harmony processes.

Spanish, while [l] substitution as well as more marginal stopping are robustly attested in Hungarian, Slovenian and Icelandic child speech (Bernhardt & Stemberger 2018).

In summary, WTB were similar to children learning rhotic trills across languages. They were generally proficient at realizing the correct place of articulation of the target consonant but experienced difficulty with the realization of the evidently complex manner dimension. Each of the main production variants observed in WTB's data and in the literature more generally is also predictable given the many ways in which speech articulations and related aerodynamic control can break down during attempts at producing this rhotic trill. As stated in Sole, Ohala & Ying (1998: 2923), "understanding the trade-offs between articulator movements and aerodynamic forces, and their acoustic result is essential for accounting for the phonological behaviour of trills, for speech pathology, and for articulatory modelling and synthesis".

We conclude the current discussion by touching briefly on aspiration as a whole, through a summary of the points discussed above in the context of stop and affricate target consonants, and the acquisition of secondary labial articulations across different consonants of Setswana.

1.5 Deaspiration of aspirated stop and affricate targets

Recall from Table 15 in section 8 of Chapter 4, that WTB's productions of target aspirated obstruent stops and affricates resulted in place effects similar to those discussed above as well as an overall shift in laryngeal productions to plain (unaspirated) outcomes. This general trend toward deaspiration was commonly displayed by W and B, also under our general observation that T displayed an overall more advanced level of phonological development than the boys. We claim that the boys' general deaspiration pattern resulted from their inability to produce the relevant amount of aspiration at the release of stops and affricates, under the understanding that the type of laryngeal control required in the production of aspiration involves a higher level of articulatory complexity than that involved in the production of plain obstruents.

Indeed, as discussed earlier, aspirated releases are inherently more challenging to produce than plain releases, due to fact that aspiration requires accurate timing between articulatory movements controlling both laryngeal settings and oral articulations (Goldstein & Browman 1986; Ladefoged & Maddieson 1996). This observation and related understanding are in line with observations about the acquisition of aspiration in English; during early stages of development, English-learning children indeed lack the type of articulatory sophistication required to accurately aspirate obstruent stops (Macken & Barton 1980; Lowenstein & Nittrouer 2008). As already stated in section 1.2.1 of the current chapter, this analysis is also compatible with Lowenstein & Nittrouer's (2008) argument that the development of aspiration in speech production is primarily constrained by articulatory constraints rather than auditory ones.

1.6 Delabialization affecting |C^w| targets

The production of labialized consonants entails lip protrusion (rounding) and simultaneous raising of the back of the tongue (Ladefoged & Maddieson 1996), with these articulatory gestures immediately consecutive to the release of the primary articulation of the consonant. As we can recall from Table 18 of Chapter 4, attempts at |C^w|s by WTB commonly resulted in delabialization, or articulatory simplification to the base phones, for virtually all of the target labialized sounds investigated. We also noted that the delabialized base phones generally patterned similar to their non-labialized target counterparts, for example with stopping and affrication commonly affecting fricatives, or gliding and lateralization attested in attempts at target rhotics.

However, attempts at labialized rhotics also yielded cases of full labial gliding (|rʷ|→[w]). We analyze this pattern as a general simplification, in the form of a merger, between the different auditory components of the target phone. As the children were coping with the manner of articulation of the rhotic, which they prominently produced as a glide, the labial place of the target phone was preserved in those cases, effectively assimilating the resulting phone to this place of articulation.

This completes our discussion of the main patterns of segmental substitution observed WTB's production data. We summarize the most central points of this discussion in the next section.

2. Chapter Summary

In this section, we summarize the discussion above concerning the sources of WTB's substitution patterns affecting fricatives, affricates, laterals, rhotics, glides as well as labialized consonants. As stated earlier, all target obstruents, nasals and nasal-consonant sequences were generally acquired early by all the children, hence their omission from this discussion.

Independent of overarching patterns of consonant harmony, prosodic factors such as stress, and patterns of post-tonic deletions, we have observed that the general CV structure of Setswana does not yield particular issues of structural complexity affecting development. Recall from section 10 of Chapter 4 that the patterns of deletion in post-tonic contexts are in line with attestations of the same patterns in adult speech; while this topic could be studied in terms of the acquisition of an optional or gradient phonotactic rule in the language, it does not directly contribute to our understanding of segmental development, the central theme of the current dissertation. Rather, the most central facts in WTB's data revolve around the production of different sound classes.

As we saw throughout the discussion above, all the substitution patterns observed in noticeable numbers can be captured through a consideration of the auditory properties of the target speech sounds, combined with an understanding of the types of articulatory gestures involved in the production of these sounds. We argued that these combinations have implications for the child-learner. The following explanations emerged from our analyses:

Concerning the fricatives, we attributed the asymmetric behaviours WTB displayed in their production of coronal (strident) and non-coronal (non-strident) fricatives to auditory differences between these two types of fricatives, especially in terms of the perceptibility of their respective places of articulation. While strident fricatives offer well defined cues to place of articulation, non-strident fricatives in comparison offer weaker, more diffused cues, which are therefore more difficult for the children to interpret.

WTB also displayed an asymmetry involving more prominent stopping for coronal fricatives (i.e., |s| and |ʃ|) than for their non-coronal counterparts (i.e., laryngeal |h| and uvular |χ|). We attributed this asymmetry to speech-motor articulatory constraints, which are predicted to affect speech production differently across different places of articulation. In the present case, the data clearly suggest that attaining the controlled gesture required toward fricative constrictions is arguably more difficult with the tongue tip or blade than it is in the context of dorsal or laryngeal constrictions.

Concerning the production of target affricates, WTB's error patterns generally reflect issues of articulatory complexity inherent to the affricate manner of articulation, through the rapid sequencing of a stop constriction followed by either a fricative or a lateral release of this constriction. In this view, deaffrication to only the simpler of these gestures imposes itself as the predicted outcome, during the stage when the children are unable to produce both gestures in a tight sequence. Beyond this general simplification process, we also observed that the place of articulation of target affricates was better preserved in attempts at non-lateral than at lateral affricates. We attributed this distinction to perceptual factors inherent to these two types of affricates. This auditory analysis also enabled an understanding of the velar substitutions variably affecting the production of lateral affricates, which we capture in terms of a general perceptual effect inherent to coronal stop+lateral sequences.

Turning to the target lateral |l|, gliding to [j] was the most prominent substitution pattern, which naturally dovetails with the lingual properties of the Setswana /l/. This substitution enables the children to maintain both the general manner and place of articulation of the target consonant during the stage when they have not yet developed the arguably more complex lateral gesture of the target (Gick et al. 2007; Rose, Almeida & Freitas 2022). These observations suggest that, perceptually, WTB did not have a problem with interpreting |l|, the only issue was in their lack of mastery in articulating the intricate lateral gesture (i.e., completing the tongue apex gesture towards the alveo-dental point of articulation which resulted in continuous airflow around the tongue body instead).

Similarly, the children's development of the rhotic apical trill /r/ requires a high level of lingual articulatory precision in addition to a high degree of aerodynamic control. In line with robust cross-linguistic observations, WTB were only able to maintain the coronality of the trill, while their control of manner lacked in various respects, resulting in glided (mainly W), lateralized (mainly B), and stopped (mainly T) outcomes.

Still in the area of airflow control, we observed general trends in the data toward the deaspiration of stops and affricate targets, in relative independence of the children's productions of the target phones, which patterned essentially in ways similar to their non-aspirated target counterpart.

