A phonetic description of Káínai Blackfoot

Authors: Natalie Weber and Donald Derrick

Draft: 2024 August 16

Abstract:
This paper presents the Blackfoot (Algonquian) phonetic system from data provided by Tootsinam (Beatrice Bullshields, 1945–2015), a native speaker of Káínai'powahsin, the Blackfoot dialect associated with the Blood Nation. There are relatively few phonetic studies of underdocumented languages, and Blackfoot is no exception. We fill this gap by providing a general articulatory description of the segmental, prosodic, and supersegmental properties of the language, with an aim to provide a starting point for future targeted studies. Blackfoot is an interesting case study because many of the basic phonetic and phonological facts of the language are still highly contested, and because there are several typologically distinctive characteristics compared to well-documented languages, such as the unusual distribution of /s/. Within each section, we summarize all previous research on Blackfoot up to this point and explain which properties are well understood and which require further research. We also present some novel observations of Tootsinam's speech which differ from existing documentation, including the distribution of short centralized vowels outside of closed syllables, and an allophonic falling tone on word-final stressed syllables.

1. Introduction

This paper presents a general articulatory description of the Blackfoot (ᓱᒪᒋᐧ, ISO 639-3: bla; Algonquian) phonetic system.[1] There are relatively few phonetic studies of underdocumented languages (Tucker & Wright 2020), and Blackfoot is no exception. Our aim is to support further phonetic studies by documenting the segmental, prosodic, and supersegmental properties of a wordlist recorded with a single speaker. We supplement this description by summarizing the previous research on Blackfoot within each section and explain which phonetic properties are well understood and which require further research. We point out some of the typologically interesting phenomena in Blackfoot, as well as areas where our consultant's speech patterns differ from existing documentation.

The paper is organized as follows. In §2 we provide some background about the speakers, dialects, and location where Blackfoot is spoken, as well as some of the major reference materials and research on the phonetics and phonology of the language. In §3 we describe our methods and transcription conventions used throughout the paper. §4 focuses on the consonants of Blackfoot, with a focus on segments with unusually wide or narrow distributions. §5 focuses on the vowels, with a focus on allophones and their distribution. We then discuss syllable structure in §6 and supersegmental prosody in §7 before concluding in §8. Finally, we include an appendix with transcriptions for all words recorded, as well as notes explaining how these differ from the transcriptions in the most recent Blackfoot dictionary.

2. Language background

Blackfoot is an Algonquian language spoken by ~1,450 people in northern Montana, USA (U.S. Census Bureau 2015; Genee & Junker 2018) and another ~2,820 people in Southern Alberta, Canada (Statistics Canada 2017; down from ~3,250 reported in Statistics Canada 2011; Genee & Junker 2018). The language as a whole is typically known in Blackfoot as Niitsí'powahsin ('Real/True/Original Language'), and in English as 'Blackfoot' in Canada or 'Blackfeet' in the United States (Genee & Junker 2018; Weber et al. 2023). It is a member of the Plains branch of Algonquian which is an areal grouping rather than a genetic subgroup (Goddard 1994; Mithun 1999). The Algonquian family is itself part of the Algic language family, the largest (in land area) of all North American language families (Sapir 1913, 1922; Haas 1958; Goddard 1975; Mithun 1999: 328).

Blackfoot has been described as having four dialects, which correspond to the four reserves and reservations shown in dark gray in Figure 1. Siksikáí'powahsin is spoken nearest to Calgary by the Siksika Nation, Aapátohsipikanii'powahsin is spoken by the Piikani Nation near Fort McLeod, Káínai'powahsin is spoken by the Blood Tribe in the region between Cardston and

---

[1] Thanks to to SSHRC funding awarded to Martina Wiltschko for providing the resources to record and document the Blackfoot language. Thank you to Tootsinam (Beatrice Bullshields), Solveiga Armoskaite, Michael Barrie, Heather Bliss, Joel Dunham, Jennifer Glougie, Meagan Louie, and Martina Wiltschko for their hard work on Blackfoot. This article is dedicated to the memories of Tootsinam (Beatrice Bullshields), our Blackfoot consultant who provided the recordings used in this description, to Abigail Scott who worked on Blackfoot research with us, and to Donald G. Frantz who authored so much excellent work on Blackfoot and who as personally helpful to both of us. You will all be missed.

Lethbridge, and Aamsskáápipikani is spoken by the Blackfeet Nation in northwest Montana to the east of Glacier National Park (Mithun 1999: 336–337; Frantz 2017; Weber et al. 2023). However, there are also generational and geographical differences within dialects, all largely unstudied (Miyashita & Chatsis 2015; Genee & Junker 2018). This description represents the speech of one speaker of Káinai'powahsin, Tootsinam (Beatrice Bullshields, 1945–2015). Tootsinam is a speaker of New Blackfoot (Miyashita and Chatsis 2015), which differs in some ways from older, more conservative varieties in terms of pronunciation and grammar, and which may not generalize to (Káinai) Blackfoot as a whole.

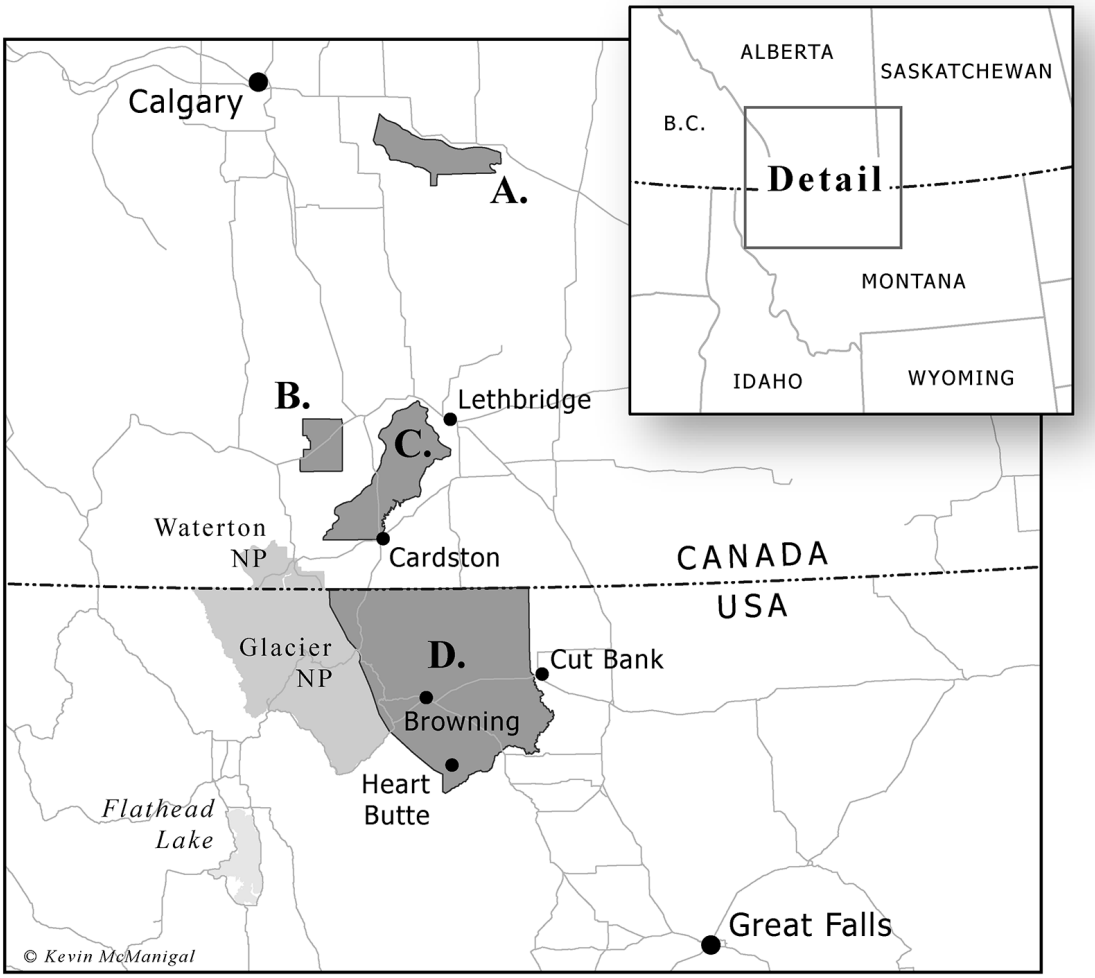

Figure 1 Map key: Blackfoot Territories: A. Siksikái'powahsin (Siksika Nation, Alberta), B. Aapátohsipikanii'powahsin (Piikani Nation, Alberta), C. Káinai'powahsin (Blood Tribe, Alberta), D. Aamsskáápipikanii'powahsin (Blackfeet Nation, Montana). Cartography by Kevin McManigal, University of Montana.

Aspects of the Blackfoot sound system have been the subject of a number of different publications. The *Blackfoot Grammar* (Frantz 2017), and the *Blackfoot Dictionary of Stems, Roots and Affixes* (Frantz and Russell 2017) are the primary references for Blackfoot. The phonetics and phonology of Blackfoot have also been described in previous grammars, such as

Taylor (1969) and Uhlenbeck (1938). More recent phonological research includes studies of speaker variation (Bliss & Glougie 2010; Miyashita & Chatsis 2015), types of [s] (Derrick 2006, 2007; Denzer-King 2009, 2012; Goad and Shimada 2014a,b); glottal stop (Peterson 2004); diphthongs and digraphs (Elfner 2006a; Weber & Miyashita 2024); pitch accent and word prosody (Kaneko 1999; Van Der Mark 2003; Stacy 2004; Glougie 2009; Weber 2016a,b, 2020; Fish and Miyashita 2017; Miyashita and Weber 2020; Weber & Shaw 2021); word-final devoicing (Bliss and Gick 2009; Gick et al. 2012; Windsor 2017a,b; Prins 2019); syllabification (Elfner 2006a; Derrick 2007; Weber 2020); voice onset timing in obstruents (Genee & Li 2023); and the relationship between phonology and syntax (Van Der Mark 2003; Stacy 2004; Peter 2014; Windsor 2017a,b; Miller & Sande 2021; Weber 2020, 2022).

3. Methods and transcriptions

This section describes our recording methods and our choices for the phonetic and orthographic transcriptions used throughout the paper. The audio recordings accompanying this article were made at the University of British Columbia from 2005 to 2007, when Tootsinam (Beatrice Bullshields) was in her 60s. The full dataset consists of 177 words, each repeated one to five times, with a total of over 4,600 phonemes labelled and segmented. The audio files used in this paper are completely unedited, and many contain background noise and microphone pops. All of our statistical analyses and images are based on unedited and uncleaned files. The full set of audio files (with PRAAT textgrids), along with additional statistical analyses and images can be found in an Open Science Foundation archive (Derrick & Weber 2024).

The examples throughout the paper include a broad phonetic transcription in square brackets and an orthographic transcription in italics. Whenever a sound varied across word tokens, the transcription reflects the variant which occurred most frequently. This was especially important for determining gradient and variable properties like the peripherality of short vowels and the realization of the back high vowel as mid or high. We sometimes diverge from the standard orthography to more closely represent Tootsinam's speech. Most saliently, we only include the verbal suffix *-a* ~ *-wa* ‘3’ or the (proximate) animate singular nominal suffix *-a* ~ *-wa* if there is an audible voiced or voiceless reflex. A full list of transcriptions of the sound files, including the major sound variants, is found in the appendix. The dataset was compiled before later research which clarified some important segmental contexts and minimal pairs. It therefore contains some gaps, which we point out where relevant.

The orthography used throughout this description was designed by Donald Frantz and described in Frantz (1978, 2017). In brief, doubled letters are long, <y> is used for /j/, <’> for /ʔ/, <h> for /x/, <ai> for /ɛː/, and <ao> for /ɔː/. Both of the vowel digraphs have multiple pronunciation variants (Frantz 2017: 2–3; Weber & Miyashita 2024). The orthography also marks pitch peaks (one of the phonetic properties associated with accent; see §7) with an acute accent. On long vowels, <V́V́> denotes a level high pitch and <V́V> denotes a falling pitch. This is the most commonly used Blackfoot orthography today, although a small number of Blackfoot speakers use the syllabary created by Anglican missionary John William Tims (1889) (e.g. Ermineskin and Howe 2005; Áístainskiaakii et al. 2013). In addition, many speakers use a variation of Frantz's orthography or create their own – often based on the English writing system – in order to reflect their own dialect and pronunciation (Genee 2020).

The remaining sections of the paper describe segmental properties (§4 and §5), syllable structure (§6), and supersegmental prosody (§7).

4. Consonants

Researchers have not yet come to a consensus on the exact consonant inventory of Blackfoot, especially regarding the affricates and pre-assibilants. In §4.1 we lay out our consonant inventory and explain how it differs from previous research. After describing the different places and manners of articulation of the short and geminate consonants, we turn in §4.2 to a discussion of the affricates and pre-assibilants, which exhibit a mix of contrastive and predictable properties. The remaining subsections focus on three consonants in Blackfoot with unusually wide or narrow distributions: the alveolar fricative [s] (§4.3), the dorsal fricative /x/ (§4.4), and the glottal stop /ʔ/ (§4.5).

4.1 Phonemic inventory

Blackfoot has 21 contrastive consonants which are listed in Table 1, along with the orthographic representation given in angled brackets, < >.[2] The inventory in Table 1 basically follows Weber (2020), except we include the alveolar affricates /t͡s/ and /t͡:s/.[3] Other inventories are proposed in Chávez Peón (2015); Denzer-King (2009, 2012); Elfner (2006a); Goad & Shimada (2014a,b); Kaneko (1999, 2000); Peterson (2004); Stacy (2004); Van Der Mark (2003). In Blackfoot, all plosives, nasals, and the alveolar fricatives and affricates have a length distinction.

Table 1 Phonemic consonant inventory of Blackfoot

	BILABIAL	ALVEOLAR	PALATAL	VELAR	GLOTTAL
PLOSIVES	p p: <p> <pp>	t t: <t> <tt>		k k: <k> <kk>	ʔ <’>
FRICATIVES		s s: <s> <ss>		x <h>	
AFFRICATES		t͡s t͡:s <ts> <tts>		k͡s <ks>	
PRE-ASSIBILANTS		(ˢt ˢt:) <st> <stt>			
NASALS	m m: <m> <mm>	n n: <n> <nn>			
GLIDES	w <w>		j <y>		

[2] For the examples throughout this paper, phonetic transcriptions are given in square brackets, [ ], and orthographic representations are italicized.

[3] The alveolar affricate /t͡s/ is transcribed in various fashions. For example, it is [tˢ] in Derrick (2007) and Kaneko (1999), [t͡s] in Elfner (2006a) and Goad and Shimada (2014a,b), and [ts] in Denzer-King (2009). We have opted to use the common affricate notation with a ligature. Note that [t] and [k] can be followed by a phonologically short /s/ or long /s:/, e.g. [t͡s], [ts], and [ts:] are distinct in this paper. This is explained in §4.3 and §6.2. We use a superscript <s> in the pre-assibilant /ˢt/ in order to emphasize that the pre-assibilant is a contour stop, and to more clearly distinguish it from s+C consonant sequences in phonetic transcriptions. This notation has precursors in the phonetic transcriptions in Elfner (2006a,b).

The most controversial segments are the affricates and the pre-assibilants, because their distributions are partially contrastive and partially predictable (see Armoskaite 2006; Chávez Peón 2015; Denzer-King 2009, 2012; Derrick 2006, 2007; Elfner 2006a,b; Goad and Shimada 2014a,b; Weber 2020). Taylor (1969: 27) excludes affricates entirely from his inventory, but other researchers include at least the alveolar affricate /t͡s/. Kaneko (2000) does not include a velar affricate /k͡s/, although the other inventories do. Blackfoot /p/ is never followed by a supershort sibilant the way that /t/ and /k/ are (as part of an affricate), and we do not include it in the inventory. However, some researchers do erroneously include a bilabial affricate, e.g. the strident /pˢ/ in Kaneko (1999) or the affricate /ps/ in Peterson (2004), presumably for reasons of symmetry with /t͡s/ and /k͡s/. Not all inventories include geminates. Of those that do, some researchers include long /t͡ːs/ and /k͡ːs/ (Chávez Peón 2015; Elfner 2006a), some include neither /t͡ːs/ nor /k͡ːs/ (Van Der Mark 2003), and some include only long /t͡ːs/ but not long /k͡ːs/ (Weber 2020). Finally, only Weber (2020) includes the pre-assibilants /ˢt/ and /ˢtː/, which we include in parentheses to signal that they are marginal phonemes (discussed in §4.2).

Blackfoot has few minimal pairs,[4] so other means have to be used to determine contrast. Here we rely on overlapping environments. Our first preference is to identify two consonants in contexts where they are surrounded by the same vowels or syllabic fricatives. Barring that possibility, we identify two consonants which occur in a word-initial (or word-final) position next to the same vowels. If stress falls on a vowel adjacent to one of the consonants of interest, we matched stress in the second example whenever we could, although this was not always possible. A pairwise comparison of Blackfoot short consonants in overlapping environments is shown in Table 2.