Finally, WTB's acquisition of target $|C^w|$s initially resulted in delabialized versions of the target consonants, with other segmental processes observed generally in line with the non-labialized counterparts of the target phones. One exception to this is the rhotic $|r^w|$, which optionally underwent a fuller merger, resulting in labial glide productions ($|r^w| \rightarrow$ [w]).

We discuss the general implications of this work, also with a focus on practical applications, in the next chapter.

Chapter 6: Conclusion

Our study set out to provide a detailed analysis of the phonetic and phonological development of three Setswana speaking children, WTB. As established earlier, the aim of the study was not to provide normative data, but to understand early patterns of segmental development in Setswana by uncovering the factors yielding their emergence in the children's speech productions.

This research had the following three main motivations: Firstly, to document facts about Setswana phonetic and phonological development such as patterns affecting the early acquisition of the sounds specific to the language. Secondly, the opportunity to analyze these phenomena through current models of phonological emergence, with an emphasis on the phonetic (perceptual and articulatory) factors which may influence the development of sounds and sound classes during Setswana child language development. Thirdly, to set an initial foundation towards developing speech-language pathology materials and services for Setswana learning children, an emerging area of public service in Botswana. We discuss these three topics in turn in the sections that follow.

1. Setswana segmental development

Concerning the first motivation, we described the substitution patterns prevalent in WTB's productions of target obstruent stops, fricatives, affricates, nasal stops, laterals, rhotics, glides, and labialized consonants. We also studied the development of /N̩C/ sequences. The following trends emerged from our data: (1) early acquisition of obstruent stops and nasals; the same holds true within the context of /N̩C/ sequences, where the substitution patterns observed were essentially in line with those observed on singleton consonants outside of these sequences; (2) variable production of fricatives characterized by various substitution patterns such as stopping and affrication affecting coronal fricatives, and debuccalization affecting non-coronal fricatives; (3) simplification (e.g. deaffrication) of affricates to stops. Non-lateral affricates also yielded fewer errors (and earlier mastery) than their lateral counterparts, whose production displayed, among other patterns, an unexpected pattern of delateralization to velar [k], in addition to deaffrication. The target approximants |j, w| and |l, r| were generally acquired early, with the exception of the rhotic |r|, whose production, as we saw in section 6 of Chapter 4, was the most variable of all consonants documented in this study, also yielding the lowest accuracy rates for all the children.

Previous studies on Setswana, Sesotho, isiXhosa, Swahili, isiZulu and Akan only focused on substitution patterns and their related developmental milestones, rather than on the origins of these patterns (Mahura 2014 and Mahura & Pascoe 2016; Demuth 1992; 2007; Mowrer & Burger 1991; Lewis 1994; Tuomi, Gxhilishe & Matomela 2001; Gangji 2012; Naidoo et al. 2005 and Amoako 2020). In addition to supplementing these earlier studies from an empirical perspective, especially through our focus on children younger than three years of age, the current study offers a unique contribution towards explaining the actual origins of the substitution patterns observed in the data. We summarize these analyses next.

2. The origins of the patterns observed

Concerning the second motivation, we discussed in Chapter 5 some of the most central phonetic and phonological factors we consider to be behind the substitution patterns affecting the sounds noted above. We employed a general emergentist framework (e.g.

MacWhinney 2015), as conceived within the area of phonology through the A-map model (McAllister Byun, Inkelas & Rose 2016), to provide an understanding of the patterns of segmental substitution observed in the data. According to the A-map, child-specific phonological patterns are rooted in the anatomical and motor-control differences that exist between young children and adults. These patterns may also be influenced by auditory aspects of speech perception. It is on this basis that the current dissertation highlights how the most prominent substitution patterns observed in the data can be captured through a consideration of the auditory properties of the target speech sounds, combined with an understanding of the types of articulatory gestures involved in the production of these sounds. These analytical elements in turn highlight some of the most central aspects of the general challenges faced by the child toward learning the auditory-articulatory mappings that form the segmental inventory of the language. For example, we observed different behaviours between two types of target fricatives: the strident |s| and |ʃ| and the non-strident |f| and |χ|. The strident fricatives prominently displayed patterns of coronal stopping, while their non-strident counterparts prominently displayed debuccalization. We also observed differences in behaviours between the non-lateral affricates |ʦ|, |ʦ^h| and |ʧ^h| and the lateral affricates |t͡ɬ| and |t͡ɬ^h|. The non-lateral affricates were systematically substituted to coronal stops, while the production of the lateral affricates was more variable for all three children, noticeably with optional velar stopping to [k].

We analyzed the difference between strident and non-strident fricatives through the fact that stridency provides well defined auditory cues to place of articulation. In comparison, non-strident fricatives display more diffuse cues to place of articulation which as such, are more difficult for the learner to interpret. Following a similar logic, we documented perceptual effects affecting coronal lateral consonantal sequences suggesting the auditory perception of such sequences as involving velar place of articulation.

Also noted were simplification patterns affecting articulatorily and acoustically complex sounds. These include deaffrication to stops, deaspiration to plain stops, as well as delabialization of /C^w/ consonants to their base phones. Beyond phonetic considerations such as these, children displayed categorical, phonological behaviours and learned structures relevant to the language consistently across different contexts (onsets vs. |ṆC| sequences; aspirated vs. non-aspirated consonants).

There are however limitations inherent to the current study that should be addressed in future research. First, data collection was supposed to be conducted in two phases: Phase 1 (April – September 2019) and phase 2 (April – September 2020). However, phase 2 could not take place due to Covid-19 travel restrictions imposed at the time. This impacted our initial intentions to carry out follow-up observations, which would have provided additional data, for example on the persistence of given phenomena, or on the children's relative rates of improvements between the end of the first phase and the beginning of the second phase. Second, future research should explore the following areas: (1) understanding the origins of processes such as nasal and affricate palatalization, rhotic lenition, and better understand issues in lexical development in light of the phonological exceptions that this process seems to yield sporadically across the dataset; (2) contextualizing the data for individual children, for example, why the girl displayed a more advanced level of phonological development than the boys; (3) understanding other processes which relate to phonological and morphological interactions, including the emergence of proto-morphemes, the children’s acquisition of optional processes observed in the adult language such as post-tonic deletion, and the emergence of consonant harmony patterns; (4) verification of our results, coupled with a determination of the relative prominence of the phonological processes we observed in the data (and/or additional phonological processes), toward the establishment of developmental norms for young Setswana speakers; (5) to this latter goal we add the development of linguistically relevant and culturally appropriate lists of words and associated educational and clinical tools, a topic we address more broadly in the next section.

Finally, as any corpus-based study of linguistic datasets never can exhaust the set of topics that may arise from even broad observations about the data, we decided to open the current corpus, which we recently published in open-access format through the PhonBank database (https://phon.talkbank.org/access/Other/Setswana/Matlhaku.html). It is our hope that additional scholars will find interest in these data, which we also plan to keep investigating in the future, as mentioned in different parts of the current dissertation.

3. Toward speech services

Toward the establishment of speech services for Setswana-learning children, this study offers a useful first step. As mentioned already, our emphasis was on uncovering the origins of the phenomena observed within our dataset, with a special focus on patterns of segmental substitution. While this study is not normative, a goal that would transcend the current methodology, also in light of the pandemic-related restrictions mentioned above, it highlights the phonological and phonetic factors driving speech development in young learners. This study thus offers a series of starting points toward the design of materials and services for speech-language pathology, an emerging area of public service in Botswana. This is particularly relevant under the consideration that positive speech treatment outcomes are often linked to the early detection of speech disorders, to the direct benefit to young children presenting with such disorders (McCleod 2007; Gxhilishe 2008; Gangji, Pascoe & Smouse 2014; Rose and Stoel-Gammon 2015).

This also holds true of the analytic approaches we took toward pattern combinations, especially in words presenting with consonant harmony. In a nutshell, by identifying and isolating the harmonizing words, we can more easily focus on word forms that do not display this phenomenon and, thus, be in a better position to determine whether the child is independently capable of producing the target sounds.

It is our hope that, by building on this and the related works cited above, we can move forward with the establishment of speech services for Setswana speakers, still in their infancy in Botswana. This work may also be adaptable to the related language Sesotho spoken in neighbouring Lesotho, given the many similarities between these two languages.

To the best of our knowledge, there are no speech-language pathologists (SLPs) trained to work specifically with monolingual Setswana-speaking children who present with instances of speech sound disorders. Furthermore, trained SLPs in Botswana are typically English-speaking with little or no proficiency in the Setswana language and culture.[48] In this context, our study can be used to help the development of phonological

48 The SLPs are typically stationed in either big towns or the capital city, compounding the issue of accessibility.

speech tests in Setswana, as it highlights areas of difficulties displayed by typical learners.

Again here, our published corpus data provides a starting point towards supporting further studies of Setswana phonetic and phonological development. This contribution will directly enable scholars to gain direct access to the data (audio recordings and their corresponding transcripts), and expand on the current findings and analyses. It is indeed our hope that both these data and the analyses formulated above will propel our understanding of the origins of child speech patterns not only in Setswana, but in other languages as well.

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Appendix 1: Informed consent form to the caregivers (Setswana translation)

This appendix presents the Setswana version of the informed consent form which was given to the children's parents/caregivers prior to allowing the children to take part in the study.

Foromo ya tsamaiso ya botsaya-karolo

Setlhogo:	Phonological Development in Setswana-speaking children
Modirapatlisiso:	Keneilwe Matlhaku Department of Linguistics Memorial University of Newfoundland St John's NL Mogala: +1 709-685-2244 / +267-7210-9495 E-mail: kmatlhaku@mun.ca
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Ngwana wa gago o lalediwa go tsaya karolo mo thuto-patlisisong e, e e bidiwang, "Phonological Development in Setswana-speaking children."

Foromo e, e ya go itsese mokgwa wa tsamaiso le tumalano ya botsaya-karolo. Gape e go tlhalosetsa ditshwanelo tsa gago fa o batla go ntsha ngwana wa gago mo go tseyeng karolo. E tshwanetse go go sedimosetsa tsamaiso ya patlisiso, le mokgwa yo botsaya-karolo jwa ngwana wa gago bo tlileng go tsamaisiwa ka teng. E go tlhalosetsa le tshwanelo e o nang nayo ya go ikgogela morago. Pele ga o tsaya tshwetso ya go dumalana le gore ngwana wa gago a tseye-karolo mo thuto-patlisisong e, o tshwanetse go tlhaloganya bodiphatsa le bomosola jwa go tsaya-karolo ga gagwe, gore se se go thuse mo go tseyeng tshwetso e e maleba e e kgotsofatsang. E ke yone tsamaiso ya go go itsese ka ga botsaya-karolo. Tsaya nako go e bala ka kelotlhoko le go tlhaloganya dintlha tsotlhe tse o di fiwang. Fa o na le dipotso kana o batla ditlhaloso mabapi le patlisiso kana botsaya-karolo jwa ngwana, pele o dumalana gore a tsaye-karolo, o kopiwa go itshwaraganya le modirapatlisiso ebong Keneilwe Matlhaku.

Ditshwetso tsotlhe tsa go dumalana le botsaya-karolo jwa ngwana wa ga gago mo patlisisong e, di dirwa ke wena ebile di tswa mo go wena. Fa o sa ka seke wa dumela gore ngwana wa gago a tseye karolo mo patlisisong e, kgotsa wa mo gogela morago patlisiso e ntse e tsweletse, ga o na go amiwa ke ditlamorago kana welwa ke diphatsa dipe, ka nako ya teng kgotsa mo nakong e e tlang.

Ikitsiso ya modirapitlisiso:

Ke moithuti mo lephateng la Linguistics kwa Yunibesithing ya Memorial kwa Canada. Dithuto tsame di itebagantse le mokgwa wa ka fa bana ba ba nnye ba ba santseng ba ithuta teme kana diteme tsa bone tse ba tsholelwang mo go tsone ba ithutang bo bua ka teng. Go tsamaisa le go diragatsa patlisiso yame, ke tshwanetse go rekhota kana go gatisa mantswe a bana ba, dinako tse di farologanyeng ka go lekalekana, mo sebakeng se se leele. Go tlhomamisa thulaganyo, tsamaiso-sentle le boleng jwa tiro e, kgatiso ya mantswe e tla dirwa fela ke modirapatlisiso kana mothusi wa gagwe, mo sebakeng sa dikgwedi tse nne ka dinako tse di farologanyeng.

Maikaelelo a thuso-patlisiso:

Dipatlisiso go tswa mo mhameng wa rona wa dithuto di supa gore mokgwa o bana ba ithutang diteme (puo) tsa bone, o tlhotlheledіwa thata ke diteme tse di dirisiwang kgotsa tse ba di utlwang/bonang di dirisiwa letsatsi le letsatsi mo mafelong a ba tshelelang ebile ba golela mo go one. Gore re supe/nopole dintlha kana diemo tsotlhe tse di tlhotlheletsang/gwetlhang tshimololo, thulaganyo, tsamaiso le kgolo ya puo mo baneng, ga mmogo le gore ditlhotlheletsi le diemo tse di ka amana gape le gore di berekisanya jang, re tshwanetse ra gatisa mantswe (rekhota) a bana ba ba farologaneng, ba ba buang diteme kana mefuta ya teme e e farologanyeng. Se se tla a dirwa ka maikaelo a go sekaseka setlha sengwe le sengwe sa thulaganyo, kgolo le tsamaiso ya go ka fa ba ithutang/anyang diteme tsa bone mo sebakeng se se rileng. Maduo a thuto-patlisiso ya mokgwa o, a mosola mo mehameng e e farologaneng. Lantha, re tlhoka maduo a go tswa ka megopolo e e tlhalosang thulaganyo ya mokgwa le tsamaiso ya go ithuta diteme/dipuo ga bana ba ba nnye. Megopolo e, thusa go tlhabolola dithuso le ditsamaiso tsa ba bongaka le tsa ba mhama wa thuto. Sekai, baitsaanape ba bongaka ba ba itebagantseng le tshekatsheko le kalafi ya matlhoko a lebaganeng le go tlhoka go bua sentle ka fa tshwanelong kana go tlhaloganya puo ba ka sekgoa ba bidiwang speech-language pathologists, ba tlhoka kitso e go kgona go dira ditshekatsheko le dikalafi tsa tse. Barutabana ga mmogo le botlhe ba ba itebagantseng le go tswa ka mananeo a tsa thuto a maleba, ba tlhokana le kitso e go thusa bana ba buang dipuo tse di farologanyeng ba tlhokang thuso ya mofuta o.