Table 2 Consonant pairs in overlapping environments

IPA	BROAD TRANSCRIPTION	ORTHOGRAPHY	ENGLISH GLOSS
/p/ /k/	[ʔaːpíksːt͡sɪt] [ʔáːkituʔtaʔpɛsːi]	*aapíksstsit* *áákito'ta'paissi*	'take it out of your mouth!' 'she will associate with him'
/t/ /n/	[ʔɪˢtːsksːkjúːmitaː] [sípstsinaːn]	*isttskssskióómitaa* *sipstsinaan*	'slim faced dog', 'grayhound' 'tipi flap pole'
/t/ /s/	[ʔaʔpsːkít] [môːtókɪs]	*a'psskít* *móotókis*	'chase it!' 'hide, skin'
/t/ /ˢt/	[ʔajaːkóxʷkiːtsːkaʔsi] [ʔɪstskíːˢtstaː]	*ayaakóóhkiitsska'si* *isstskíststaa*	'she is gonna act strange/foreign' 'bay'
/k/ /t͡s/	[ʔaʔpsːkít] [ʔaːpíksːt͡sɪt]	*a'psskít* *aapíksstsit*	'chase it!' 'take it out of your mouth!'
/k/ /k͡s/	[môːtókɪs] [motːok͡sís]	*móotókis* *mottoksís*	'hide', 'skin' 'knee'
/k/ /m/	[ʔaːsíːkukiː] [ʔimitɔ́ʔkomi]	*aasíikokii* *imitáó'komi*	'bear grass' 'flea'

[4] Some minimal pairs are collected in Denzer-King (2009) and in Weber (2020, Appendix A).

/k/ /n/	[ki:píp:o] [ní:pa̰]	*kiipíppo* *níípa*	‘hundred’ ‘leaf’
/j/ /k/	[ʔikstsíʔpʊji] [ʔa:sí:kuki:]	*ikstsi’poyi* *aasííkokii*	‘she implied’ ‘bear grass’
/j/ /w/	[ʔá:kitʊpɐkɪˢtó:pi:ja:] [má:tɛ:ns:pópi:wa:tsɪks]	*áákitopakistóópiiyaa* *máátainsspópiiwaatsiksi*	‘they will sit side by side’ ‘she does not sit still’
/ts/ /ks/	[nɪtsɪná:n] [ʔi:kítsɪksɪnamʔa̰]	*nitsináan* *iikítsiksinamma*	‘my belonging/possession’ ‘he looks sickly’
/m/ /n/	[mɛ:ɛ̂:] [nɛ:ɛ́:wa]	*maiáí* *naiáíwa*	‘robe’ ‘my robe’

All plosives (except the glottal plosive), all nasals, the alveolar affricate /ts/, and the fricative /s/ have contrastive short and long (geminate) forms between vowels (Elfner 2006a; Derrick 2007; Frantz and Russell 2017), as shown in Table 3.

Table 3 Short and geminate consonants in overlapping environments

IPA	BROAD TRANSCRIPTION	ORTHOGRAPHY	ENGLISH GLOSS
/p/ /p:/	[ki:píp:o] [ná:toʔki:kɪp:i:tɐpí:ja:]	*kiipíppo* *nááto’kiikippiitapííyaa*	‘hundred’ ‘they are two hundred people’
/t/ /t:/	[ʔɪskxʷkótɐwɛ:] [ʔot:ɛ́pitoxʷtsi]	*isskohkótawayi* *ottápitoohtsi*	‘he was given it back’ ‘behind the house’
/k/ /k:/	[ʔɪs:akím:ɪs] [ʔɛ́:pɐk:ɪtɐkaʔsi]	*issakímmis* *áípakkitaka’si*	‘get over him!’ ‘motorcycle’
/m/ /m:/	[nitɛ́:sɪmɪm:oka̰] [ʔɪm:ɪstsî:]	*nitáísimimmokaʔ* *immisstsíí*	‘he is talking gossip about me’ ‘grease/cooking oil’
/n/ /n:/	[ʔɛ́sksɪnimaʔtstxʷki] [ʔaxkójɪn:ɪma:n]	*áíssksinima’tstohki* *aahkóyinnimaan*	‘he teaches’ ‘pipe’
/ts/ /t:s/	[spɐ́tsɪko] [ʔɛ́ˢt:síkɐt:si]	*spátsiko* *áísttsíkattsi*	‘sand’ ‘it looks shiny’
/s/ /s:/	[ʔɪn:óxʷksɪsi] [nɪs:ís:]	*innóohksisi* *nissíss*	‘long nose’, ‘elephant’ ‘my younger sibling’ (of female)

Geminate consonants are about 2x longer than short consonants, with the exception of geminate affricates, which are more than 3x longer than their short counterparts. The median lengths and standard deviations in mifor each short/geminate pair can be seen in Table 4. We have included [ks] for comparison to the other short consonants, even though our corpus includes no instances of geminate [k:s].

Table 4 Short vs geminate durations in milliseconds (median and standard deviations)

IPA	COUNT	MEDIAN DURATION (ms)	STANDARD DEVIATION (ms)	RATIO

[p] [pː]	244 18	143 259	47.9 64.8	 1.8x
[t] [tː]	381 34	115 252	48.8 91.8	 2.2x
[k] [kː]	493 57	133 259	47.3 83.3	 1.9x
[m] [mː]	150 63	98 186	40.2 81.5	 1.9x
[n] [nː]	259 31	98 228	44.0 85.9	 2.3x
[t͡s] [t͡ːs]	148 9	94 359	52.9 64.8	 3.8x
[k͡s] [k͡ːs]	103 ---	98 ---	82.0 ---	 ---

The glottal stop /ʔ/, the velar fricative /x/, and the alveolar fricative /s/ can all occur in overlapping environments before a short obstruent where they contrast with each other, shown in Table 5. (The glottal stop /ʔ/ can additionally occur before nasals or glides.) No consonants may occur before a geminate. In Table 5 the sounds [ç] and [xʷ] are allophones of /x/ (discussed in §4.4, and all vowels before an /sC/ cluster are predictably centralized, such as [ɐ] in [ápɐ̱staːminamː] (discussed in §5.2).

Table 5 Consonants in overlapping environments before a short consonant

/ʔ/ /x/	[náːto̱ʔkiːkɪpːiːtɐpíːjaː] [mox̱ʷkínʔsːt͡sɪs]	*nááto̱'kiikippiitapíiyaa* *moohkínsstsis*	'they are two hundred people' 'elbow'
/ʔ/ /s/	[ʔéːskskaʔ̱taki] [ʔápɐ̱staːminamː]	*áissskaʔ̱taki* *ápass̱taaminaamm*	'he is thinking about it' 'apple'

All three consonants contrast with null (the absence of a consonant) before a consonant, as shown in (1)–(3).

(1) a. /ʔ/ [ʔéːskskaʔ̱taki] *áissskaʔ̱taki* 'he is thinking about it'
b. Ø [ʔakɔ́ːmɐṯɐpɐkːíspoː] *akáómaṯapakkísspoo* 'she has started to get much higher'

(2) a. /x/ [ʔiç̱téːsitokoː] *iihṯáísitokoo* 'he went through the center'
b. Ø [ʔiːṯénʔçtɔwʔpa̰] *iiṯáínnihtao'pa* 'cooking pot'

(3) a. /s/ [ʔápɐ̱staːminamː] *ápaiss̱taaminaamm* 'apple'
b. Ø [ʔakɔ́ːmɐṯɐpɐkːíspoː] *akáómaṯapakkísspoo* 'she has started to get much higher'

There is no laryngeal contrast for obstruents, which are unaspirated and voiceless. Voice onset time (VOT) was measured from initial pitch pulse during stop closure to release burst for negative VOT, and from stop burst to initial voicing pitch pulse for positive VOT. The mean

VOTs for all obstruents was 11.5 ms (s.d. = 43.5), with slight variations depending on consonant type, as seen in Figure 2. These numbers are in line with the results in Genee & Li (2023), who analyzed 2,096 tokens of short /p/, /t/, and /k/ produced by 13 participants in two different tasks: an English-to-Blackfoot translation task and a picture naming task. They found that stops in Blackfoot have a mean voice onset timing (VOT) ranging from 11.6–32.7 milliseconds (Genee & Li 2023). Interestingly, fully 9.5% of our consultant's stop and affricate tokens had negative voice onset times, whereas the VOT values in Genee & Li (2023) are all non-negative.

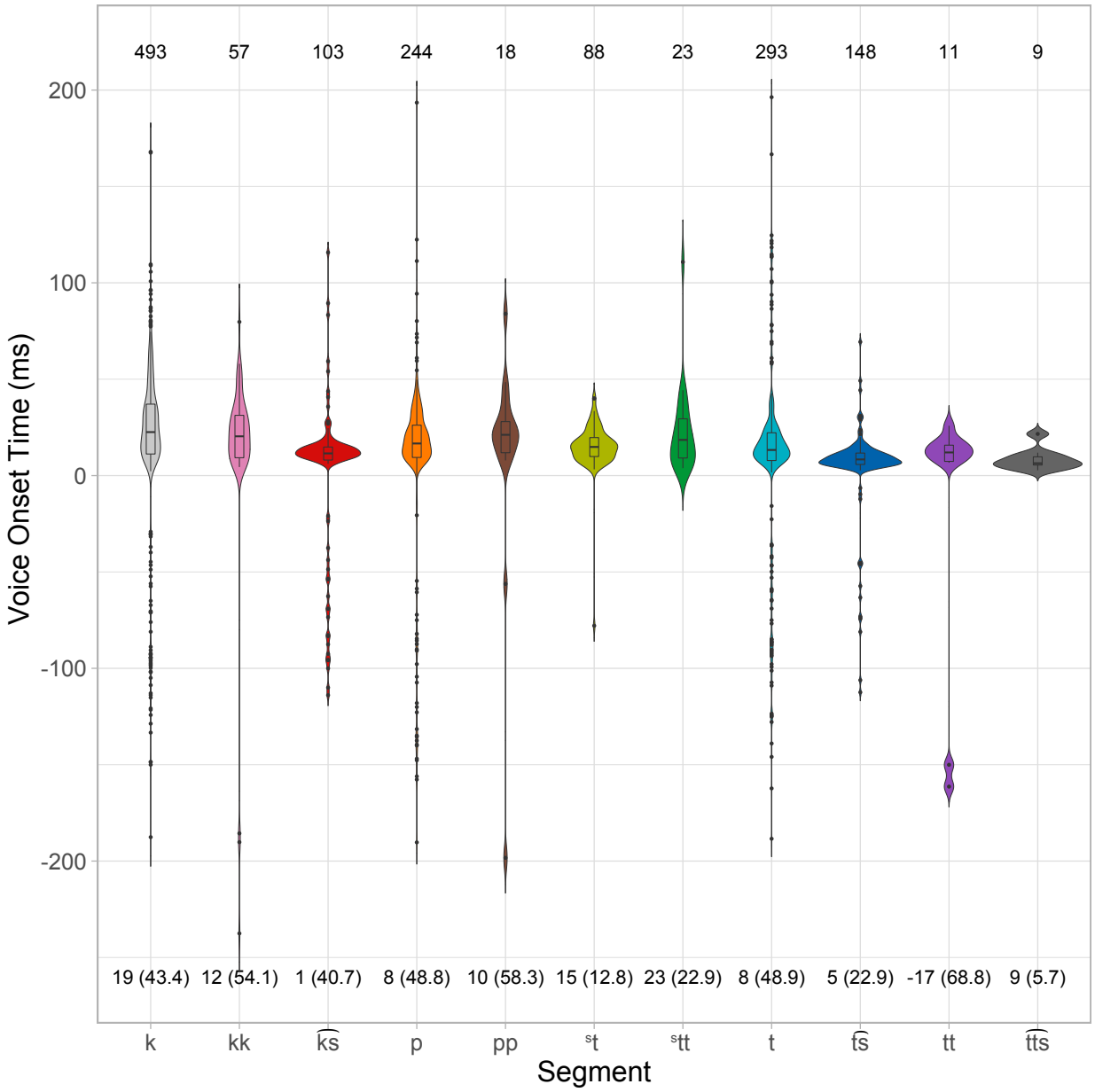

Figure 2 Violin plots of voice onset time (VOT) for Blackfoot stops and affricates. Top numbers = token counts. Bottom numbers = mean (standard deviation) in milliseconds.

The palatal glide /j/ is typically produced very similarly to the high-front vowel /i/, and the labio-velar glide /w/ is similar to some high allophones of /o/. The labial nasal /m/ and the

alveolar nasal /n/ are both produced like their English counterparts. Blackfoot's glottal plosive /ʔ/ may sometimes be produced as a fully-closed glottal stop, but is often produced as creaky voice or simply length on the preceding vowel (Peterson 2004).

4.2 Affricates and pre-assibilants

This section describes the distributional properties of the affricates and pre-assibilants in our dataset. This discussion is necessarily incomplete because our dataset does not contain each contour segment in all possible environments. We focus on the properties that led us to analyze some contour segments as phonemic (Table 1) and other as predictable allophones. We begin with the pre-assibilants /ˢt/ and /ˢtː/, then turn to the alveolar affricates /t͡s/ and /t͡sː/, and conclude with the velar affricates /k͡s/ and [k͡ːs].

The pre-assibilants /ˢt/ and /ˢtː/ are marginal phonemes which only occur after front vowels, in which position they contrast with the alveolar plosive. This is shown for short /ˢt/ vs. /t/ in Table 2. (Our dataset does not contain examples of geminate [tː] after a front vowel, so we have no pairs of words showing [tː] and [ˢtː] in overlapping environments.) The supershort [s] in the pre-assibilant /ˢt/ is distinct from a phonologically short /s/ before /t/, as shown in (4). The duration of the sibilant [s] in different segmental contexts, and the relationship to orthographic and phonological transcriptions, is discussed in §4.3.

(4) a. /ˢt/ [ʔáːkitʊpɛkɪˢtóːpiːjaː] *áákitopakistóópiiyaa* 'they will sit side by side'
b. /st/ [kjéːkitumʔsːtskɪsts] *kiáákitoomsstskisstsi* 'you will lie face down'

The difference in duration of the sibilants in (4a) and (4b) has also been analyzed as a contrast between short /s/ and long /sː/ before /t/ (Derrick 2006, 2007; and implicitly in Frantz's 1978 orthographic notation) or a contrast between non-moraic and moraic /s/ before /t/ (Elfner 2006a,b). We follow Weber (2020) in analyzing /ˢt/ as a (non-moraic) contour segment and /sC/ as a (moraic) coda-onset cluster for the following reasons. (1) A supershort pre-consonantal [s] only occurs before /t/ or /t͡s/. In constrast, a phonologically short /s/ can occur before any plosive or affricate, {sp, st, sts, sk, sks}. (2) Vowel length is distinctive before /ˢt/ but is neutralized to short before an /sC/ cluster (see §6; Elfner 2006a,b; Weber 2020). (3) The short pre-assibilant /ˢt/ has a geminate counterpart /ˢtː/, just like the other obstruents (except /x/). In contrast, a phonologically short /s/ never occurs before a geminate (see §6; Elfner 2006a,b; Weber 2020). (4) There is a restricted morphophonological alternation between the pre-assibilant [ˢt] and the first half of a geminate [kː], as discussed in Weber (2020: 36). This parallels an alternation between [t] and the first half of a geminate [kː] in the same morphological context, but there are no such alternations for the phonologically short /s/ in an /sC/ cluster. These observations make sense if the supershort [s] is part of a contour segment /ˢt/ or /ˢtː/ and the phonologically short /s/ is an independent segment which freely occurs in consonant clusters. Like other codas, this /s/ is moraic and shortens preceding vowels (Elfner 2006a,b; and §6 below).

The alveolar affricate [t͡s] is a predictable allophone of /t/ before high front vowels and glides (Armoskaite 2006; Chávez Peón 2015; Frantz 2017; Weber 2020). Both [t͡s] and [t] can occur before other vowel qualities (Weber 2020), as in (5). Even in those positions, [t͡s] could potentially be analyzed as underlying /t/ under an abstract, opaque analysis where a high front vowel or glide conditions affrication and later deletes (Frantz 2017; Weber 2020), but we follow the majority of researchers in including it as a separate phoneme here.

(5) a. [ʔáː.ki.tʊ.pɐ.kɪ.ˢtóː.piː.jaː] *áákitopakistóópiiyaa* ‘they will sit side by side’
b. [ʔíːksksːtsʊwaʔpiː] *iíksksstsowa’pii* ‘it was a chance happening’

Many instances of [k͡s] are derived from underlying /k/ before some high front vowels (Armoskaite 2006; Armoskaite & Chávez Peón 2005; Weber 2020). However, this affricate contrasts with the plain velar plosive /k/ before some instances of /i/ (shown in Table 2) as well as other vowel qualities, like [o] in (6), and so we include it in the inventory.

(6) a. [ʔimitɔ́ʔkomi] *imitáó’komi* ‘flea’
b. [ʔiːtsíʔtsk͡sojі] *iitsí’tsksoyi* ‘picnic’

There happen to be no examples in our wordlist of a long velar [k͡ːs], which is an allophonic variant of geminate /kː/ before some instances of [i] or [iː] (Weber 2020).

As the discussion above shows, the status of the alveolar fricative [s] is complicated. This segment occurs in multiple positions, with multiple durations, and with multiple phonological representations. We turn to a discussion of this unusual segment in the next section.