Ngwana wa gago o tlaabo a dira eng mo thuto-patlisising e?
Ka bokhutshwane ke kopa tetla mo go wena ya go rekhota thulaganyo, tsamaiso le mokgwa wa go ithuta Setswana ga ngwana wa gago mo lobakeng lwa dikgwedi tse nne (4). Ke kopa gape le tetla ya go dirisa kgatiso e ya lentswe la gagwe mo go direng ditshekatsheko tsa patlisiso e ga mmogo le tse dingwe mo isagong tsa mhama yo wa dithuto. Ke kopa go dirisa sekapa-mantswe go rekhota puisanyo magareng game le ngwana wa gago, beke le beke kana mo sebakeng sa dibeke tse tsedi, fa a dira dilo tsa tlwaelo tsa letsatsi le letsatsi jaaka fa a tshameka ka setshamekiwa (thoe) kana re lebile mmogo buka e nang le ditshwantsho. Ke tla a tlisa tsotlhe tse di tlhokegang mabapi le se, jaaka sekapa-mantswe, dibuka le ditshamekisiwa tse di tlaa abelwang ngwana wa gago kwa bofelelong jwa patlisiso e. Se ke se se tlaa diragalang, ke tlile go simolola ka go tshuba sekapa-mantswe mme puisanyo e tswelele sebaka sa oura kana ka fa tlase ga yone. Ke tsile go boelela lefoko lengwe le lengwe le le buiwang ke ngwana le le sa tlhaloganyesegeng, sekai, fa ngwana a re o a re, “ntša” abo a re “wawa”, tiro yame e tlaa nna go boeletsa lefoko la nnete la se a se bonang/se a lekang go se bua, ke re, “ e-e ke ntša”, kwa ntle ga go boeletsa lefoko “wawa” le ngwana a le dirisang kana go baakanya phoso e ngwana a e dirang.

Go tlhoka go bua mafoko sentle ga bana ke selo se se tlwaelesegileng ebile ke tlholego; ka jalo ba ithuta bo bua sentle fa nako entse e tsamaya, fa ba gola, ba ntse ba tsweletse ka go anywa le go oketsa botsipa jwa teme ya bone. Mafoko a ba iseng ba itse go a bua sentle a ke a tla a boeletsang, a tlaa thusa ka tshedimoso ya se ngwana a buang a ka sone ka nako ya fa go gatisiwa lentswe la gagwe. Re ka buisana ka sengwe le sengwe se o eletsang go se itse kana se se go gwetlhang, tlhobaetsang, nako le nako ya fa re kopana. Mo godimo ga go kgobokanya, go rulaganya, go gatisa, go ranolela mantswe a ngwana mo mokwalong, le go boloka dipuisanyo tse, ke tla a femela batsaya-karolo ka go sutlha tsotlhe tse di ka sedimosang botho jwa bone, tse di ka ba golaganyang le patlisiso e, jaaka maina a bone, mafelo le malatsi a dikgatiso di dirilweng ka one. Morago ga tse tshotlhe di sena go dirwa, modirapatlisiso o tlaa dira ditshekatsheko tse di itebagantseng le dintlha tse di tlhagelelang mo puong ya motsaya-karolo, kwa Yunibesithing ya Memorial. Ka tetlelelo ya gago, o (modirapatlisiso) tlaa abelana dikitso le dintlha ka ga tshekatsheko e, le bakaulengwe le baithuti ka ene mo mhameng wa dithuto tsa mofuta yo, ka tiriso ya maranyane a letlole la dikitso mo khompiutaeng (database) le le bidiwang PhonBank le le fitlhelwang mo lefelong la inthanete le: (https://phon.talkbank.org). Tiriso ya maranyane a, e fa baithuti le badiradipatlisiso ba bangwe tshono ya go aga le go tsweledisa ditshekatsheko tse dingwe tsa tlaleletso ba dirisa dintlha tsa patlisiso e.

Sebaka se patlisiso e, e se tsayang:

Jaaka go setse go boletswe fa godimo, patlisiso e tsile go tsaya sebaka sa dikgwedi tse nne-tlhano. Mo sebakeng se re tlaa bo re beile mo go wena; mo bopeloteleleng jwa gago, fa re rekhota ngwana a bua, mo sebakeng sa oura, beke le beke kana morago ga dibeke tse pedi. Kwa ntle ga se, re ka rulaganya bokopano, fa o na le dipotso kana o batla dintlha / tshedimoso mabapi le thulaganyo ya ithuta puo ga ngwana wa gago.

Dikatso/ditebogo:

Ka maswabi ngwana wa gago ga a na go dulelelwa go tsaya karolo mo patlisisisong e. Le fa go ntse jalo, o tla a lebogiwa ka P50,00 letsatsi lengwe le lengwe fa re tsile go mo rekhota. Se ga se tuelo, ke go supa malebo le go lebogela tshepo ya gago mo go rona ka go letlelela gore ngwana wa gago a tsee karolo mo patlisisong e. Gape re tla a go neela meruti yotlhe ya dikgatiso ga mmogo le mekwalo ya tsone, ka mofuta wa keletso ya gago (ele CD, mo khompiutareng kana mokwalo yo o porintilweng.

Go ikgogela morago mo go tseyeng karolo:
O gololesegile nako nngwe le nngwe go tsaya tshwetso ya go gogela morago mo go tseyeng karolo jwa ngwana wa gago patlisiso e ntse e tsweletse. Fa go ka diragala jalo, o tla a laola gore go dirwe jang ka dikgatiso tse di setseng di dirilwe: o ka re fa tetla ya go di dirisa mo ditshekatshekong tsa rona ga mmogo le go di anamisa (go sutlhilwe maina a maina a gagwe le tsotlhe tse di ka sedimosang botho jwa gagwe) mo letloleng la maranyane a dikitso mo khompiutareng la inthanete. Gape o na le tshwanelo, nako nngwe le nngwe go laola gore maduo a patlisiso e, a dirisiwe fela ke baithuti le badiri ba Yunibesithi ya Memorial, kgotsa, wa emisa le go itsa dikgatiso tsa ngwana wa gago go dirisiwa mo patlisisong e kana mo go tse di tla a dirwang mo nakong e tlang.

Bo-mosola jwa patlisiso e:
Ga gona tekanyetso ya bomosola jwa patlisiso e mo go wena kana mo ngwaneng wa gago. Le fa go ntse jalo, go na le kgonagalo e ntsi ya gore dinako tsotlhe tse dikgatiso di dirwang tsone di solegele ngwana molemo thata ka go rotloeletsa le go tlhabololela pele go ithuta puo ga gagwe. Patlisiso e, e na le mosola o tiileng mo mhameng wa Linguistics le maranyane a itebagantseng le mhama yo, mabapi le go tokafatsa ditsela le mekgwa ya go dira tiro ya mehama ya bongaka le ya tsa thuto. Sekai, go ithuta ka mokgwa o bana ba anyang/ ithutang teme ya bone ya ntlha kana ya bobedi ka one, go re thusa go itemogela le go tlhaola bana ba ba nang le kgwetlho kana ba ba bonya go kapa/anya puo ka tlhamalalo le ka fa mokgweng, mo go ba ba ithutang ka tlwaelo. Se se ga se reye gore gatwe ngwana wa gago o tlile go nna le dikgwetlho mo go ithuteng puo ga gagwe, selo sa konokono tiriso ya dikgatiso tse re di tsayang go tokafatsa mefuta ya ditsamaiso tse di teng tsa ka fa bana ba anyang/puo ya bone ya ntlha ka gone. Mefuta ya ditsamaiso e, e thusa go farologanya mokgwa o bana ba ithutang puo e nngwe (1) mo go ba ba ithutang tse pedi nako e le nngwe. Ke ka mokgwa wa kgobokanyo ya dithuto tse di farologanyeng tse di tswang mo maduong a dipatlisiso tsa mofuta wa e tshwanang le patlisiso e re ikaelelang go o dira e, e re fang bokgoni ebile o re baya mo seemong se se botoka sa go ka tswa ka mefuta ya ditsamaiso e le thulaganyo ya yone.

Gape, dithuto tse di fa barutabana jaaka ba ba rutetsweng dithuto tsa bana le tsa go ruta puo, maele le dintlha tsa konokono tse ba ka di dirisang ka natla go ruta bana ba diteme tse di farologanyeng.

Kgonagalo ya diphatsa tse di ka itemogelwang:
Gona le selo se le sengwe se re akanyetsang gore se ka diragala mo patlisisong e se ka na bakang gore gore ngwana a seka a phuthologa, sekai, go tlhoka go kgatlhegela se re eletsang go se dira jaaka go tshameka ka setshamekisi (thoe) kana go leba buka ya ditshwantsho, tse maikaelelo a tsone eleng go mo gwetlha gore a nne tlhaga go bua. Phuthologo le tlhokomelesego ya ngwana di tla pele, ka jalo, fa se se ka diragala, re tlaa emisa go dira kgatiso letsatsi leo, mme re e suteleletse kwa nakong e tlang fa ngwana a dumela go tsaya karolo.

Melawana ya khupamarama:
Dikitso/dintlha tse di tlaa tswang mo patlisisong e tseneletseng e, di tlaa gatisiwa, gape di supiwe le go begwa kwa diphuthegong-kgolo. Le fa go ntse jalo, tshedimoso ya botho jwa batsaya-karolo botlhe e tla a nna sephiri. Motsayakarolo mongwe le mongwe o tlaa bidiwa leina le eseng la gagwe, go timetsa motlhala o ka sedimoseng gore ke mang, gape, go tlaa sutlhiwa tshotlhe tse di fang tshedimoso ya botho jwa motsaya-karolo jaaka maina, mafelo le malatsi a go dirilweng dikgatiso ka one. Ka jalo tse tsotlhe ga di kitla di tlhagelela gope mo dikgatisong le mekwalo e e amanang le patlisisiso e.

Tshireletsego ya tshedimoso-botho:
Go ya ka mokwalo o o fa godimo, go tlaa dirwa ka natla go tlhomamisa gore maduo otlhe mabapi le patlisiso e, a tlaa bipa ka botlalo tsotlhe tse di ka sedimosang botho jwa batsaya-karolo botlhe.

Kgatiso ya dikitso tsa patlisiso:
Dikitso le dintlha mabapi le dipatlisiso di tlaa gatisiwa ka tiriso ya sekapa mantswe, ka gore tshomarelo kitso ka tiriso ya sekapa mantswe e botlhokwa thata mo ditsamaisong tsotlhe tse di amanang le patlisiso e, go simologa ka ntlha ya go thusa go fetolela puo mo mokwalong, go dira ditshekatsheko ka tiriso ya maranyane a tseneletseng a maleba,

go meta mokgwa/boleng jwa puo jo bo utlwelwang thateng mme bo le mosola mo dithutong tsa thulaganyo -tsamaiso ya go anya/ithuta puo.

Go boloka dikitso tsa patlisiso:

Dikitso tsotlhe gotswa mo patlisisong tse di gatisitsweng, di tla a bolokwa mo khompiutareng-kgolo ka tiriso ya senotlolo sa maranyane a a sireletsegileng, mo ntlong ya ditiro tsa maranyane (Speech Science and Language Acquisition Laboratory) kwa Yunibesithing ya Memorial. Fa re sena go fetsa go dira tiro yotlhe e amanang le patlisiso (jaaka, go fetolela puo mo mokwalong le go dira tsa tshireletso tshedimoso ya botho) re tlaa bo re sutlha dikgatiso tsotlhe tse di supang maina a batho, mafelo le matsatsi a dikgatiso tse di didrilweng ka one. Nna le motlhokomedi wame (supervisor) ke rona fela kwa Memorial ba re tlaa bong re kgona go bona dintlha le dikitso tsa patlisiso. Foromo e, le tshotlhe tse di tshwanang le yone, di tlaa bolokwa mo lefelong le sele, di lotleletswe mo kobotlong e e mo ofising ya motlhokomedi wame kwa Memorial, se ele go hema gore di amanngwe le dikgatiso tsa patlisiso a mmogo le mokwalo wa dikgatiso wa one. Difaele tsa patlisiso tse di sutlhilweng maina le sengwe le sengwe se se ka senolang batsayakaarolo di tlaa tsenngwa mo letloleng la maranyane a dikitso mo khompiutaeng gore di kgone go dirisiwa mo isagong. Se se tlaa dirwa fela ka tetlelelo ya gago.

Go bega maduo:

Maduo gotswa mo patlisisong e, a tla a gatisiwa ele bontlha bongwe jwa dithuto a digerata tsa maemo a Doctorate kana Master’s; dipego kwa diphuthego-kgolo, dipampiri tse di tlhagelelang mo dijenaleng, dibuka le go tlhagelela kwa mafelo a mangwe a a nang le kgatlhego ya dipatlisiso tsa dithuto tsa thulaganyo ya go ithuta puo ga bana. Fa go kgonagala, dipego tse tsa maduo a patlisiso di tla a bewa mo motlobong wa dibuka kana di tsenngwe mo maranyaneng a inthanete gore di kgone go bonwa batho mo sechabeng lefatshe ka kakaretso. Jaaka go setse go boletswe fa godimo, maina a batsayakarolo ga a kitla a tlhagelela mo dipegong tse.

Go begela batsaya-karolo maduo a patlisiso:

Re tla a go fa dikgatiso tsotlhe ga mmogo le mokwalo wa tsone, go ya ka mokgwa wa keletso ya gago. Se se tlaabo ele sesupo sa sennelaruri se se kayang thulaganyo le tsamaiso ya ditiragalo tsa botlhokwa tse ngwana wa gago a di fitlheletseng fa a ne a ithuta puo mo lobakeng lwa tiragalo ya patlisiso e. O gololesegile/amogelesegile go mpotsa sengwe le sengwe, nako nngwe le nngwe ka dipego tse dintšha tsa maduo a dipatlisiso tse di tlaa dirwang mo isagong (dinakong tse di tlang).

Dipotso:

O amogelesegile go botsa dipotso nako nngwe le nngwe pele ga ngwana a tsaya karolo, kana nako e ntse e tsweletse kgotsa fa patlisiso e sena go wediwa. Fa o batla go itse go le go ntsi ka patlisiso e, itshwaraganye le:

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Mogopolo-mogolo wa patlisiso e, o sekasekilwe ke ba ofisi ya "Interdisciplinary Committee on Ethics in Human Research" (ICEHR) mme wa dumelelwa gore o setse molao wa Yunibesithi ya Memorial, wa dira le go tsamaisa dipatlisiso. Fa o na le matshwenyego mabapi le patlisiso e, kana ka fa e tsamaisiwang ka teng, jaaka mokgwa yo o tserweng ka teng kana ka fa ditshwanelo tsa gago di tserweng ka teng ole motsayakarolo, o kopiwa gore o itshwaraganye le Modulasetilo wa ICEHR ka e-mail kwa icehr@mun.ca kana ka mogala kwa nnomoreng ya: +1 709-864-2861.