4.3 Alveolar fricative [s]

The alveolar fricative [s] has a much wider distribution than the other consonants and is the only consonant which can occur before, after, or between other consonants in up to three distinctive durations (Denzer-King 2009; Derrick 2006, 2007; Elfner 2006b; Goad and Shimada 2014a,b). In this section we describe the distribution and duration of alveolar sibilants in analysis neutral terms, focusing on how this relates to the orthography and to phonological contrasts. We return to the question of how the different types of [s] are syllabified in §6.

We begin with the orthography. The unusual distribution of [s] has been implicitly observed in the design of the orthography, where Blackfoot can have one, two, or three <s>’s in a row (Frantz and Russell 2017; see discussion in Goad and Shimada 2014a,b). Table 6 arranges the number of orthographic <s>’s by phonological environment. Within each environment (e.g., across a row) greater numbers of <s>’s in the orthography correlates with a relatively greater duration. There are only two environments (in the last two rows) which allow triple <sss>. In exactly these two environments, the single <s> is highly restricted and occurs only next to a subset of consonants: after <(t)t> or <(k)k> in a [C_V] environment, or before <t(t)> in a [V_C] environment. These are the affricates and pre-assibilant discussed in §4.2.

Table 6 Distribution of Blackfoot orthographic <s> by environment

Environment	<s>	<ss>	<sss>
#_	<#s>	<#ss>	
_#	<s#>	<ss#>	
V_V	<VsV>	<VssV>	
C_C	<CsC>	<CssC>	
C_V	<(t)tsV>, <(k)ksV>	<CssV>	<CsssV>
V_C	<Vst(t)>	<VssC>	<VsssC>

Table 7 organizes the cells of Table 6 into groups based on acoustic duration, with Group A being the shortest and Group G being the longest. (The precise measurements and the linear model underlying these groups are given below in Figure 3.) By examining each column, it is clear that the number of <s>’s does not correlate with an absolute duration. For example, a single

<s> usually has a fairly short duration (Groups B and C), but it is relatively long in a word-final environment [_#] (Group E), and supershort as part of an affricate or pre-assibilant (Group A). The cell in parentheses is not represented in our corpus but probably falls into Group F .

Table 7 Duration of Blackfoot orthographic <s> by environment

Environment	<s>	<ss>	<sss>
#_	BC	CDEF	
_#	E	G	
V_V	C	E	
C_C	B	D	
C_V	A	D	F
V_C	A	D	(F)

Finally, we explain the relationship of our transcriptions to orthography. If we set aside the supershort durations of [s] from Group A in Table 7 (which are always part of an affricate or pre-assibilant), then each phonological environment has a binary contrast between two sibilant durations. For example, the [C_C] environment hosts a contrast between Group B and Group D durations, the [C_V] environment hosts a contrast between Group D and Group F durations, and the [V_V] environment hosts a contrast between Group C and Group E durations. A binary contrast is easily explained by a contrast between a phonologically short /s/ and phonologically long /s:/, which have different acoustic durations depending on the phonological environment. Our transcriptions use [s] for the short contrast and [s:] for the long contrast. In this way, our transcriptions never need include a "superlong" transcription like [s::].

Table 8 shows how the Blackfoot orthography relates to phonological length by environment. In most environments, a single <s> in the orthography corresponds to a phonologically short /s/ and a double <ss> corresponds to a phonologically long /s:/. However, in the [C_V] and [V_C] environments (in the last two rows) a double <ss> corresponds to a phonologically short /s/, and a triple <sss> corresponds to a phonologically long /s:/. The reason is that in these two environments only, a single <s> is used as part of an affricate or pre-assibilant, forcing the phonologically short /s/ to be written with a double <ss> and the phonologically long /s:/ to be written with a triple <sss>.

Table 8 Correlation of the Blackfoot alveolar fricative to orthographic <s> by environment

Environment	short	long
#_	<#s>	<#ss>
_#	<s#>	<ss#>
V_V	<VsV>	<VssV>
C_C	<CsC>	<CssC>
C_V	<CssV>	<CsssV>
V_C	<VssC>	(<VsssC>)

Table 9 lists the types of [s] which occur in our dataset with examples. The labels in the first column ("Environment and Duration") are drawn from the cell values in Tables 6 and 7, except that we also explicitly label "Affricates" and "Pre-assibilant". The transcriptions are explained by the mapping between orthography and in Table 8. Three rows are marked with daggers (†) because they are absent in our dataset (<VsssC>) or only occur in two words (<#ss> and <ss#>).

There are other asymmetries in our dataset, like the fact that word-final <s#> only occurs after vowels in our dataset, even though it may occur after the consonants /ʔ/ or /x/ in other words.

Table 9 Distribution of Blackfoot sibilants based on duration and segmental context

ENVIRONMENT AND DURATION	TRANSCRIPTION	ORTHOGRAPHY	ENGLISH GLOSS
AFFRICATES <CsV> (Group A)	[ʔi:t͡síʔtsksoji]	*iitsí'tsksoyi*	'picnic'
PRE-ASSIBILANT <VsC> (Group A)	[mi:ˢt͡sís]	*miistsís*	'tree'
<CsC> (Group B)	[ʔápspini:k͡s]	*ápspiniiksi*	'geese'
<#s> (Group BC)	[spɛ́t͡sɪko]	*spátsiko*	'sand'
<VsV> (Group C)	[ni:síp:o]	*niisíppo*	'forty'
<CssV> (Group D)	[pisɛ́t͡sɛski]	*pisátssaisski*	'flower'
†<#ss> (Group CDEF)	[s:popî:]	*sspopíí*	'hawk owl', 'turtle'[5]
<VssC> (Group D)	[ʔɪspómʔçta:t]	*isspómmihtaat*	'help out!'
<CssC> (Group D)	[mowɛ́ps:pɪn]	*mowápsspin*	'eye'
<s#> (Group E)	[moxʷkínʔs:t͡sɪs]	*moohkínsstsis*	'elbow'
<VssV> (Group E)	[nɪs:ís:]	*nissíss*	'my younger sibling' (of f.)
<CsssV> (Group F)	[níts:oʔto:kạ]	*nítsssoʔtooka*	'he felt me (up)'
†<VsssC> (Group F)	(none)	(none)	(none)
†<ss#> (Group G)	[nɪs:ís:]	*nissíss*	'my younger sibling' (of f.)

Figure 3 illustrates the durations of [s] by the phonological environments in Tables 6 and 7; the labels match Table 9. The rows marked with a dagger (†) in Table 9 are excluded from Figure 3 because there are too few tokens for statistical significance. There were only nine tokens of <#s> before vowels, which we excluded as well. The durations shown were extracted from 1,465 tokens of [s] within our dataset. A linear model was applied comparing the 11 [s] groups by duration using R's lm package (R Core Team, 2024), and the results were placed into significance groups using the postHoc package (Labouriau R, 2020). The results show that affricates and preassibilants share the shortest duration group (A). A single <s> in the environments <CsC> and <#sC> share the next group (B); the < #sC> case also overlaps with <VsV> to form group C. The next group (D) includes <CssV>, <VssC>, and <CssC>. The fifth group (E) includes <Vs#>, and <VssV>. (Our does not include words ending in <Cs#>, but presumably those would also be in group E.) The sixth group (F) includes <CsssV>.

[5] The meaning is currently narrowing and younger speakers associate this word only with 'turtle'. We thank an anonymous reviewer for pointing this out to us.

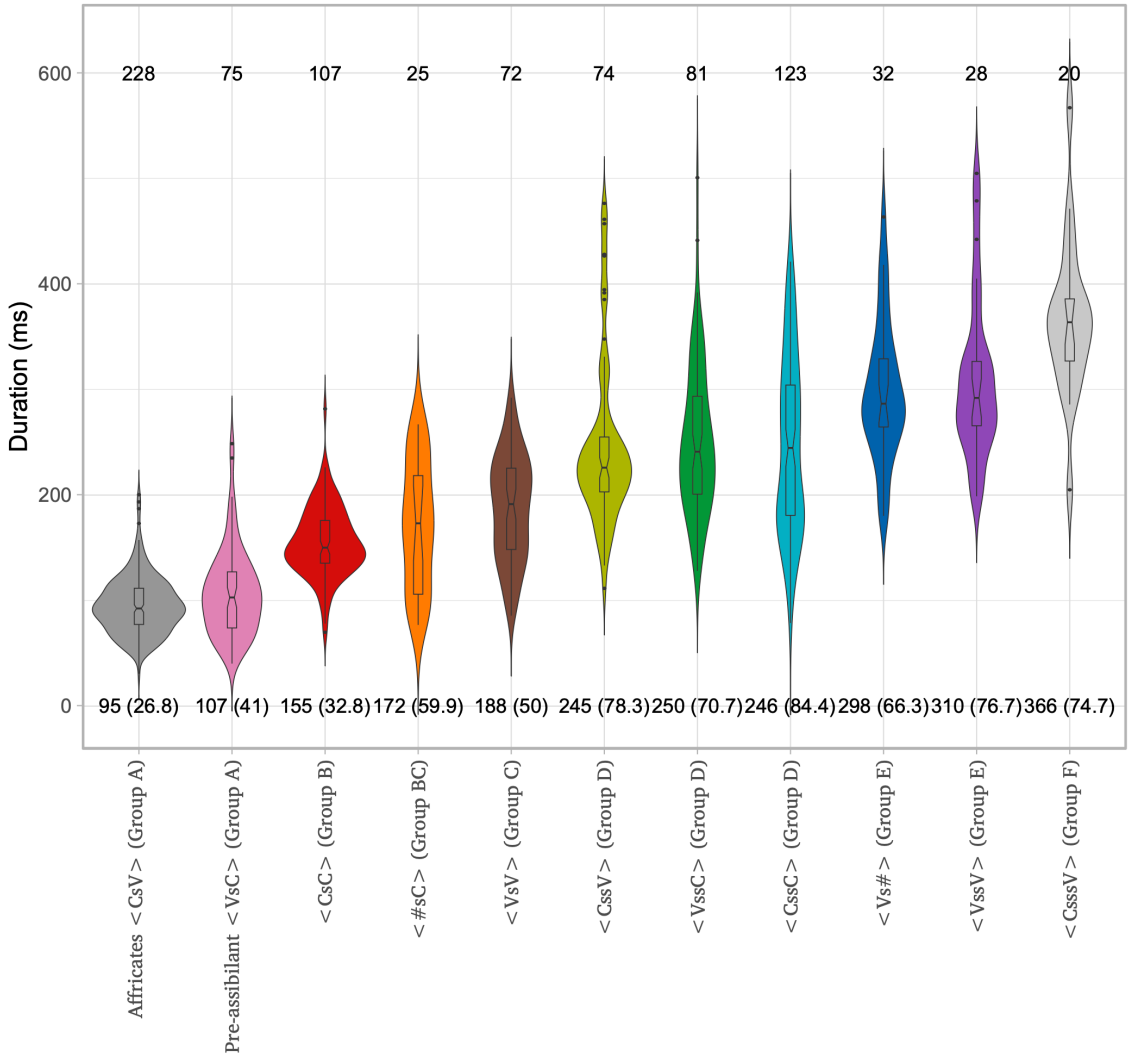

Figure 3 Violin plots of duration in milliseconds for types of Blackfoot [s]. Top numbers = token counts. Bottom numbers = mean (standard deviation) in milliseconds.

As shown in Figure 3, the mean duration of the supershort sibilants in Group A (affricates and pre-assibilants) is ~100 ms.[6] Compared to Group A: Group B is a little over 1.5x as long, Group C is a little over 1.75x as long, Group D is 2.5x as long, Group E is 3x as long, and Group F is 3.5x as long. Note that the duration of <VssC> has a mean of 245 ms, which is nearly 2.5x as long as the supershort [s] (mean = 107 ms) in the pre-assibilant /ˢt/. This acoustic difference is one of our arguments for treating /ˢt/ as a single contour segment. Another argument involves differences in syllable structure (discussed in §6).

[6] Affricates were annotated as a single unit, and the duration of the sibilant in the affricates was estimated as half the duration of the affricate. The [s] in the pre-assibilant was annotated as a separate unit, so their duration is not an estimate.

We conclude this section with a note on intraspeaker variation involving /s/. There is known variation between a so-called *t*-dialect and a *k*-dialect. This variation was described on Donald Frantz's website (now defunct, but a summary exists in Peter 2014: 15). Speakers of the *t*-dialect reportedly neutralize the distinction between /t/ and /k/ towards [t] in the environment of [s]. For example, a *t*-dialect speaker might replace [k͡s] with [t͡s]. However, Tootsinam neutralizes this distinction in many more words than the ones listed in Frantz and Russell (2017), often in the opposite direction (towards [k]), e.g., she has a [k] *k* in a word that has a *t* in the dictionary (Frantz and Russell 2017). This suggests that a greater number of items can exhibit [t]/[k] variation than are explicitly mentioned in the dictionary, and that different speakers have different patterns of variation. This would be an interesting area for future study.

4.4 Dorsal fricative /x/

Previous research shows that the dorsal fricative /x/ has a fairly restricted distribution, and this is borne out in our dataset: it only ever precedes obstruents and it only ever follows a short vowel or a consonant. Drawing on analyses in Elfner (2006a) and Miyashita (2018), we argue that this distribution can be explained if /x/ is restricted to coda positions and undergoes coalescence with a preceding short vowel. The dorsal fricative has three allophones (in post-vocalic and post-consonantal positions), which are predictable based on underlying vowel quality.

In terms of distribution, /x/ always precedes a obstruent [p], [t], [k], [t͡s], [k͡s], [s] or [sː]. Because of this, some have suggested that the back fricative is actually pre-aspiration (see Reis-Silva 2008; Weber 2016a,b). There are two distributional facts against this analysis: (a) there are no pre-aspirated geminate consonants, and (b) vowel length is neutralized before /x/, just as before other codas. Those surface phonotactics suggest instead that /x/ is a separate coda consonant which closes the syllable; Elfner (2006a,b) and Weber (2020) analyze this segment as moraic. The restricted distribution of /x/ has a historical explanation – the first consonant of most Proto-Algonquian true consonant clusters neutralized in Blackfoot to /s/ after *i, *iˑ, and /x/ after other vowels (Berman 2006; Proulx 1989).

The back fricative has several allophonic variants after vowels: it has a palatal place of articulation [ç] following [i] (7a), a velar place of articulation [x] following [a] and [o] (7b), and a somewhat more rounded velar articulation [xʷ] following [o] and [ɔ] (7c,d). The phonetic realization of /x/ after low vowels is quite far back, and some researchers write it as a uvular [χ] (Denzer-King 2009; Uhlenbeck 1938). Whenever /x/ follows a vowel, as in (7), the duration of the vowel is short. No long vowels occur in this position.

(7)	a.	[ʔiçpokónʔsːkaː]	*iihpokónsskaa*	'he has gotten the ball'
	b.	[ʔaxkójɪnːɪmaːn]	*aahkóyinnimaan*	'pipe'
	c.	[ʔéːpoxʷsápaːpik͡sɪmːɛː]	*áípoohsápaapiksimmayi*	'he is throwing it towards me'
	d.	[ʔákɔxʷtɛːtskçpiji]	*ákaohtaitskihpiyi*	'she has danced past'

The pronunciations in (7a-d) are corroborated by different center of gravity measurements: the dorsal fricative /x/'s center of gravity is 1269 (standard deviation = 538.1) Hz following [i], 825 (s.d. = 247.2) Hz following [a], 786 (s.d. = 320.0) Hz following [o], and 741 (s.d. = 356.9) Hz following [ɔ]. Figure 4 shows the power spectra for the dorsal fricatives in one token of each of the four words in (7). The power spectra exhibit local minima (circled in red) between 1000 and 400 Hz for all of the dorsal fricatives except [ç], which has a much narrower and local minima (not circled) that involves less amplitude reduction than the others. The COG is higher in

[ç] compared to the other dorsal fricative allphones because of slight but consistently higher amplitude high frequency noise, which can be seen by comparing the amplitudes in the rightmost quarter of each figure.