Sesupo sa tetlelelo ya ngwana go tsaya-karolo:

Go saena kana go baya monwana wa gago mo foromong e go raya gore:

- O badile dintlha ka ga patlisiso e.
- O kgonne go botsa dipotso ka ga patlisiso e.
- O kgotsofaletse dikarabo tsotlhe tse di mabapi le dipotso tse o di boditseng.
- O tlhaloganya gore patlisiso e ke ka ga eng, le gore ngwana o tla a bo a dira eng.
- O tlhaloganya gore o gololesegile go ntsha ngwana wa gago mo botsaya-karolong, kwa ntle ga go fa mabaka. Se ga se kake sa go ama ka gope mo bogompienong kana mo isagong.
- O tlhaloganya gore fa o emisa botsaya-karolo jwa ngwana wa gago patlisiso e ntse e tsweletse, modirapatlisiso o tla a tsaya dikgatiso tsotlhe tse di setseng di gatisitwe mo nakong e o, fa e se o ka supa keletso ya gore o batla go di tsaya.
- O tlhaloganya gore fa o ka tsaya tshwetso ya go ntsha ngwana wa gago mo botsaya karolong jwa patlisisong e morago ga e sena go wediwa, kgatiso ya dintlha le tshedimoso tsa puo ya ngwana di kgona go ntshiwa mo patlisisong le morago ga dingwaga tse tlhano patlisiso e sena go wela.

Ke dumalana le gore lentswe la ngwanake le gatisiwe	☐ Ee ☐ Nnyaa
Ke dumalana le gore maina a rona le ngwanake a bipiwe a seka a sedimosiwa mo dikgatisong tse di mabapi le puo ya ngwanake kgotsa yame	☐ Ee ☐ Nnyaa
Ke fa tetla ya gore dintlha/dikitso tse di kgobokantsweng mabapi le patlisiso e, di bolokwe, ele bontlha-bongwe jwa letlole la maranyane a enthanete mo khompiutareng la PhonBank, mme di dirisediwe dipatlisiso tsa dinako tse di tlang, tsa dithuto tsa thulaganyo ya go ithuta puo ga bana.	☐ Ee ☐ Nnyaa

Go baya monwana kana go saena foromo e, ga go reye gore o ikamoga ditshwanelo tsa gago, gape gago re e gore moradipatlisiso a itlhokomolose go dira tiro ga gagwe ka manontlhotlho, a setse tsamaiso morago.

Monwana wa gago o tlhomamisa:

- ☐ Ke badile gore patlisiso e ke ka eng, ebile ke tlhalogantse diphatsa le bomosola jwa yone. Ke nnile le nako go ikakanya ka se. Ke nnile le tshono/sebaka sa go botsa dipotso gape le dipotso tsame di arabilwe.
- ☐ Ke dumela go tsaya karolo mo patlisisong e ke tlhaloganya diphatsa le seabe sa botsayakarolo jwa ngwanake; gore ke file tetla ke sa patelediwa gore a tseye karolo, le gore ke kgona go mo gogela morago mo go tseyeng karolo.
- ☐ Ke filwe moruti (khophi) ya foromo e go e ipolokela.

________________________________ ________________________________

Monwana wa motsaya-karolo Letsatsi/kgwedi/ngwaga

Monwana wa modirapatlisiso: ______________________________

Ke tlhalositse patlisiso e le tsamaiso ya yone ka botlalo le bojotlhe jwame. Ke letleletse/lalediste dipotso gape ke file dikarabo. Ke dumela gore motsayakarolo o tlhaloganya ka botlalo sengwe le sengwe ka ga patlisiso e, kgonagalo ya diphatsa tse di ka diragalang mo patlisisong e. Motsayakarolo o dumetse gore ngwana wa gagwe a tseye karolo mo patlisisong e, a sa patelediwe.

________________________________ ________________________________

Monwana wa modiradipatlisiso Letsatsi/kgwedi/ngwaga

Appendix 2: Informed consent form to the caregivers (English version)

This appendix presents the English version of the informed consent form which was given to the caregivers prior to allowing the children to take part in the study.

Title: Phonological Development of Setswana-speaking children

Researcher: Keneilwe Matllhaku
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Tel: 709-685-2244
E-mail: kmatlhaku@mun.ca

Supervisor: Dr. Yvan Rose, Professor
Department of Linguistics
Memorial University of Newfoundland
St. John's NL A1B 3X9
Tel: 709-864-2332
E-mail: yrose@mun.ca

You are invited to take part in a research project entitled “Phonological development of Setswana-speaking children.”

This form is part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. It also describes your right to withdraw from the study. In order to decide whether you wish to participate in this research study, you should understand enough about its risks and benefits to be able to make an informed decision. This is the informed consent process. Take time to read this carefully and to understand the information given to you. Please contact the researcher, Ms. Keneilwe Matlhaku, if you have any questions about the study or would like more information before you consent.

It is entirely up to you to decide whether to take part in this research. If you choose not to take part in this research or if you decide to withdraw from the research once it has started, there will be no negative consequences for you, now or in the future.

Introduction:
I am a student within the Department of Linguistics at Memorial University. I specialize in how children acquire their first or second languages. In order to perform my research, I must collect audio-video recordings of their speech productions at regular intervals, over long periods of time. In order to ensure the validity of these recordings, they must be performed by the child's caregivers (e.g. parents, nanny) at regular intervals, and for approximately two years.

Purpose of the study:
Research in our field shows that the way in which children develop their languages is greatly influenced by the languages and dialects that are used in their everyday environments. In order to identify the exact factors that influence a child's language development, and how these factors may interact with one another, we must record different children from different language backgrounds, and study their language development over a long period of time. The results from this type of study help us in many areas. First, we need these results to build theories of language acquisition. These theories in turn support the refinement of clinical and educational applications. For example, speech-language pathologists rely on this work to diagnose and treat speech disorders. In a similar way, teachers and people responsible for the design of educational programs rely on this knowledge to address the needs of children with different language backgrounds.

What you will do in this study:
In practical terms, I am requesting your help to record your child's language development over an extended period of time, and your permission to use the

recordings for current and future research in the field. I am asking you to audio-video record your interactions with your child every two weeks, while doing normal activities such as playing with quiet toys or looking at picture books with him/her. I will supply you with all of the equipment as well as with picture books and a set of toys, which you can simply add to your child's current belongings. In addition to running the camera for approximately one hour each time, my only request is that your repeat your child's word productions each time they may be difficult to understand by a third person. For example, if a child says "wawa" for "giraffe", all you need to do is say something like "that's right, a giraffe", without either repeating the child's own pronunciation or attempting to correct your child's production. Mispronunciations of words are perfectly normal for children to do; they will learn the correct pronunciation as they get older and more experienced with their language. Your adult repetition of their production will help us identify what s/he was talking about at the time of the recording. I will meet with you periodically to pick up the memory cards containing the recordings. We can discuss any detail you may be interested in, or concerned with, each time we meet. We will then engage in processing these recordings. Aside from doing transcriptions required for my own analysis, I will make sure to remove all names of persons and place and dates from the recordings, so as to make sure that my resulting corpus is fully anonymized. After these steps are completed, the researcher will perform linguistic analyses based on your child's data at Memorial University and, with your permission, share these anonymized data with other researchers in the field, using a web-accessible database system called PhonBank (https://phon.talkbank.org). Using this system, other researchers and students will be able to access these anonymized data to perform additional analyses.

Length of time:

As mentioned above, the study may involve up to two years of your commitment, with the goal of obtaining a one-hour recording every week or two weeks. Additional time commitments involve the researcher periodical meetings over the phone or skype and the research assistant either at your home or elsewhere (wherever convenient) to carry out the recordings and/or pick up the memory cards containing your recordings and, if needed, discuss observations or questions you may have about your child's language learning process.

Compensation:

We offer P50,00, as a token of appreciation, per the time you spend recording your child. We will also give you full copies of your recordings and, at a later time, the textual transcripts of these recordings. We will offer you both the recordings and the transcripts in the format of your preference, for example in computer or DVD format (or both) for the recordings, and in computer or printed format (or both) for the textual transcripts.

Withdrawal from the study:

You can decide to stop your participation to this study at any time. If you were to decide to stop your participation, you would also be able to decide what we can do with the recordings already performed: you could either give us permission to perform research based on these recordings and/or to published them (still in anonymized format) to the web-accessible database. You also have the right, at any time, to either restrict research to Memorial University only, or to completely withdraw the recordings of your child from any ongoing or future study.

Possible benefits:

There are no measurable benefits to your child or yourself for participating in this study. However, it is possible that your child will be exposed to a linguistically stimulating environment in the context of data recording.

The benefits of this study more concretely relate to research in linguistics and related applications for the improvement of both clinical and educational approaches to language. For example, by studying how children acquire their first and/or second languages, we are in a position to better tease apart typically-developing children from children with speech impairments. As we have absolutely no reason to think that your child will encounter difficulties in the development of his/her language, we plan on using the recordings to refine current models of typical language development. These models are also useful to distinguish how monolingual versus multilingual children acquire their language. It is through the accumulation of different studies such as the one we intend to conduct with your child that we are in a position to build these models, and to provide child and/or language educators with the information they need to adapt their teaching methods to children with different linguistic backgrounds.

Possible risks:

The only conceivable risk inherent to our study proposed relates to moments when your child may be uncomfortable, for example not interested in the types of activities (e.g. playing with quiet toys or looking at picture books) that we encourage you to do to stimulate him/her to speak. Keeping your child's well-being in mind, each time this may happen, we recommend that you do not insist on performing these activities and postpone them until your child is again willing to engage in them.

Confidentiality:

The data from this research project will be published and presented at conferences. However, the identity of every person recorded will be kept confidential. Every participant to the recordings will be given a pseudonym, and all identifying information (names of persons, places, and dates) will be removed from both the media recordings and associated transcripts.

Anonymity:

In accordance with the above statement, every reasonable effort will be made to ensure that every outcome of this research ensures the full anonymity of all of the participants involved.

Recording of data:

The data will be audio-video recorded, as access to both the audio and the video information is necessary for virtually all steps involved in this research, from the transcription of the speech productions to their analysis using specialized software program to measure fine properties of speech which are not detectable by the human ear but are useful for the detailed study of speech acquisition. The video information will help our overall understanding of your child's speech productions as well as other means of communication that s/he might use (e.g. pointing, mimicking, etc.).

Storage of data:

All of the recorded data will be stored on an encrypted (password-protected) server system located within the Speech Science and Language Acquisition Laboratory at Memorial University. As soon as we have completed every task related to data transcription and anonymization (as described above), we will securely erase the original recordings containing the names of persons, places and dates. Only myself and students and/or research assistants involved in this work will have access to these data. The consent forms (i.e. this document) will be stored in a separate location, in a locked cabinet located in my personal office at Memorial University, in order to prevent any association between these forms and the recorded data and associated transcripts. Only the anonymized versions of these files will be contributed to the scientific database for further research, and only under your explicit permission.

Reporting of results:

The results emerging from this and future research may be published as part of Masters or Doctoral theses, conference presentations, journal articles, books, or other venues interested in research on language acquisition. Whenever possible, these publications will be accessible to the public, for example as part of library collections or via the Internet. As mentioned above, none of these reports will contain personally identifying information.

Sharing of Results with Participants:

A side benefit is that we will provide you the full set of data recordings and related transcripts, in the format of your choice, which will form a record of the milestones of language development achieved by your child during the course of the study. You will be welcome to inquire with me at any time to obtain updates about future research outcomes.

Questions:

You are welcome to ask questions at any time before, during, or after your participation in this research. If you would like more information about this study, please contact:

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St John’s NL A1B3S7

Tel: 709-685-2244
Email: kmatlhaku@mun.ca

Dr. Yvan Rose, Associate Professor
Department of Linguistics
Memorial University of Newfoundland
St. John's NL A1B 3X9

Tel: 709-864-2332
E-mail: yrose@mun.ca

The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University’s ethics policy. If you have ethical concerns about the research, such as the way you have been treated or your rights as a participant, you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at 709-864-2861.

Consent:
Your signature on this form means that:

- You have read the information about the research.
- You have been able to ask questions about this study.
- You are satisfied with the answers to all your questions.
- You understand what the study is about and what you will be doing.
- You understand that you are free to withdraw participation in the study without having to give a reason, and that doing so will not affect you now or in the future.

- You understand that if you choose to end participation **during** data collection, any data collected from you up to that point will be retained by the researcher, unless you indicate otherwise.
- You understand that if you choose to withdraw **after** data collection has ended, your data can be removed from the study up to five years after the end of the data recordings.

I agree that my child and I be audio-video recorded	☐ Yes ☐ No
I agree to the use of anonymized direct quotations produced by my child or by me	☐ Yes ☐ No
I allow data collected as part of this research to be archived as part of the PhonBank web-accessible scientific database for future research on language acquisition	☐ Yes ☐ No

By signing this form, you do not give up your legal rights and do not release the researchers from their professional responsibilities.

Your signature confirms:

☐ I have read what this study is about and understood the risks and benefits. I have had adequate time to think about this and had the opportunity to ask questions and my questions have been answered.

☐ I agree to participate in the research project understanding the risks and contributions of my participation, that my participation is voluntary, and that I may end my participation.

☐ A copy of this Informed Consent Form has been given to me for my records.

______________________________ ______________________________

Signature of participant Date

Research assistant's/Researcher's signature:

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

________________________________ ________________________________

Signature of Principal Investigator Date

Appendix 3: Caregivers' assessment of the children's language background

This appendix presents a caregiver's questionnaire (in Setswana) assessing children's knowledge of general concepts.

Research Title: Phonological Development in Setswana-speaking children

Parent Questionnaire

Tsweetswee re bolelele puo/teme eo e dirisang kwa gae/lwapeng:

- Setswana
- English /Sekgoa
- Dipuo tse dingwe tsa mo Botswana

Leina la ngwana: ___________________________________
Puo/teme ya kwa gae: _______________________________
Matsalo: ____
Dingwaga: ____
Bong: ____
Letsatsi la gompieno: _______________________________

Dikaelo: Tsweetswee bala mafolo a latelang ka mabapi le botsipa jwa go itse puo ga ngwana wa gago. Sekaseka seele sengwe le sengwe ka kelotlhoko mme o dire letshwao la (✓) mo teng ga bokoso (✓) e, kana go bapa le yone seemo ka botlalo sa go itse go bua ga ngwana wa gago.