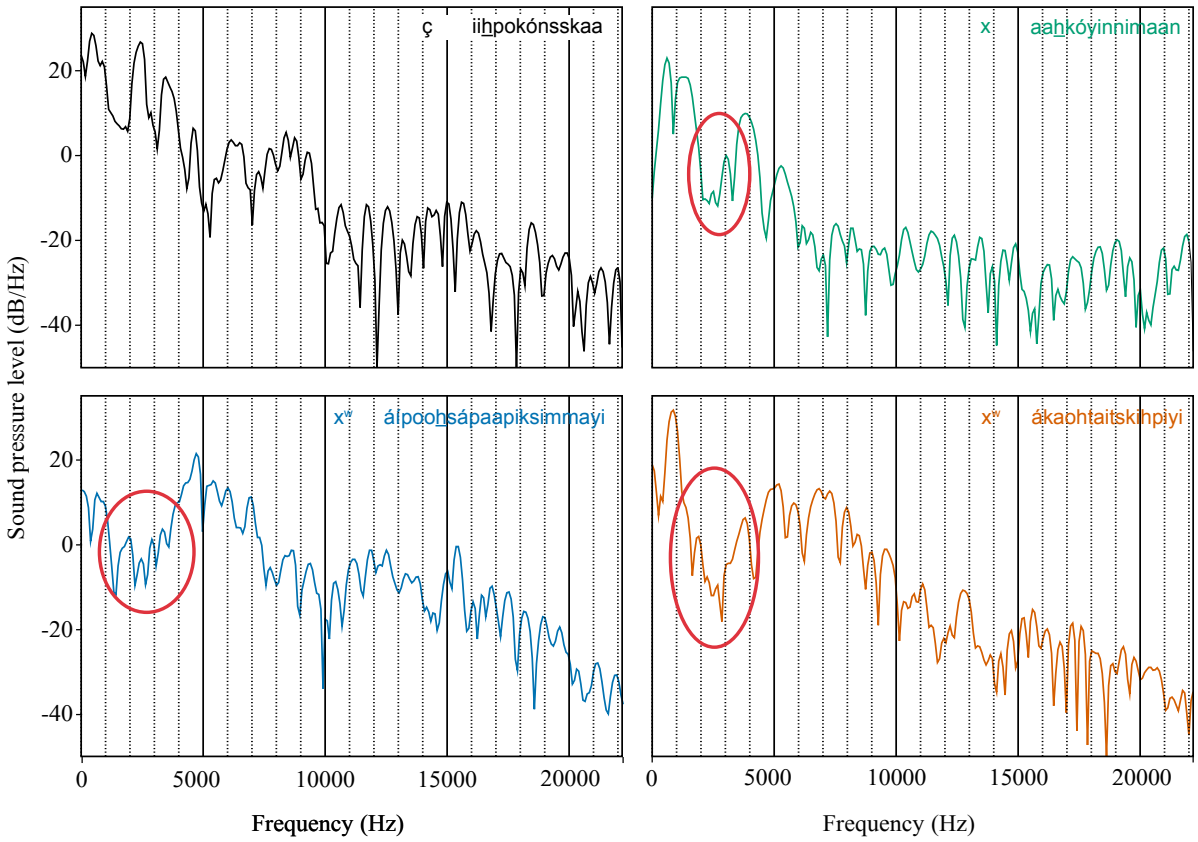

Figure 4 Power spectra (spectral slices) of 1 token of each of the 4 words in (7), from 5 millisecond portions of the midpoint of the relevant dorsal fricative allophone. Top left = [ç] after [i]; Top right = [x] after [a]; Bottom left = [xʷ] after [o]; Bottom right = [xʷ] after [ɔ].

The same three allophones of /x/ in (7) above also occur between consonants, as in (8), where they are predictable based on the underlying quality of the preceding short vowel. For some speakers the dorsal fricative is pronounced as [h] or simply as devoicing on the preceding vowel. This is not Tootsinam's prototypical pronunciation, but does occur occasionally, (8d). Miyashita (2018) analyzes these fricatives as the result of coalescence between the dorsal fricative and a preceding short vowel, creating a syllabic fricative which takes on the formants of the adjacent underlying vowel quality. Similarly, she analyzes the coda /x/ in examples like (7) as the result of coalescence between the dorsal fricative and the second mora of the preceding long vowel. This solution accounts for why there are no long voiced vowels before /x/ in Blackfoot, as well as the distribution of each allophone.

(8)	a.	[ʔákɔxʷtɛːtsk͡çpiji]	*ákaohtaitskihpiyi*	'she has danced past'
	b.	[ʔómʔxksːk͡sɪsi]	*ómahkssksisi*	'big nose'
	c.	[ʔáːkxʷtsɪtokoː]	*áákohtssitokoo*	'she will go through the center'

d. [ʔɪsksk͡sínʔhkaː] *isskskssínihkaa* ‘she broke glass’

All allophones of the dorsal fricative are typically highly fricated in Tootsinam’s speech. Figure 5 shows the spectrogram for [ʔaxkójɪnːɪmaːn] *aahkóyinnimaan* ‘pipe’, which includes a post-vocalic [x]. Figure 5 shows that the vowel (highlighted in the dotted gold box) is short before the dorsal fricative (highlighted in the solid blue box). The /x/ also lends some breathiness to the first half of the preceding vowel, which is why the voicing bar during the vowel [a] in Figure 5 is so short. Despite this, the vowel is readily perceptible.

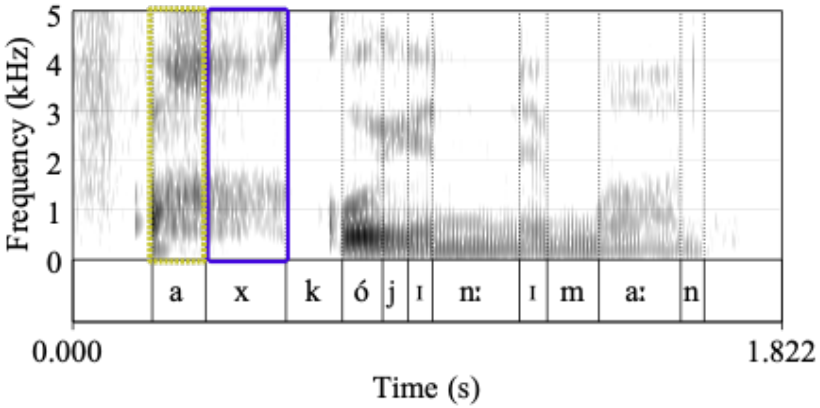

Figure 5 Spectrogram of [ʔaxkójɪnːɪmaːn] *aahkóyinnimaan* ‘pipe’. Dynamic spectrogram range = 45 dB. Blue box highlights dorsal fricative. Dashed gold box highlights breathy vowel preceding dorsal fricative.

Figures 6, 7, and 8 show the spectrograms for interconsonantal [x], [ç], and [xʷ], respectively. These three figures show different spectral qualities for each dorsal place of articulation. All three figures also show strong frication througout nearly the entire interval between the surrounding consonants. This frication distinguishes interconsonantal /x/ from word final voiceless vowels in Blackfoot (discussed in §5.3).

Figure 6 shows the spectrogram for [ʔómʔxksːk͡sɪsi] *ómahkssksisi* ‘big nose’. This word includes an interconsonantal [x] with considerable frication in the 1000 and 4000 Hz range.

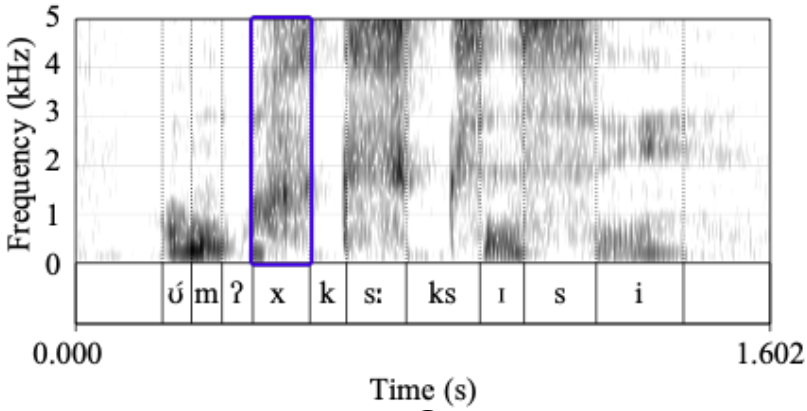

Figure 6 Spectrogram of [ʔómʔxksːk͡sɪsi] *ómahkssksisi* ‘big nose’. Dynamic spectrogram range = 45 dB. Blue box highlights dorsal fricative.

Figure 7 shows the spectrogram for [ʔákɔxʷtɛːtskçpiji] *ákaohtaitskihpiyi* ‘she has danced past’. This word includes an interconsontal [ç] with somewhat less frication in the 1000-2000 Hz range, but more centered at 3000 Hz.

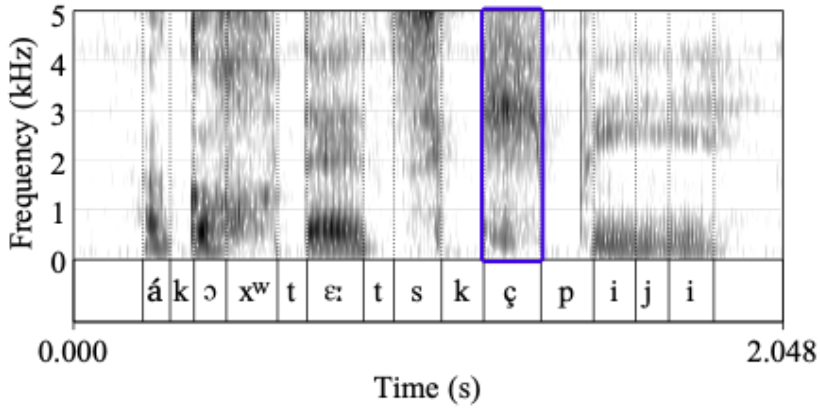

Figure 7 Spectrogram for [ʔákɔxʷtɛːtskçpiji] *ákaohtaitskihpiyi* ‘she has danced past’. Dynamic spectrogram range = 45 dB. Blue box highlights dorsal fricative.

Figure 8 shows the spectrogram for [ʔáːkxʷtsɪtokoː] *áákohtssitokoo* ‘she will go through the center’. This word includes an interconsonantal [xʷ], which has most of its frication, like Figure 6, in the 1000 and the 4000 Hz range, with attenuation elsewhere.

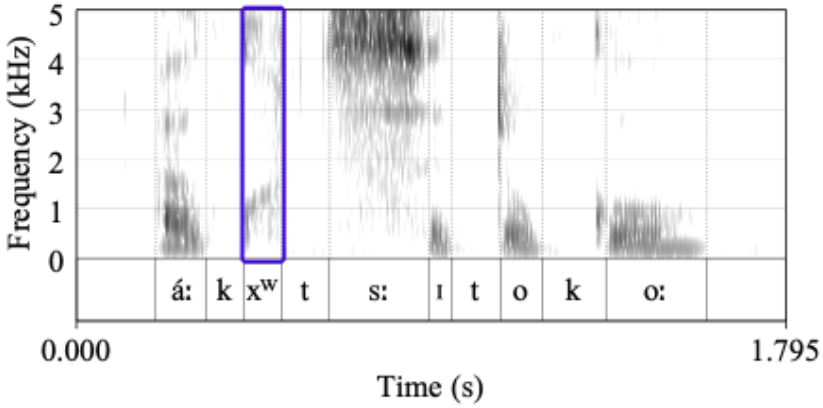

Figure 8 Spectrogram for [ʔáːkxʷtsɪtokoː] *áákohtssitokoo* ‘she will go through the center’. Dynamic spectrogram range = 45 dB. Blue box highlights dorsal fricative.

The next subsection turns to the glottal stop, another consonant with a restricted distribution.

4.5 Glottal stop /ʔ/

The glottal stop is another segment with a fairly restricted distribution. This segment prototypically occurs before a non-geminate obstruent, nasal, or glide. As Peterson (2004) notes, the dictionary (Frantz & Russell 2017) also includes a few entries with a glottal stop between vowels, but there were none in our dataset. The intervocalic cases are marked in the sense that morpheme alternations typically avoid intervocalic glottal stops: a glottal stop at the right edge of a prefix either metathesizes with the following vowel to surface just before a consonant, or deletes, depending on the surrounding phonological context. (See Peterson 2004 for details.) In

this section we focus on the acoustic manifestation of glottal stops in our dataset, as well as positions where glottal stops are predictably epenthesized.

The glottal stop is variably pronounced as a full glottal stop, creaky voice, or simply length on the preceding vowel (Peterson 2004). The exact realization depends on the speaker, rate of speech, and morphophonological context. Despite this, a vowel followed by a glottal stop is phonemically different than a long vowel, as shown in (9).

(9)	a.	[ʔaʔps:kít]	*a̱'psskít*	'chase it!'
	b.	[ʔá:ps:ki]	*áápsski*	'white face' (horse)

The spectrograms for both examples in (9) are shown in Figures 9 and 10, respectively. As shown in Figure 9, the glottal stop in [ʔaʔps:kít] *a̱'psskít* 'chase it!' is realized in a relatively short period towards the end of the long vowel, with only one strong glottal pulse. Nevertheless, it is distinct from the long vowel without a glottal stop in Figure 10. Glottalization is reported as the most frequent pronunciation of phonemic glottal stops in other languages as well (see Whalen et al. 2016 on Arapaho and Davidson 2021 on Hawaiian). For simplicity, we continue to refer to this segment as a glottal stop in this llustration while recognizing that it is often quite weak in the acoustic signal.

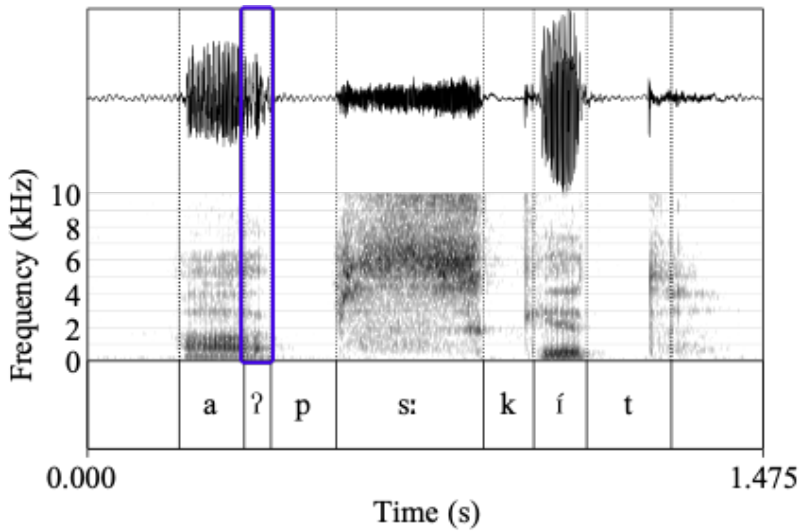

Figure 9 Spectrogram and waveform for [ʔaʔps:kít] *a'psskít* 'chase it!'. Dynamic spectrogram range = 45 dB. Blue box highlights glottal stop.

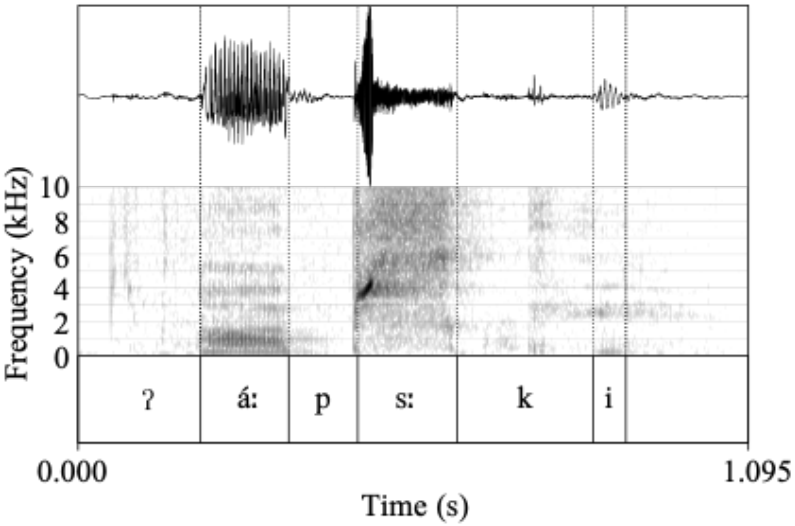

Figure 10 Spectrogram and waveform for [ʔáːpsːki] *áápsski* 'white face' (horse). Dynamic spectrogram range = 65 dB.

Because a full glottal stop is only one of several realizations, this raises the question of whether /ʔ/ is the best representation for this segment at all. Peterson (2004) argues that this phoneme is better analyzed as a laryngeal feature of a vowel. Specifically, he argues that it is a subsegmental constricted [CG] feature which is moraically licensed. He accounts for the three surface realizations in the following way. If the [CG] feature is the only segment parsed to the final mora of the syllable, the vowel is short and the [CG] feature surfaces as a full glottal stop. If it is parsed to the final mora of the syllable which is also linked to the vowel, then the vowel is long and the [CG] feature surfaces as creaky voicing on the vowel. If the [CG] feature is left unparsed, then the vowel simply surfaces as long. Note that crucially, vowel length is neutralized before a full glottal stop, which is unsurprising if the segment is moraic, as it is in Peterson's analysis. We return to this fact in §6 to explain our analysis of syllable structure. Interestingly, the two most recent descriptive grammars of Blackfoot (Frantz 2017; Taylor 1969) also note that vowel length is variable or difficult to determine before glottal stop. Both authors write the vowel as long in this position unless there are morpheme alternations showing the vowel is short. We take this as corroborating evidence that vowel length is not contrastive before this segment, which is compatible with Peterson's (2004) analysis.

There are several positions where glottal stops are predictable rather than contrastive. A glottal stop is epenthesized at the left edge of words which begin in an underlying vowel (Derrick 2007). This is shown in (10) for words beginning in the three short contrastive vowels. Our dataset consists of words in isolation, so it remains to be seen whether this epenthesis occurs at the left edge of each word or the left edge of some larger domain like a phrase or utterance.

(10)	a.	[ʔakɔ́ːmɐtɐpɐkːíspoː]	*akáómatapakkísspoo*	'she has started to get much higher'
	b.	[ʔokɛ́ːsɪnaːksiːˢ͡ts]	*okáísinaakssiistsi*	'his debts'
	c.	[ʔikímʔxʷsiːtą̊]	*ikímmohsiita*	'pity yourself!'

A glottal stop is epenthesized predictably between sonorants and a voiceless fricative or vowel (described in Frantz 2017: 7). In (11) we include examples between a [j], [m], or [n] and a long interconsonantal [sː]. (A glide [w] never occurs before long [sː].) As we discuss in §5.2,

short vowels become centralized in the position before all sonorants, and long vowels neutralize to a short, centralized vowel before nasals only.

(11)	a.	[ʔɔ́:ko:jʔs:ka:]	*áókooysskaa*	‘carpenter’
	b.	[ʔiçpokónʔs:ka:]	*iihpokónsskaa*	‘he has gotten the ball’
	c.	[ʔi:kómʔs:pikaʔpsi]	*iikómsspika’pssi*	‘he is hard to take care of’

In contrast, [p], [t], and [k] can occur directly before [s:], as seen in (12).

(12)	a.	[ʔaʔps:kít]	*a’psskít*	‘chase it!’
	b.	[ʔɔ́:ts:k͡si:ˢtsta:ni]	*áótssksiiststaani*	‘he kneaded it’
	c.	[ʔíʔks:kɪmʔa̰]	*í’ksskimma*	‘metal’

Nasals are also separated from dorsal fricatives by a glottal stop, (13). There is one example of a phonemically short nasal /n/ in this position, (13a), as well as geminate /n:/, (13b), and geminate /m:/, (13c). (There were no instances of phonemically short /m/ before a dorsal fricative in our corpus.) Underlying nasal length is neutralized in this position (discussed in §6).

(13)	a.	[ʔɪsksk͡sínʔhka:]	*isskskssínihkaa*	‘she broke glass’
	b.	[ʔi:tɛ́nʔçtɔwʔpa̰]	*iitáínnihtao’pa*	‘cooking pot’
	c.	[ʔɪspómʔçta:t]	*isspómmihtaat*	‘help out!’

Figure 11 includes a spectrogram of (13a), where there is a period of silence between the nasal and the noise of the following fricative.

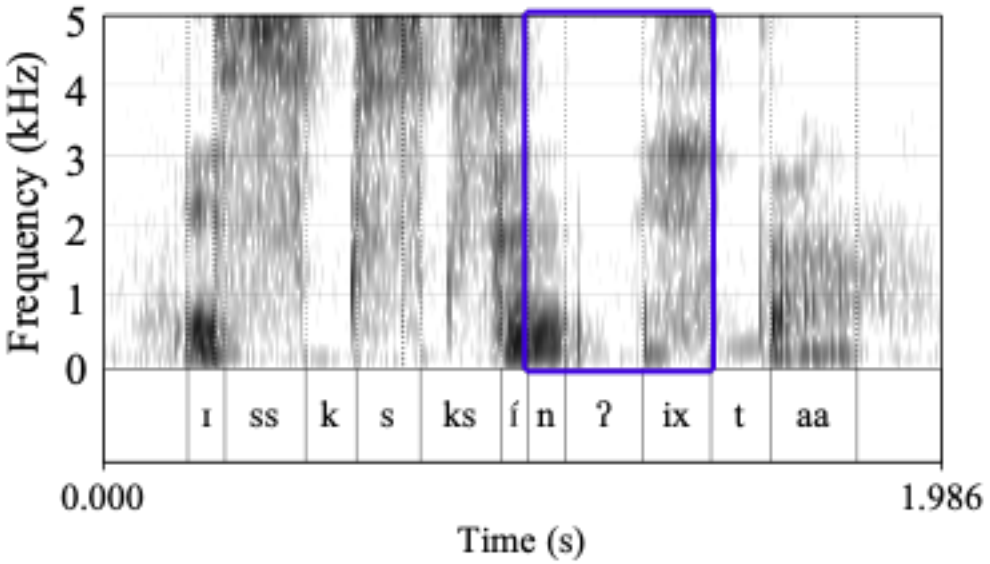

Figure 11 Spectrogram of nasal separated from a following dorsal fricative by a glottal stop for [ʔɪsksk͡sínʔhka:] *isskskssínihkaa* ‘she broke glass’. Dynamic spectrogram range = 45 dB.

Finally, nasals are often separated from voiceless word-final vowels by a glottal stop. There is an examples of a phonemically short nasal [n] in this position, (14a), as well as an

underlyingly geminate [mː], (14b). Nasal length is neutralized before this epenthetic glottal stop, which we discuss further in §6.

(14)	a.	[nɪtɛ́nʔa̰]	*nitána*	'my daughter'
	b.	[ʔíʔksːkɪmʔa̰]	*í'ksskimma*	'metal'

A few examples of kinship terms end in a geminate nasal followed by a voiceless vowel, (15). There is no epenthetic glottal stop in these cases, and the geminate nasal remains long. These datapoints may indicate that glottal stop epenthesis is not an obligatory rule, or perhaps glottal stop epenthesis is blocked here due to some minimal size constraint.

(15)	[níns̥ːa̰]	*nínna*	'my father'

Having completing a discussion of consonant contrasts and distribution within our dataset, we turn to Blackfoot vowels in the next section.

5. Vowels

In contrast to the consonant inventory, there is largely agreement among researchers about the main vocalic contrasts and allophones in Blackfoot. Much of the variation discussed in the literature surrounds the long mid vowels, [ɛː] and [ɔː], which are pronounced as diphthongs in some dialects and phonological contexts. Our dataset does not contain these vowels systematically across different environments. What we can demonstrate is that there is a large amount of intraspeaker variation for some other allophones, especially for the centralization of short vowels in open syllables, as well as the presence of word-final voiceless vowels. This type of variation would be an interesting place for further study.

In §5.1 we lay out our vowel inventory and explain how it differs from previous research. We then turn in §5.2 to a description of systematic and gradient allophones. Finally, §5.3 describes the distribution of word-final voiceless vowels in our dataset.

5.1 Phonemic inventory

Blackfoot has five long vowels, /iː/, /ɛː/, /aː/, /ɔː/, and /oː/, and three short vowels, /i/, /a/, and /o/. We follow Weber (2020, submitted) and Weber & Miyashita (2024) in including the long mid vowels /ɛː/ and /ɔː/, which are not in traditional descriptions of Blackfoot (e.g. Taylor 1969; Frantz 2017). The Blackfoot vowel chart is shown in IPA style in Figure 12. Note that we use [a] for typographic convenience to represent a low central vowel, rather than a low front vowel.

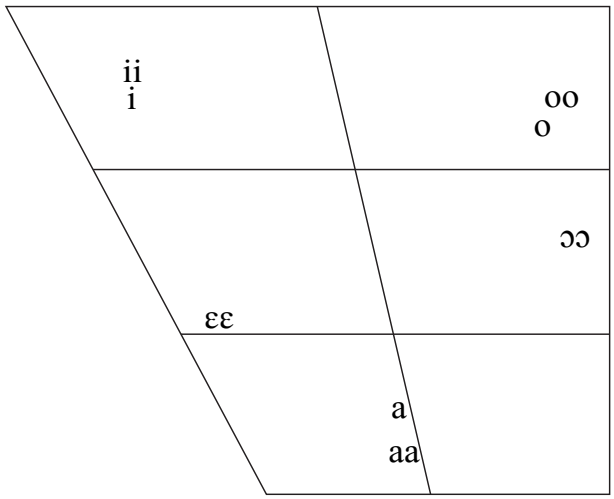

Figure 12 Blackfoot vowel chart in IPA format

The three phonemic short vowels are given in (16) in the frame [#ʔ_k…]. This shows that these three vowels occur in overlapping environments and have the potential to contrast.

(16)	a.	[ʔakɔ́ːmɐtɐpɐkːíspoː]	*akáómatapakkísspoo*	‘she has started to get much higher’
	b.	[ʔokɛ́ːsɪnaːksiːˢt͡s]	*okáísinaakssiistsi*	‘his debts’
	c.	[ʔikímʔxʷsiːtą̊]	*ikímmohsiita*	‘pity yourself!’

Four of the five phonemic long vowels are given in (17) in the frame [#ʔ_k…]. This shows that these four long vowels occur in overlapping environments and have the potential to contrast.

(17)	a.	[ʔáːkɛːˢtaːpik͡sɪmmɛː]	*áákaistaapiksimayi*	‘he will throw it’
	b.	[ʔɛ́ːkɪmʔxʷsi]	*áíkimmohsi*	‘he is pitying himself’
	c.	[ʔɔ́ːkoːjʔsːkaː]	*áókooysskaa*	‘carpenter’
	d.	[ʔíːksksːtsʊwaʔpiː]	*íiksksstsowa’pii*	‘it was a chance happening’

Our corpus does not include any words beginning underlyingly in the fifth long vowel, /oː/. However, this vowel does occur word-finally in the frame […k_#], which overlaps with the distribution of long /aː/ and long /iː/, shown in (18).

(18)	a.	[ʔiçpokɔ́nʔsːkaː]	*iihpokónsskaa*	‘he has gotten the ball’
	b.	[ʔáːkxʷtsɪtokoː]	*áákohtssitokoo*	‘she will go through the center’
	c.	[ʔaːsíːkukiː]	*aasíikokii*	‘bear grass’

The surface distribution of long vowels in (17) and (18) shows that all five vowels occur in overlapping environments. However, the long mid vowels [ɛː] and [ɔː] in (17) are not underlying vowels, but arise via vowel coalescence of the imperfective prefix [a-] with the following stem). Long [ɛː] arises from an underlying /a+i/ sequence, and long [ɔː] arises from an underlying /a+o/ sequence (see Elfner 2006a; Weber 2020, submitted for vowel coalescence in Blackfoot). Many authors argue that *all* long centralized mid vowels [ɛː] and [ɔː] arise predictably across

morpheme boundaries and therefore are not contrastive (e.g. Kinsella 1972; Frantz 2017; Taylor 1969). However, these vowels occasionally occur morpheme-internally where they overlap in distribution with the other long vowels. For example, the dependent (bound) noun root /-ɛːɛː/ -*aiai* 'robe' contains an underlying /ɛː/, which occurs in an overlapping local environment with long /aː/ in (19). Following Weber (2020, submitted) and Weber & Miyashita (2024), we take this as evidence that long mid vowels contrast with other long vowels.[7]

(19)	a.	[nɛ̲ːɛ́ːwa]	*n-aiái-wa*	'my robe'
	b.	[na̲ːáxsɪk͡s]	*n-aaáhs-iksi*	'my grandparents'

Long vowels have a median duration of 188 ms (484 tokens, standard deviation = 64.9), and short vowels have a median duration of 115 ms (605 tokens, standard deviation = 55.1), making long vowels 1.6x longer than short vowels. The long vowels are slightly more separated and uniform in production than the short vowels, as seen in Figure 11. The ellipses outline 1.5 standard deviations for each vowel. Long vowels are encircled with a solid line and short vowels with a dotted line. Figure 13 was produced using 1,089 vowel tokens.

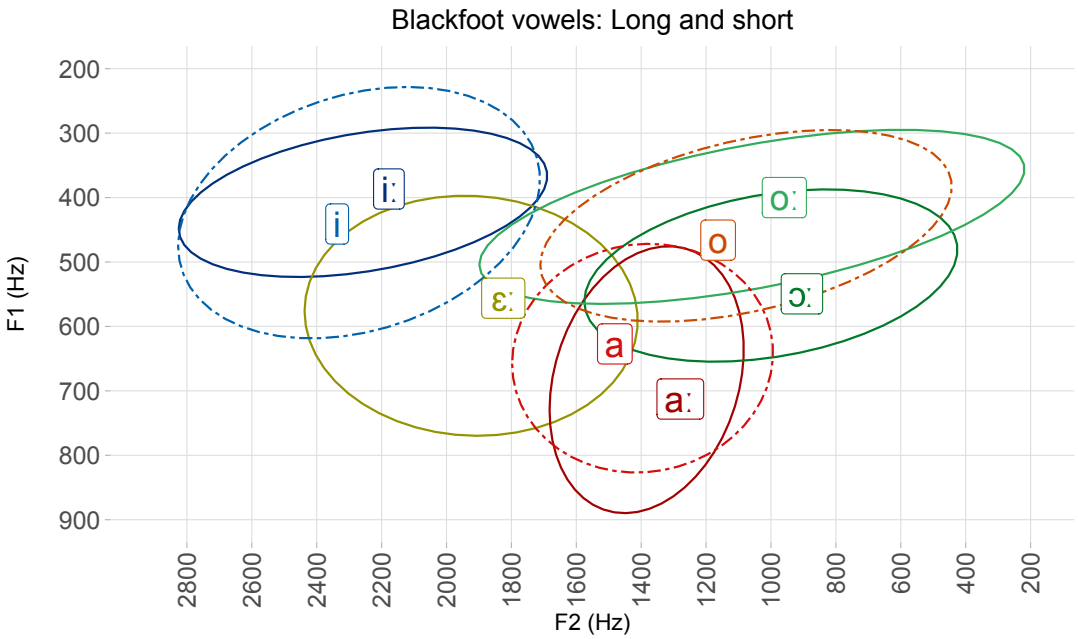

Figure 13 Phonemic long and short Blackfoot vowels (based on 1089 vowel tokens: [i] = 303, [iː] = 144, [ɛː] 65, [a] = 157, [aː] 184, [ɔː] = 32, o = 145, [oː] = 59; 1.5 standard deviation outlines shown for clarity). Solid outlines are phonemic long vowels and dashed/dotted lines are phonemic short vowels.

The high back vowel is frequently lower than English /u/, and is closer to English /ʊ/ or /o/ in quality. The mid and high pronunciations occur in overlapping environments. The high front vowel is also often lower than English /i/, often sounding like /ɪ/ or /e/, especially in word-final

[7] All instances of long /ɔː/ in our dataset occur in derived environments. Weber (2020, Appendix A) includes a list of words with non-derived /ɛː/ and /ɔː/ which occur in Frantz & Russell (2017).

position. The mid centralized vowels are like English /ɛ/ and /ɔ/; the mid front vowel can also be quite low, like English /æ/.

5.2 Allophones

Blackfoot vowels have several predictable allophones. We described long vowel shortening before /x/ and short vowel coalescence with /x/ in §4.4. Therefore, in this section we focus on the distribution of short, centralized vowel allophones. These fall into three types: (1) systematic in environments where vowel length is neutralized (no long vowels occur), (2) systematic in environments where vowel length is not neutralized (long vowels occur), and (3) gradient and variable in other environments. The first type is well-described in the literature, while the second and third types are not described to our knowledge.

Short, centralized vowels occur in several contexts. Length is neutralized for all vowel qualities to a short, centralized quality [ɪ ɛ ɐ ɔ ʊ] before geminate stops (Frantz 2017), as shown in examples (20), including before a geminate pre-assibilate [ˢtː], (20e). (There are no instances of a back mid centralized vowel [ɔ] before a geminate in our dataset, but the other four vowel qualities are shown in example (20).)

(20)	a.	[k͡sɪ̱kːokúːwa]	*ksi̱kkokóówa*	'tent'
	b.	[ʔɛ̱́kːatoʔpa̰]	*áikkatoo'pa*	'balloon'
	c.	[ʔɛ́ːpɐ̱kːɪtɐkaʔsi]	*áipakkitaka'si*	'motorcycle'
	d.	[nítsːkxʷkʊ̱kːɛː]	*nítsskohkokkayi*	'he gave back to me'
	e.	[ʔɪ̱ˢtːsksːkjúːmitaː]	*isttskssskióómitaa*	'slim faced dog', 'grayhound'

Length is also neutralized for all vowel qualities, including the diphthong [oj], to a short, centralized quality before a [sC] cluster (Frantz 2017), as shown in (21). (There are no instances of a back vowel of any kind, [ɐ], [ɔ], or [ʊ], before an [sC] cluster in our dataset.)

(21)	a.	[ʔakɔ́ːmɐtɐpɐkːíspoː]	*akáómatapakkísspoo*	'she has started to get much higher'
	b.	[ʔápɛ̱staːminamː]	*ápaisstaaminaamm*	'apple'
	c.	[ʔiːtóíst͡siːji]	*iitóísstsiiyi*	'he went to a sweat'

Length is also neutralized to a short, centralized quality before a nasal followed by a glottal stop. This is shown in (22a) for the vowel [ɐ] before [mʔ], (22b) for the vowel [ʊ] before [nʔ] and [mʔ], and (22c) for the vowel [ɪ] before [nʔ]. This vowel neutralization was also described in Elfner (2006a) for a different speaker of Blackfoot, although she did not transcribe glottal stops between the nasals and /s/.

(22)	a.	[stɐ̱́mʔsːaːkonoːs]	*stámsssaakonoos*	'try to recognize her!'
	b.	[ʔiçpokʊ́nʔsːkaː]	*iihpokónsskaawa*	'he has gotten the ball'
		[ʔiːkʊ́mʔsːpikaʔpsi]	*iikómsspika'pssi*	'he is hard to take care of'
	c.	[moxʷkínʔsːt͡sɪs]	*moohkínsstsis*	'elbow'

The vowel length neutralization in (20)–(22) is discussed in the literature (Elfner 2006a; Frantz 2017). However, we also found that centralized vowels occur as systematic allophones of short vowels in positions where vowel length remains distinctive. Most of this allophony has not been mentioned in the previous literature, so we describe it at some length.