1. Ngwanake o itse go bua medumo ya mafoko sentle:

- ☐ eseng ka bontsi
- ☐ ka bontsi
- ☐ medumo yotlhe

2. Ke tlhaloganya se ngwanake a se buang:

- ☐ Ga ke tlhaloganye gotlhelele
- ☐ Ke mo tlhaloganya go le gonnye
- ☐ Ke mo tlhaloganya nako tse dingwe
- ☐ Ke mo tlhaloganya ka nako tshotlhe

3. Ngwanake o tlhaloganya se ke se buang:

- ☐ Ga a tlhaloganye gotlhelele
- ☐ O tlhaloganya go le gonnye
- ☐ O tlhaloganya nako tse dingwe
- ☐ O tlhaloganya ka nako tshotlhe

4. Ngwanake o tlhaloganya se batho ba bangwe ba se buang:
   - ☐ Ga a tlhaloganye gotlhelele
   - ☐ O tlhaloganya go le gonnye
   - ☐ O tlhaloganya nako tse dingwe
   - ☐ O tlhaloganya ka nako tshotlhe

5. Sekaseka mafoko a a latelang ka botlalo a a dirisediwang go fa lesedi kana go kaya go itse puo ga ngwana wa gago. Ka jalo o kopiwa go tshwaya (✓) mafoko a o kileng wa utlwa ngwana a dirisa, mme o seka wa tshwaya a o iseng o utlwe a dirisa kana a bua. Se se botlhokwa mo thutong e, ke mafoko a ngwana itseng go a bua.

   <u>Ela tlhoko</u>: jaaka ele tlwaelo, ngwana wa gago o kgona go bua mafoko mangwe ka tsela e e sa tshwaneng le a kwadilweng fa tlase a, mme mafoko a gagwe a le mabapi le mafoko a. Sekai, fa are "yotho" kana "lotho" fa a leka go bua are *borotho*, "kgotsa "kako" a re o are *setlhako*, se se kaya kitso ya gagwe ya lefoko/mafoko a, ka jalo a tshwae gore o a itse. Se se supa gore ngwana o itse gape o setse a tlhaloganya mafoko a le ntswa a ise a itse go a bitsa sentle ka fa tshwanelong.

   <u>Tsiboso:</u> Mafoko a ke mafoko a go tlwaelesegileng gore bana ka go farologana ba setse ba itse. Le fa go ntse jalo se tshwenyege fa ngwana wa gago a itse a le mmalwa fela mo nakong e. Se ga se supe gore gona le bothata ka go ithuta puo ga ngwana.

(A) DIPHOLOGOLO TSA MO GAE, DINONYANE LE DITSHIDINYANA

☐ koko	☐ segogwane	☐ ntša
☐ ntsi	☐ nonyane	☐ katse
☐ tshoswane	☐ tlhapi	☐ pitse
☐ notshi	☐ khudu	☐ nku
☐ mmutla	☐ pidipidi	☐ tonki
☐ serurubele	☐ podi	☐ kgomo
☐ peba		☐ kolobe

(B) DIPALANGWA (TSA NNETE KANA DITSHAMEKISIWA)

☐ eropleine	☐ terena	☐ terekere
☐ selei	☐ base	☐ sekepe
☐ baesekele	☐ sekuta	☐ llori
☐ helikoptara	☐ koloi	

(C) MAFOKO A TLHALOSANG TIKOLOGO

☐ kwa ntle	☐ mmu	☐ metsi
☐ naledi	☐ tlhaga	☐ phefo
☐ maru	☐ lewapi	☐ ngwedi
☐ pula	☐ swinki	☐ garawe
☐ mosi	☐ setlhare	☐ letlapa
☐ letsatsi	☐ sethunya	☐ lentswe
☐ folaga	☐ seolo	

(D) DIJO

☐ apole	☐ borotho	☐ mmidi
☐ tlhapi	☐ aesekhirimi	☐ coke
☐ dijo	☐ lephutshe	☐ manoko
☐ panana	☐ kheikhi	☐ digaugau
☐ namune	☐ popoaese	☐ metsi
☐ dinawa	☐ dikherotse	☐ mae
☐ tapole	☐ jeme	☐ yokate
☐ bisikitsi	☐ letswai	☐ tamati
☐ legapu	☐ motogo	☐ morogo
☐ chokolete	☐ jusi	☐ salate
☐ mashi	☐ tirinki	☐ botoro
☐ supu (sopho)	☐ chapisi	☐ chickene
☐ nama	☐ swiitsi	☐ khabeche
	☐ dichipisi	

(E) MAFOKO A BOTSANG

☐ kae	☐ jang
☐ mang	☐ leng
☐ eng	☐ ka goreng

(F) DIDIRISIWA TSA MO LAPENG

☐ kobo	☐ radio	☐ boratšhe jwa meno
☐ poleiti	☐ bokoso	☐ sejana
☐ lebotlele	☐ boratšhe	☐ foroko
☐ sepache	☐ lebone	☐ watšhe
☐ beisane	☐ khantlele	☐ galase
☐ tafole	☐ sekere	☐ senepe
☐ dikhii	☐ kgamelo	☐ digalase
☐ sekamo	☐ emere	☐ mosamo
☐ kopi	☐ sesepa	☐ foune
☐ setilo	☐ loswana	☐ molemo

(G) MAFOKO A TLHALOSANG

☐ tsamaile	☐ lwala	☐ nnye
☐ ya	☐ thubega	☐ tshoga
☐ kgora	☐ mogote	☐ tlhokomela
☐ tlala	☐ molelo	☐ lefifi
☐ thulametse/thulamela	☐ thubegile	☐ modumo
☐ tsogile	☐ otsela	☐ tenega
☐ montle	☐ tshwerwe ke tlala	☐ lapile
☐ siama	☐ bonya	☐ metsi
☐ botoka	☐ utlwa botlhoko	☐ fedile
☐ itumetse	☐ borethe	☐ ntšha
☐ bokete	☐ sekono	☐ lebelo
☐ leswe	☐ tsididi	☐ ka pele

(H) MADIRI

☐ nwa	☐ kokota	☐ penta
☐ bala	☐ bona	☐ relela
☐ tsamaya	☐ kgotlhokgotsha	☐ tlhapisa
☐ ja	☐ akanya	☐ apaya
☐ kgweetsa	☐ kuka	☐ khurumela
☐ taboga	☐ jesa	☐ tshela
☐ palama	☐ rata	☐ ema ka dinao
☐ thuba	☐ latlhela	☐ nna fatshe
☐ roba	☐ kapa	☐ bereka
☐ tlola	☐ senka	☐ sega
☐ bina	☐ tsikitla	☐ thusa
☐ kgagola	☐ reetsa	☐ goga
☐ lela	☐ fetsa	☐ iphitlha
☐ tsholola	☐ alola	☐ feela
☐ wa	☐ kobakoba	☐ betsa
☐ reka	☐ leleka	☐ baakanya
☐ thula	☐ opela	☐ kgorometsa
☐ robala	☐ fetsa	☐ fologa
☐ thulamela	☐ nna	☐ tswala
☐ tsaya	☐ ema	☐ fa
☐ tlisa	☐ tsoga	☐ supa
☐ sutlha	☐ aga	
☐ raga	☐ bua	

(I) MAEMEDI /MASUPI

☐ ene	☐ tse
☐ nna	☐ gago
☐ bone	☐ wena
☐ rona	☐ gagwe
☐ yame	☐ se
☐ same	☐ o
☐ tsame	☐ e
☐ rona	