Short vowels are centralized before a final consonant, shown in (23). Most of our examples involve a short, centralized [ɪ], (23a–d), but there is also an instance of a centralized diphthong [ʊɐ] before a final [n], (23e). This is not a case of vowel length neutralization, since long vowels can also occur in this position, as in [stɐ́mík:sksi:s] *stámíkksksiis* ‘test her knowledge!’.

(23)	a.	[ʔaʔps:kít]	*a’psskít*	‘chase it!’
	b.	[ʔa:píksɪn]	*aapíkssin*	‘sores’
	c.	[ʔɪs:akím:ɪs]	*issakímmis*	‘get over him!’
	d.	[má:tɛ:nʔs:pópi:wa:t͡sɪk͡s]	*máátainsspópiiwaatsiksi*	‘she does not sit still’
	e.	[kím:ataʔpsíja:pi:kʊɐn]	*kímmata’pssíyaapiikoan*	‘poor walker’

Short vowels centralize before a word-final consonant even when this is followed by a word-final voiceless vowel, (24).

(24)	a.	[sojíˢt:ɐjɪtą̊]	*soyísttayita*	‘dive!’
	b.	[stɐ́mɪką̊]	*stámika*	‘steer’

Short vowels become centralized before a glide followed by a glottal stop. This is shown in (25a) for the vowel [ɐ] before [jʔ]. Again, vowel length is not neutralized in this position, because long vowels occasionally occur before sonorants followed by glottal stops, as in (25b).

(25)	a.	[nit͡sí:kɐjʔs:po:ką̊]	*nitsíikaysspooka*	‘she parted my hair’
	b.	[ʔɔ́:kojʔs:ka:]	*áókooysskaa*	‘carpenter’

Short vowels become centralized before a consonant followed by an interconsonantal or postconsonantal /s/ of any length. This is shown in (26a) before an interconsonantal short /s/, in (26b) before an interconsonantal long /s:/, in (26c) before a postconsonantal short /s/, and (26d) before a postconsonantal long /s:/. Again, vowel length is not neutralized in this position, because long vowels occur in this position, as in [ʔá:ps:ki] *áápsski* ‘white face (horse)’.

(26)	a.	[sípst͡sina:n]	*sípstsinaan*	‘tipi flap pole’
	b.	[mowɐ́ps:pɪn]	*mowápsspin*	‘eye’
		[stɐ́mɪts:kɪtą̊]	*stámitsskita*	‘leave it (anim.)!’
	c.	[pisɐ́tsɛski]	*pisátssaisski*	‘flower’
		[nitá:kʊksɪt͡sɪpsak:ą̊]	*nitáákokssitsipssakka*	‘he will talk deceptively to me’
	d.	[ʔóm̥ʔxkítɛ:sɐps:i:ˢtstɐkjoʔpą̊]	*omahkítaisapsssiiststakio’pa*	‘washtub’

Short vowels become centralized before a [Cj] cluster. This is shown in (27) for the vowels [ɐ] and [ɪ]; there are no examples of [ʊ] in our corpus in this position. Again, vowel length is not neutralized in this position, because long vowels also occur here, as in [na:mjó:jɪs] *naamióóyis* ‘bee hive’.

(27)	a.	[ʔóm̥ʔxks:ɐpjaʔt͡sɪs]	*ómahksssapia’tsis*	‘big field glasses’
	b.	[ʔiçtɔ́:kspɛn:ɪkjoʔpą̊]	*iihtáókspainnikio’pa*	‘glue’

Allophonically, the short vowel [i] often has a centralized quality [ɪ] adjacent to sibilants in other contexts (Taylor 1969). In our corpus, we found centralized [ɪ] following the sibilants /s/, /t͡s/, and /k͡s/, (28), except word-finally or before glottal stops where a peripherial [i] occurs, (29).

(28)	a.	[ʔiçtɛ́ːsɪ̱tokoː]	*iihtáisitokoo*	'he went through the center'
	b.	[nɪt͡sɪ̱nâːn]	*nitsináan*	'my belonging/possession'
	c.	[ʔɛ́sk͡sɪ̱nimaʔtstxʷki]	*áissksinima'tstohki*	'he teaches'

(29)	a.	[nitɛ́ːsi̱ʔkiʔpa̰]	*nitáisi'ki'pa*	'I am covering it'
	b.	[ʔɛ́ːkɪmʔxʷsi̱]	*áíkimmohsi*	'he is pitying himself'

Outside of the positional allophony and neutralization patterns described above, there were also many exceptional and unexplained instances of centralized vowels in open syllables. In many cases the centralized and peripheral short vowel were in free variation across multiple tokens of the same word. Recall from §3 that our transcriptions reflect the most frequent allophone in those cases, potentially imposing categorization on what may be a gradient pattern of centralization. Nevertheless, because vowel centralization is apparently quite widespread in Blackfoot, we have marked these where we heard them, and we leave a full study of vowel centralization in Blackfoot for future research.

There were some trends in these exceptional cases of centralized vowels. For example, the first vowel of the suffix /-imaː/ *-imaa* was nearly always centralized, (30a); centralized vowels often occur in multiple adjacent syllables as if undergoing harmony, (30b); the vowel before a morpheme-final consonant is often centralized, as for the vowel in /kan-/ 'dry' in (30c); and the vowel *following* a geminate is frequently centralized, (30d). There were not enough cases to determine whether these trends are systematic or not.

(30)	a.	[ʔaxkójɪnːɪ̱maːn]	*aahkóyinnimaan*	'pipe'
	b.	[ʔakɔ́ːmɐ̱tɐ̱pɐkːíspoː]	*akáómatapakkísspoo*	'she has started to get much higher'
	c.	[kɐ̱́nik͡sɪmː]	*kániksimm*	'stump', 'big branch'
	d.	[ʔɛ́ːpɐkːɪ̱tɐkaʔsi]	*áípakkitaka'si*	'motorcycle'

Finally, there are a few exceptional cases where vowels did not sound centralized before a geminate consonant (where vowel neutralization is otherwise systematic, as in (20)). Example (31) includes all instances in our corpus. Interestingly, this phenomenon is also commented on by Frantz (2017: 7), who suggests that peripheral short vowels before geminates are underlyingly long while centralized short vowels before geminates are underlyingly short.

(31)	a.	[ʔápɛstaːmi̱nam̱ːm]	*ápaisstaaminaamm*	'apple'
	b.	[ʔɪst͡sáːpiṉaṯːsi]	*isstsáápinaattsi*	'it looks bright'
	c.	[nitáːkʊksɪt͡sɪpsa̱kːa̰]	*nitáákokssitsipssakka*	'he will talk deceptively to me'
	d.	[mo̱tːok͡sís]	*mottoksís*	'knee'
	e.	[ʔo̱tːɐ́pitoxʷt͡si]	*ottápitoohtsi*	'behind the house'

The acoustic production of peripheral and centralized vowels overlaps considerably. Figure 14 plots all five centralized vowels [ɪ ɛ ɐ ɔ ʊ] against a peripheral vowel with the same height

and backness. The peripheral vowel is long for the two mid vowels, [ɛː] and [ɔː]; otherwise it is short. Note that the centralized vowels in Figure 14 include the systematically centralized vowels in positions where vowel length does and does not neutralize, as well as the cases of free variation or gradient centralization in open syllables.[8]

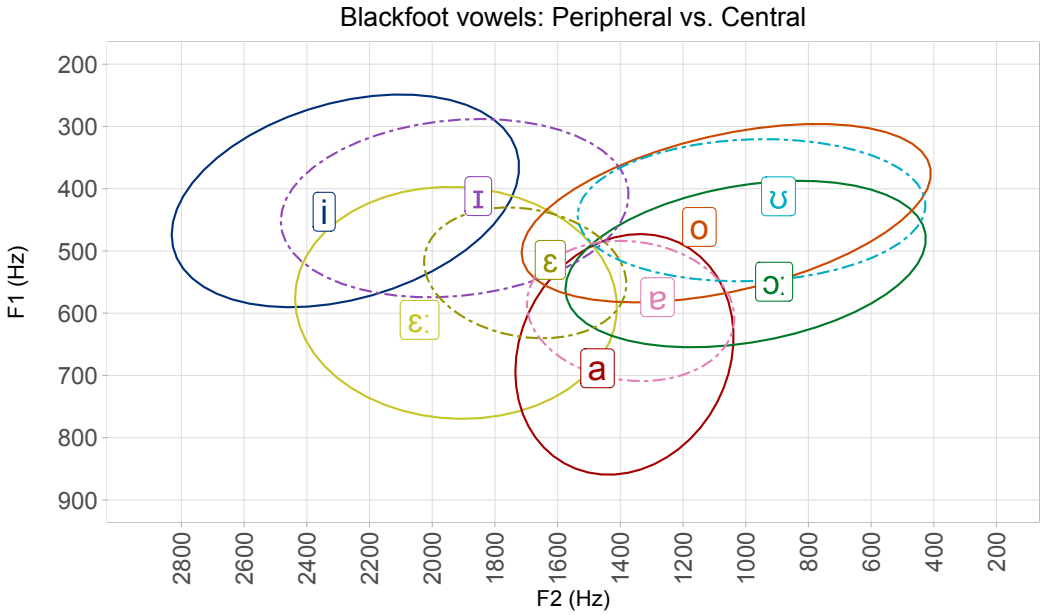

Figure 14 Peripheral and centralized Blackfoot vowels (Based on 1592 vowels: [i] = 453, [ɪ] = 352, [ɛː] = 65, [ɛ] = 53, [a] = 340, [ɐ] = 51, [ɔː] = 32, [ɔ] = 2 (not shown), [o] = 202, [ʊ] = 42. 1.5 standard deviation outlines shown for clarity). Solid outlines are peripheral vowels and dashed/dotted lines are centralized.

Finally, we briefly mention allophony of the long mid vowels before glottal stops, where they are frequently diphthongized. The vowel qualities differ depending on dialect, speaker, and phonological context, with [ɛː] frequently pronounced as [ej] or [aj] and [ɔː] frequently pronounced as [aw]. Although the description of this allophony takes up considerable space in reference materials (Frantz 1978, 2017: 2–3; Kinsella 1972; Lowery 1979; Taylor 1969; Uhlenbeck 1938; Weber & Miyashita 2024), there were few examples of long mid vowels before glottal stops in our dataset, and we found that the diphthongized positional variant did not always occur. The only example of a front mid vowel before a glottal stop had a mid-close monophthong, (32). There are two examples of a back mid vowel before a glottal stop; one was monophthongal, (33a), while the other was dipthongized, (33b).

---

[8] An anonymous reviewer points out that the figure would be more principled if the categorization were additionally based on environment rather than auditory impressions, so that peripheral and centralized vowels could be compared by context. While we agree, our dataset is not systematic in such a way. The number of systematically centralized vowels is also far greater than the number of gradiently centralized vowels, such that we doubt the gradiently centralized vowels have greatly skewed the formant values here. Still, this figure should be taken as a first step towards more systematic studies.

(32)	a.	[ʔáɔ́weʔtaki]	*áówai'taki*	'he is asking for a wife'

(33)	a.	[ʔiçtɛ́ːkskɪmɔʔpiːˢt͡s]	*iihtáíkskimao'piistsi*	'hunting equipment'
	b.	[ʔiːtɛ́nʔçtɔwʔpa̰]	*iitáínnihtao'pa*	'cooking pot'

5.3 Word-final voiceless vowels

Previous studies show that short vowels devoice word-finally (e.g. Taylor 1969: 43–47; Frantz 2017: 6; Windsor 2017a,b; Prins 2019), and many also show that long vowels shorten in word-final position (Bliss & Glougie 2010; Frantz 2017: 6; Gick et al. 2012; Windsor 2017a,b; Bliss & Gick 2017). In addition, Windsor (2017a,b) argues that word-final plosives are aspirated, and presents an analysis that unites word-final vowel devoicing, vowel shortening, and plosive aspiration. The extent to which word-final voiceless vowels are pronounced is known to vary widely across speakers (Bliss & Glougie 2010; Bliss 2013; Bliss and Gick 2017). Although Tootsinam is described in some of the previous studies as a speaker without voiceless vowels, we find this is not always true. Tootsinam allows both voiceless and voiced vowels at the right edges of words, showing that right edge voicelessness is not solely conditioned by prosodic structure or position. Vowels in some morphosyntactic contexts never devoice, and devoiced vowels in other contexts frequently vary with nothing. As we discuss below, some final voiceless segments in Tootsinam's speech are ambiguous between final vowel [a] devoicing and final aspiration. Both sound identical, so we write final aspirated releases with devoiced vowels in all cases.

Voiceless word-final vowels are almost soundless and low in amplitude, contrasting sharply with the higher-amplitude of the partially or fully devoiced vowels which have coalesced with /x/, which can be seen by comparing the spectrograms in this section with those in §4.4. When audible, final voiceless vowels are visible on the spectrogram and different vowel qualities sound distinct. In many cases they are completely soundless (Bliss & Gick 2009, 2017; Gick et al. 2012), but speakers will notice if you repeat a word back incorrectly and instruct you to look at their faces while they repeat the word.

Some voiceless vowels are due to aspiration on phrase-final consonants (Windsor 2017a,b). For Tootsinam this aspiration is frequently optional. For example, the imperative suffix *-t* may be followed by a voiceless vowel, (34a), but there are also many instances where there was no audible or visible aspiration on the spectrograph, (34b).

(34)	a.	[sojíˢtːɐjɪta̰]	*soyísttayita*	'dive!'
	b.	[ʔaʔpsːkít]	*a'psskít*	'chase it!'

Other final voiceless vowels are straightforwardly instances of devoicing. For example, the word in (35a) ends in a final verbalizing suffix *-i*, which is devoiced on the surface. Not all final vowels devoice: bare nouns like (35b) never devoice for Tootsinam as a general rule. This is not true for all speakers (see Windsor 2017a,b).

(35)	a.	[kɪt͡sɪk͡síkːɐkoːmḭ]	*kitsiksíkkakoomi*	'you married young'
	b.	[ʔimitɔ́ʔkomi]	*imitáó'komi*	'flea'

Figure 15 shows the voiceless [ḭ] from (35a), in comparison to Figure 16, which shows the voiced word-final [i] from (35b). Both vowels occur after [m] in a similar environment.

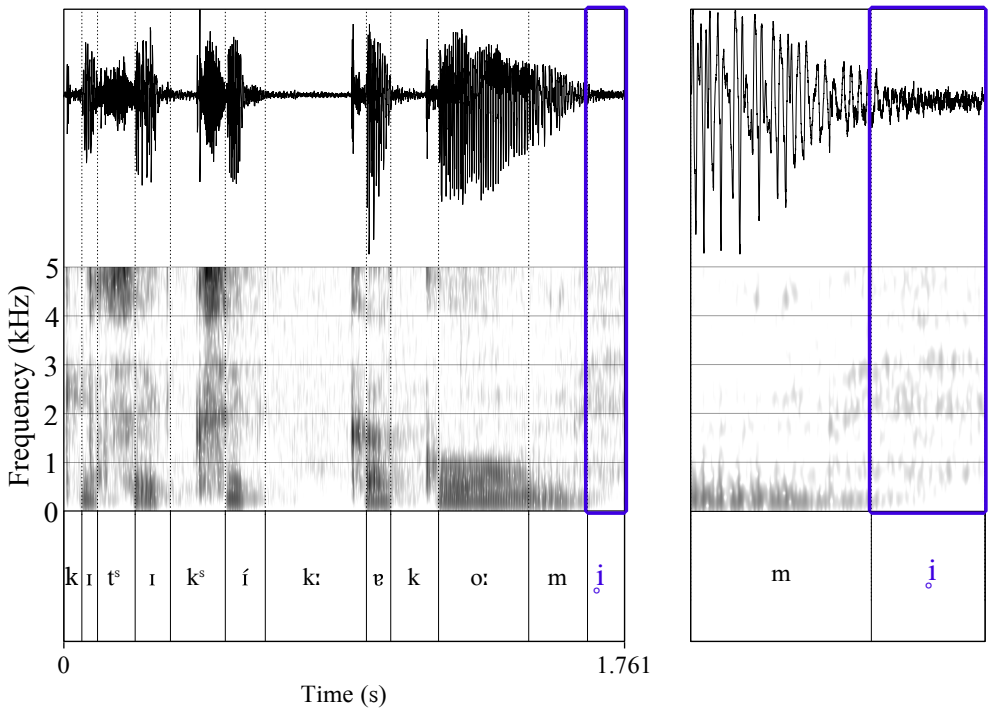

Figure 15 Waveform and spectrogram for [kɪt͡sɪk͡sík:ɐkoːmi̥] *kitsiksíkkakoomi* ‘you married young’. Dynamic spectrogram range = 50 dB. Blue box highlights final voiceless vowel.

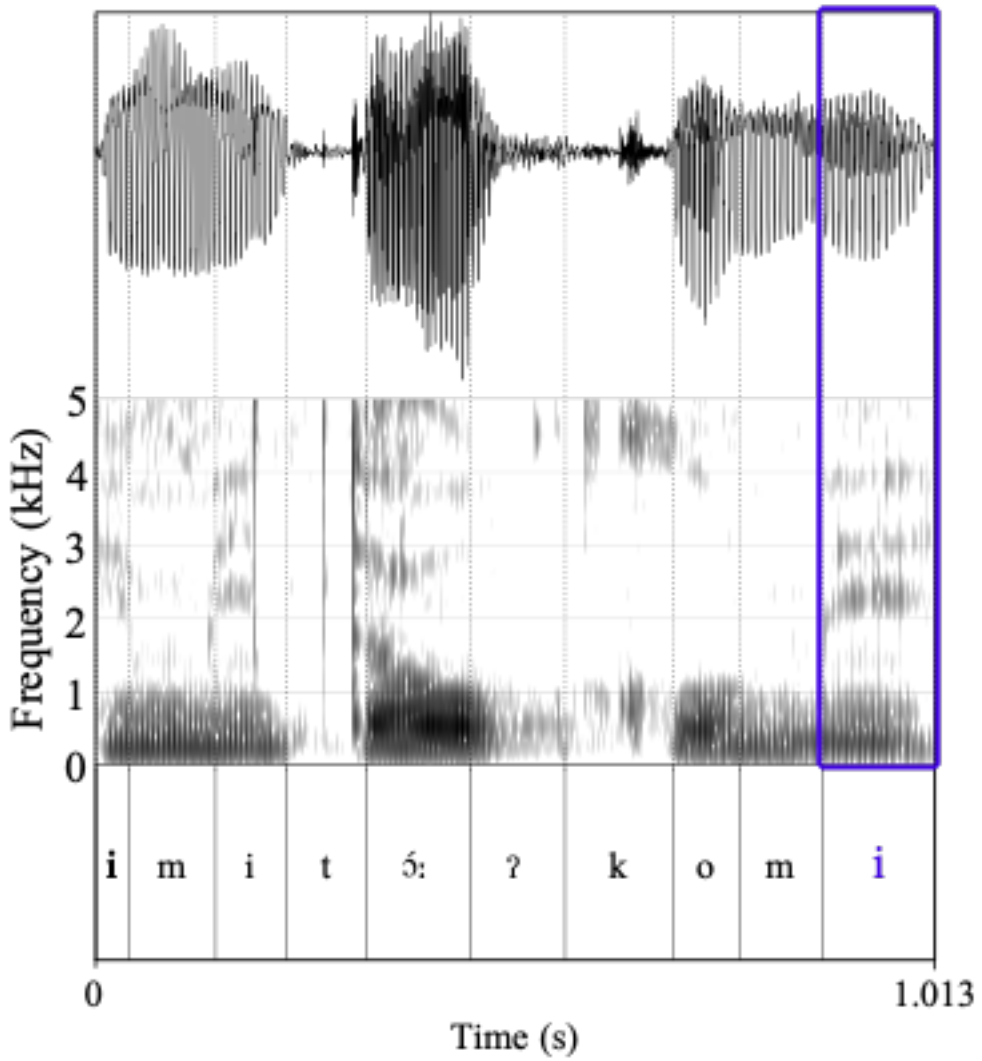

Figure 16 Waveform and spectrogram for [ʔimitɔ́ʔkomi] *imitáó'komi* 'flea'. Dynamic spectrogram range = 40 dB. Blue box highlights final voiced vowel.

Examples of a final [a̰] and [a:] after [k] are given in (36). We cannot include a direct comparison between a final [a̰] and short voiced [a] in this position, because all word-final non-high voiced vowels in our dataset are long (except that short [a] occurs after [w]).

(36)	a.	[nitɛ́:sɪmɪm:oka̰]	*nitáísimimmoka*	'he is talking gossip about me'
	b.	[pʊnokâ:]	*ponoká*	'elk'

Figure 17 includes the spectrogram for [nitɛ́:sɪmɪm:oka̰] *nitáísimimmoka* 'he is talking gossip about me', (36a), which ends in a voiceless [a̰]. There is no voicing bar, but the formants are faintly visible throughout this vowel. There is also general excitation across a wide range of frequencies, e.g. the spectrogram is darker here than it is for the voiceless consonant [k]. For comparison, Figure 18 includes the spectrogram for [pʊnokâ:] *ponoká* 'elk', (36b), which ends in a fully voiced vowel [a].

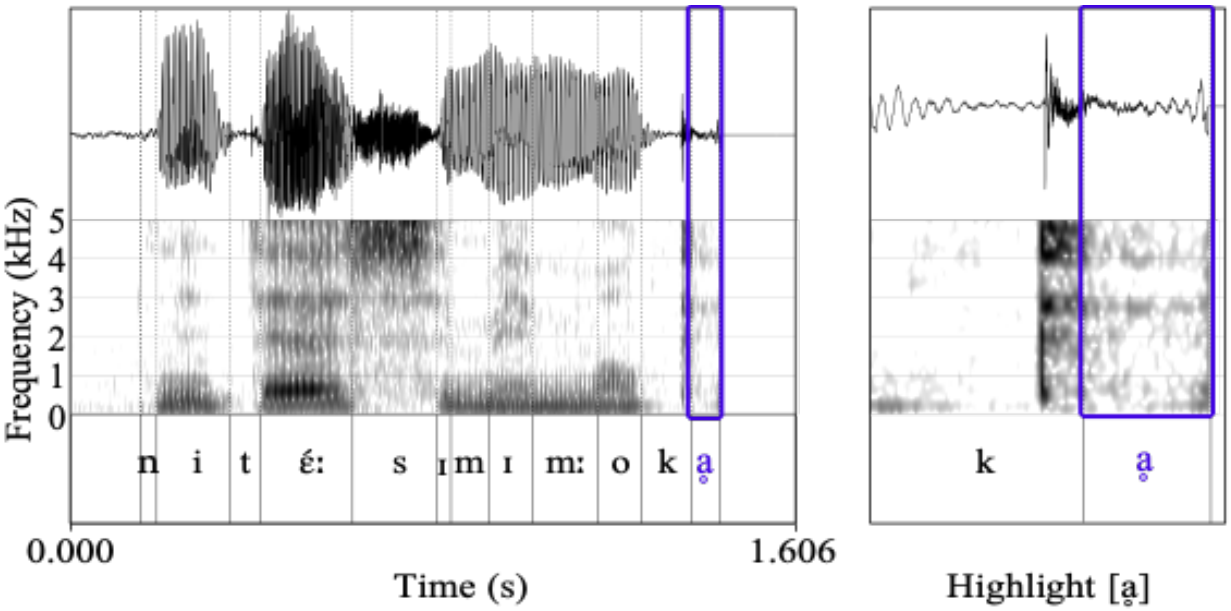

Figure 17 Waveform and spectrogram for [nitɛ́ːsɪmɪmːokḁ] *nitáísimimmoka* 'he is talking gossip about me', with a final voiceless [ḁ]. Dynamic spectrogram range = 45 dB. Silence at end zero-padded. Right side zooms in to highlight the final voiceless [ḁ].

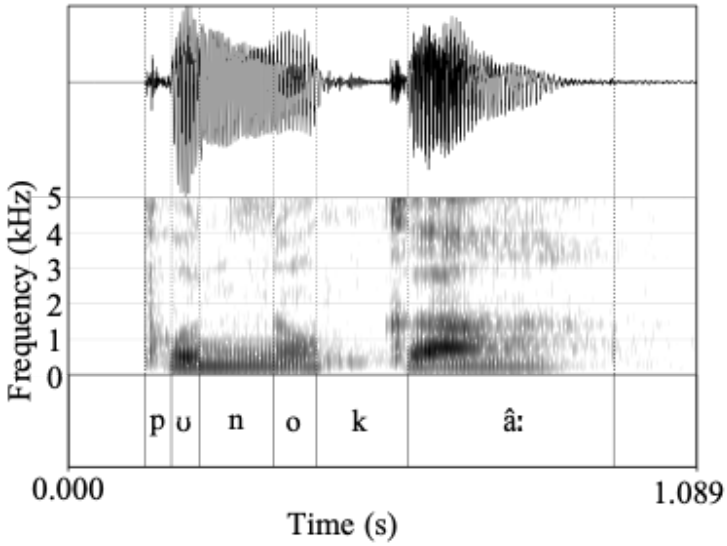

Figure 18 Waveform and spectrogram for [pʊnokâ̰ː] *ponoká* 'elk', with a final voiced [aː]. Dynamic spectrogram range = 45 dB. Silence at beginning zero-padded.

The final voiceless vowel in (36a) is ambiguous between an underlying vowel which is devoiced or from aspiration of a final plosive. Final voiceless vowels are particularly common in verbal and nominal singular suffixes (Bliss & Glougie 2010; Bliss & Gick 2017; Prins 2019), and previous analyses treat the word-final [ḁ] in (36a) as a devoiced reflex of an underlying third singular agreement suffix [-a] (after consonants) or [-wa] (after vowels) (Frantz 2017). Another paper working with Tootsinam claims she lacks an acoustic reflex of final voiceless vowels even

when she maintains certain phonological alternations triggered by voiceless vowels (Bliss and Glougie 2010), but we found that although this suffix is never audible after a vowel, it is frequently audible after a plosive and infrequently audible after a sonorant consonant. The distribution could be because Tootsinam maintains the suffix in verbs in some cases, or the words may be consonant final and undergo the optional process of aspiration from (34).

In kinship terms, (37), the singular suffix *-a* ~ *-wa* can be sometimes be pronounced [ḁ]. This final [ḁ] is optional or short in many words, making it look like aspiration, but it can occur after nasals and /s/, as in (37), where it is unlikely to arise from aspiration.

(37)	a.	[nínːḁ]	*nínna*	'my father'
	b.	[nímʔsḁ]	*nímssa*	'my daughter-in-law'

The spectrograms for [nínːḁ] *nínna* 'my father' and [nímʔsḁ] *nímssa* 'my daughter-in-law', both from (37), are shown in Figures 19 and 20. In both cases, the final voiceless vowel is clearly visible on the spectrogram. There is no voicing bar, but the formants are faintly visible.

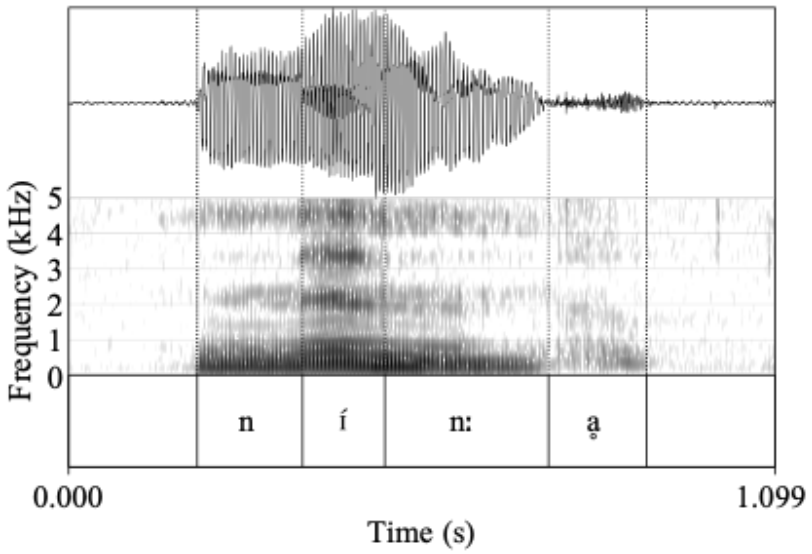

Figure 19 Waveform and spectrogram for [nínːḁ] *nínna* 'my father'.

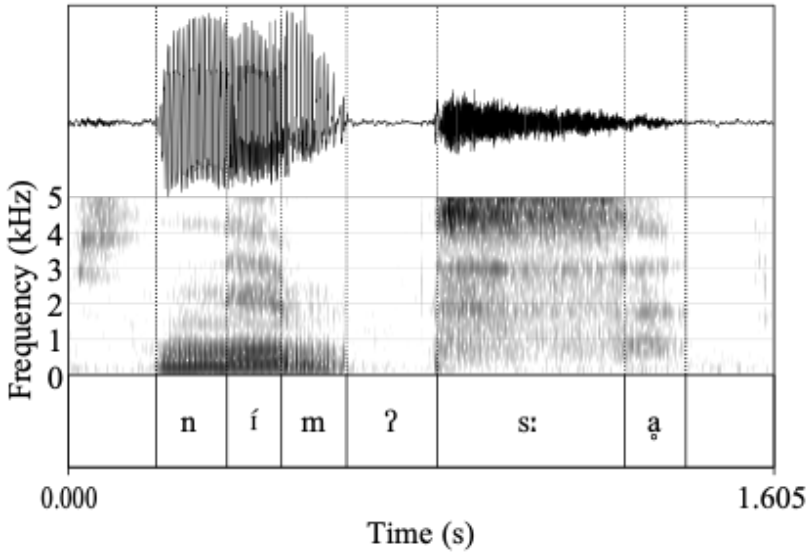

Figure 20 Waveform and spectrogram for [nímʔsḁ] *nímssa* 'my daughter-in-law'. Dynamic spectrogram range = 45 dB.

Two different studies argue that final voiceless vowels occur at the right edge of phrases rather than the right edge of each word (Taylor 1969: 38; Windsor 2017a,b; Prins 2019). Since the words in our dataset were elicited in isolation, they are at once an utterance, an intonational phrase, a phonological phrase, and a word, which means that our dataset cannot distinguish the two hypotheses. The claim that final voiceless vowels occur only at phrasal boundaries could be checked in a narrative or other discourse with full utterances. Interestingly, the right edge of demonstratives are never the site of vowel devoicing, which would be explained by phrase-final devoicing if demonstratives are always parsed into the same phrase as the following word.

6. Syllable structure

There are many open questions pertaining to Blackfoot syllable structure, including the syllabification of certain clusters and final devoiced vowels, as well as how /s/ and /x/ syllabify (Goad and Shimada 2014a,b; Elfner 2006a,b; Miyashita 2018). We first discuss evidence for basic syllable structure in §6.1. In §6.2 we argue that affricates and the pre-assibilant are complex segments. In §6.3 we justify the syllabification of phonologically short /s/ and long /sː/ in different environments and show how these account for the many acoustic durations of [s].

6.1 Basic syllable structure

Setting aside the unusual distribution of /s/ and /x/, Blackfoot has a relatively simple syllable structure. Syllables are maximally CVV or CVC, except at the right edge of the word where CVVC and CVCC syllables are possible (Elfner 2006a; Weber 2020).

We couch the following analysis in terms of moraic structure (Hayes 1989; Hyman 1985), in order to account for the length contrast for many segments, and the patterns where length is neutralized. Recall that all plosives, nasals, and the alveolar fricatives and affricates have a length distinction. Vowels also contrast length. We adopt the representations in Figure 21. Short consonants are nonmoraic, while any long consonant is monomoraic. Short vowels are monomoraic, while long vowels are bimoraic.

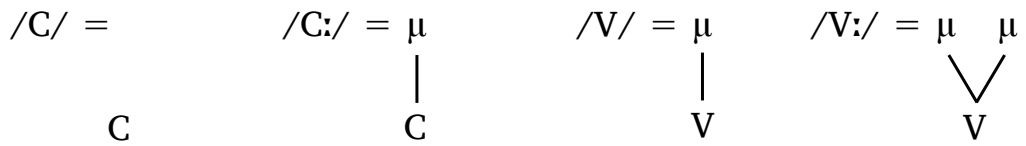

Figure 21 Moraic representation of contrastive length in consonants and vowels. From left to right: short consonant, long (geminate) consonant, short vowel, long vowel.

With these representations the maximal syllable is bimoraic in Blackfoot (Figure 22), as argued in Elfner (2006a). This can be filled by a bimoraic vowel, or by a monomoraic vowel followed by a moraic coda consonant. This explains why non-final syllables are maximally CVC or CVVC; an extra consonant is allowed at the right edge of the word. The following discussion explains how consonants are parsed to onset and coda positions.

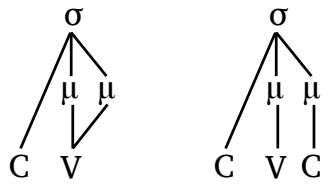

Figure 22 Maximally bimoraic syllable structure for non-final syllables.

Most syllables begin with an onset consonant, which may be any monomoraic consonant except for /x/, which only occurs before an obstruent. As we discussed in §4.5, the word-initial onset position is filled by a glottal stop for words which begin with an underlying vowel. One exception is that that certain vowel sequences are allowed to remain in hiatus, even though vowel sequences across a morpheme boundary are typically resolved via coalescence, diphthongization, or deletion (Elfner 2006a; Weber 2020). Our corpus only contains sequences of [ɛː.ɛː] and [aː.a]. The pitch tracks for [mɛːɛ̂ː] *maiáí* 'robe' and [naːáxsɪk͡s] *naaáhsiksi* 'my grandparents' are given in Figures 23 and 24, with pitch shown with a solid blue line. In both cases, the first vowel in the sequence contains a falling pitch; the pitch then rises steeply on the second vowel in the sequence. We take pitch peaks and accent to be a syllabic phenomenon (see §7), which means that the beginning of the pitch change is evidence for a syllable boundary.

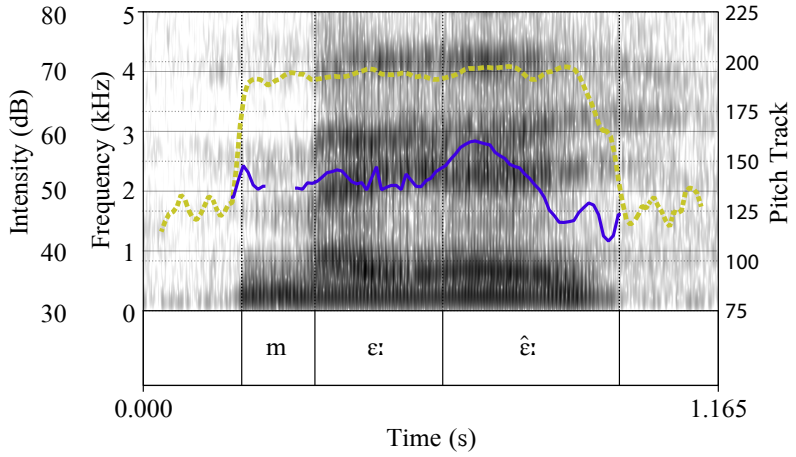

Figure 23 Spectrogram and pitch track for [mɛːɛ̂ː] *maiáí* ‘robe’. Pitch = Blue lines, Intensity = Dashed gold lines. Dynamic spectrogram range = 45 dB.

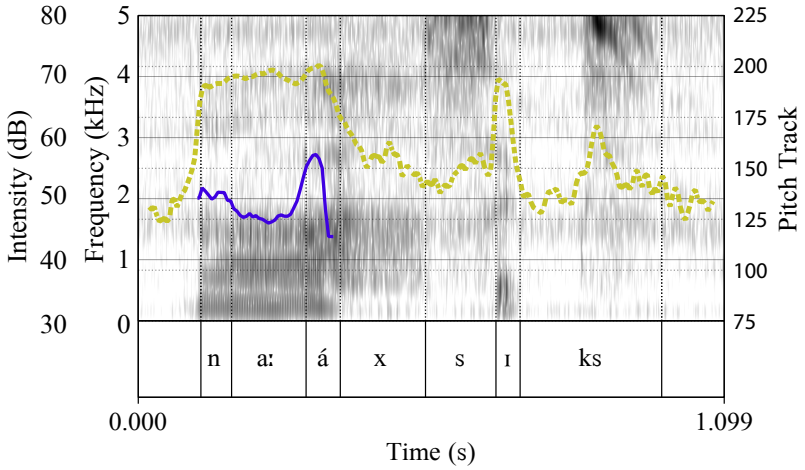

Figure 24 Spectrogram and pitch track for [naːáxsɪk͡s] *naaáhsiksi* ‘my grandparents’. Pitch = Blue line, Intensity = Dashed gold line. Dynamic spectrogram range = 45 dB.

Coda consonants are restricted to /s/ (38a), /x/ (38b), a glottal plosive /ʔ/ (38c), the first half of a geminate consonant (38d), or a nasal before an epenthetic glottal stop (38e). The evidence that these consonants are parsed to a coda rather than as part of a complex onset is that vowel length is neutralized to short before these consonants (Elfner 2006a; Weber 2016a, 2020). This derives the maximal syllable shapes CVV and CVC, but not *CVVC, within the word. Examples (38a–d) were discussed in §4, and (38e) is from §4.5.

(38)	a.	[ʔɪs.póm.ʔç.taːt]	*isspómmihtaat*	‘help out!’
	b.	[ʔax.kó.jɪn.nɪ.maːn]	*aahkóyinnimaan*	‘pipe’
	c.	[ʔaʔ.psː.kít]	*a’psskít*	‘chase it!’
	d.	[kiː.píp.po]	*kiipíppo*	‘hundred’
	e.	[ʔiç.po.kón.ʔsː.kaː]	*iihpokónsskaa*	‘he has gotten the ball’

We assume that geminates are moraic consonants which are parsed to a coda position and “flopped” into the onset position of the following syllable (Hayes 1989: 258). The syllabification of geminate [pː] from (38d) is given in Figure 25. In syllabified transcriptions, we represent ambisyllabic parses with a doubled symbol, as in [kiː.píp.po] *kiipíppo* ‘hundred’.

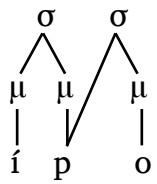

Figure 25 Syllable structure for the last two syllables for [kiː.píp.po] *kiipíppo* ‘hundred’.

It is important to keep in mind that vowel neutralization and vowel centralization overlap but are distinct processes. For example, vowel length may be neutralized to a centralized vowel, (38a,d,e), or an uncentralized vowel, (38b,c). In addition, there are many positions where short

vowels are centralized, but vowel length is not neutralized, as we discussed in §5.2. We assume that only vowel length neutralization can be taken as evidence that a syllable is closed.

Finally, the diagnostic of vowel length neutralization provides supporting evidence for rising and falling diphthongs in Blackfoot (Elfner 2006a; Weber & Miyashita 2024) and no evidence for complex [Cj] onsets (contra Weber 2020). A [Cj] sequence does not cause the preceding vowel to neutralize to short, (39a), suggesting this is not an ambisyllabic cluster, but either a complex onset or a consonant followed by a diphthong. The vowel following [Cj] is always long in Tootsinam's speech, (39b), unless followed by a coda consonant, (39c). This suggests that the rising diphthong analysis is correct, and that the [j] contributes a mora to a complex nucleus. As a result of this analysis, all onsets in Blackfoot are simplex.

(39)	a.	[naːmjóːjɪs]	*naamióóyis*	'bee hive'
	b.	[ni.tsí.pɐ.ksː.kí.nja̯ː]	*nitsípaksskíniaa*	'I hit him on the back'
	c.	[ʔiçtɔ́ːkspɛnːɪkjo̯ʔpa̰]	*iihtáókspainnikio'pa*	'glue'

Falling diphthongs can be short or long, (40). The post-vocalic [j] does not cause the preceding vowel to neutralize to short, suggesting that [j] is not a coda but a non-moraic portion of a diphthong.

(40)	a.	[ni.t͡síː.kɐ̯j.ʔsː.poː.ka̰]	*nitsíikaysspooka*	'she parted my hair'
	b.	[ʔɔ́ː.koːj̯.ʔsː.kaː]	*áókooysskaa*	'carpenter'

Two additional syllable shapes are allowed word-finally. First, vowel length is not neutralized before word-final short consonants, as shown in (41), where either a short [i] or long [iː] can occur before word-final [s].[9] This means that a CVVC syllable may occur word-finally.

(41)	a.	[moxʷ.kín.ʔsː.t͡sɪs]	*moohkínsstsis*	'elbow'
	b.	[stɐ́.mík.ks.k͡siːs]	*stámíkksksiis*	'test her knowledge!'

Second, geminates can occur in word-final position, (42), while word-internal codas are limited to a single consonant or the first half of a geminate. This means that a CVCC syllable may occur word-finally. (This syllable shape suggests that clusters would also be allowed word-finally, but there are no clear examples in our dataset.)

(42)	a.	[kɐ́.ni.k͡sɪmː]	*kániksimm*	'stump', 'big branch'
	b.	[ɪk.ks.t͡sóxʷ.kɪnː]	*ikkstsóóhkinn*	'sharp necklace'
	c.	[nɪs.sísː]	*nissíss*	'my younger sibling' (of female)

In §4.4 we showed that /x/ can occur between consonants for this speaker. It is possible that /x/ is syllabic in this position, especially since it derives from the coalescence of /x/ with a preceding short vowel (Miyashita 2018). Here again, a preliminary syllable tapping study suggests that some instances of /x/ in interconsonantal position are syllabic, and that tapping studies could be a useful method of probing for syllable structure (Miyashita 2024).

---

[9] In many ways, word-final consonants do not have the same properties as word-internal codas. Weber (2020) treats word-final singleton consonants as onsets, based on the fact that vowel length does not neutralize before word-final consonants as it does before word-medial onsets.

6.2 Affricates and pre-assibilants

The diagnostic of vowel length neutralization provides evidence that the affricates and pre-assibilant are complex segments instead of clusters. Unlike the clusters above, vowel length contrasts before [t͡s] and [k͡s], indicating that the affricates are parsed to an onset position. Example (43) shows both affricates preceded by short vowels, (43a), and long vowels, (43b).

(43)	a.	[nɪ.t͡sɪ.nâːn]	*nitsináan*	'my belonging/possession'
		[mot.to.k͡sís]	*mottoksís*	'knee'
	b.	[ʔiː.t͡síʔ.ts.k͡so.ji]	*iitsí'tsksoyi*	'picnic'
		[ʔo.ké:.sɪ.naː.ks.siːˢt͡s]	*okáísinaakssiistsi*	'his debts'

By a similar argument, a short pre-assibilant [ˢt] is parsed to an onset. The evidence is that the preceding vowel length remains contrastive (44a). This makes [ˢt] distinct from a consonant cluster [st]. A geminate pre-assibilant [ˢtː] is parsed to a coda position and the following onset (like other geminates), and the preceding vowel length is neutralized to short, (44b).

(44)	a.	[ʔáː.ki.tʊ.pɐ.kɪ.ˢtóː.piː.jaː]	*áákitopakistóópiiyaa*	'they will sit side by side'
		[miː.ˢt͡sís]	*miistsís*	'tree'
	b.	[ʔɪˢt.ts.ksː.kjúː.mi.taː]	*isttsksskióómitaa*	'slim faced dog', 'grayhound'
		[ʔéˢt.t͡sí.kɐt.t͡si]	*áísttsíkattsi*	'it looks shiny'

Figure 26 shows how the complex segments are syllabified. Short, nonmoraic segments are parsed to the onset (left), while long, moraic segments are parsed to a coda position and "flopped" into the following onset.

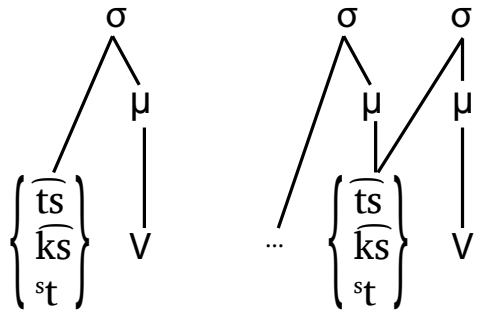

Figure 26 The syllabification of the complex segments (affricates and pre-assibilant). Left = short complex segments; right = long complex segments.

6.2 Syllabification of [s]

In this section we explain how [s] is syllabified in different phonological contexts, and how this syllabification accounts for the various durations of [s]. Our syllabification is based on the phonologically binary contrast we argued for in §4.3, as well as other patterns of distribution such as vowel length neutralization in closed syllables. We therefore make different predictions

than previous proposals, which were based solely on the distribution of orthographic <s>'s (Goad & Shimada 2014a,b) or patterns of vowel length neutralization (Elfner 2006a).

We start with the insight from Goad & Shimada (2014a,b) that [s] is unique because it patterns with consonants and also vowels. For example, [s] can occur after, between, and before other consonants in two different lengths. In this distribution, it patterns exactly like a vowel (Derrick 2007; Denzer-King 2009; Goad and Shimada 2014a,b). Because of this unusual distribution, Goad and Shimada (2014a,b) argue that /s/ can be non-moraic, monomoraic, or bimoraic (Figure 27) and occur in any syllable position (onset, nucleus, coda). As Goad & Shimada (2014a,b) argue, the syllabification of [s] does not need to be stipulated, but is derived from the segmental context and the underlying moraicity of [s]. For clarity, in this section we mark the moraic status of consonants with one or two raised μ.

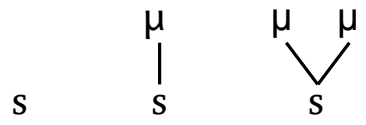

Figure 27 Three moraic representations of [s]. From left to right: nonmoraic, monomoraic, bimoraic.

To start with the consonant-like distribution of [s], a non-moraic /s/ is parsed to an onset position when it occurs next to vowels, either at the beginning of the word, (45a), or between vowels, (45b). Intervocalic onset /s/ is relatively short in duration (Group C). (There were too few instances of word-initial /s/ before vowels to include in the linear model of duration in §4.3.)

(45) Non-moraic /s/ as onset

a.	[sí.psᵘ.t͡si.naːn]	*sípstsinaan*	'tipi flap pole'
b.	[niː.sípᵘ.po]	*niisíppo*	'forty'

A moraic /s/ can occur in a coda position before another consonant, (46a), where it is relatively longer than non-moraic /s/ (e.g., Group D). The /s/ in this position must be moraic, because the preceding vowel length is always neutralized. A word-final /s/ like that in (46b) could be parsed as a moraic coda, though word-final consonants also have some properties unlike codas. (As a convenience, we have indicated word-final short /s/ in this section as non-moraic and word-final long /sː/ as moraic.) Word-final /s/ is longer than a word-internal coda (Group E), possibly due to some word-final lengthening process.

(46) Moraic /s/ as coda

a.	[ʔɪsᵘ.póm$^{\mu}$.ʔç.taːt]	*isspómmihtaat*	'help out!'
b.	[mox$^{w\mu}$.kínᵘ.ʔs$^{\mu\mu}$.t͡sɪs]	*moohkínsstsis*	'elbow'

Finally, a moraic /s/ can occur as a geminate consonant between vowels, (47a), and word-finally, (47b). Intervocalic geminates are longer than a moraic coda (Group E). In our analysis, this additional duration could be because moraic consonants "flop" onto the following syllable. Word-final geminates are very long (Group G), possibly due to some word-final lengthening process. We leave the exact differences between word-final short /s/ and long /sː/ for future research, as well as the syllabification of word-initial long /sː/, which is not in our dataset.

(47) Moraic /s/ as a geminate consonant

a.	[nɪsᵘ.sísᵘ]	*nissíss*	‘my younger sibling’ (of f.)
b.	[nɪsᵘ.sísᵘ]	*nissíss*	‘my younger sibling’ (of f.)

These syllabifications do not need to be stipulated. Like other consonants, the intervocalic position can host a non-moraic /s/ or a moraic /s/, which are parsed as onsets and geminates, respectively. Like other consonants, codas must be moraic. Leaving aside the question of how [s] is parsed at word edges, [s] patterns like the other consonants with a length contrast.

Turning to the vowel-like distribution of [s], there is a contrast between monomoraic /s/ and bimoraic /sː/. Both can occur as a syllable nucleus word-initially before a consonant, (48a) and (49a), or between consonants, (48b) and (49b). The monomoraic nucleic /s/ is shorter than an onset /s/: Group BC in word-initial position, or Group B between consonants. The bimoraic nucleic /sː/ is about as long as a monomoraic coda /s/: Group CDEF in word-initial position, or Group D between consonants. This shows that acoustic duration of [s] is affected by syllabic position in addition to moraic status.

(48) Monomoraic /s/ as nucleus

a.	[sᵘ.pɛ́.t͡sɪ.ko]	*spátsiko*	‘sand’
b.	[ʔá.psᵘ.pi.niː k͡s]	*ápspiniiksi*	‘geese’

(49) Bimoraic /sː/ as nucleus

a.	[sᵘᵘ.po.pîː]	*sspopíí*	‘hawk owl’, ‘turtle’
b.	[mo.wɛ́.psᵘᵘ.pɪn]	*mowápsspin*	‘eye’

A short /s/ and long /sː/ also occur in the environment [C_V], always at a morpheme boundary. We adopt the analysis in Goad & Shimada (2014a,b) that the short /s/ is monomoraic and the long /sː/ is bimoraic. A monomoraic /s/ is parsed as a short nucleic /s/ and then “flopped” onto the following syllable, (50a). This ambisyllabic parse is reflected in the duration measurements. The acoustic duration (Group D) is longer than a word-internal monomoraic nucleic /s/ (Group C). A bimoraic /sː/ is parsed as a long nucleic /sː/ and then “flopped” onto the following syllable. Bimoraic /sː/ has a superlong duration (Group F). A non-moraic /s/ is prohibited in the environment [C_V] due to phonotactics: a [Cs] cluster cannot be parsed because the only allowable ambisyllabic clusters are /xC/, /sC/, or /ʔC/, and complex onsets never occur.

(50) Monomoraic and bimoraic /s/ in the environment [C_V]

a.	[pi.sɛ́.tsᵘ.sɛsᵘ.ki]	*pisátssaisski*	‘flower’
b.	[ní.tsᵘᵘ.soʔᵘ.toː.ka̰]	*nítssso’tooka*	‘he felt me (up)’

Finally, a short /s/ and long /sː/ also occur in the environment [V_C]. We propose that the short /s/ is a monomoraic coda, (51a), as discussed above. The long /sː/ in this position (corresponding to a triple <sss> in the orthography) is highly restricted and only occurs in derived environments. There is only a single example of <VsssC> in all of Frantz & Russell (2017), shown in (51b) with a hypothesized phonetic transcription. The abstract representation of this word is *oss* ‘his son-in-law’, followed by an obviative suffix *-i*, followed by a post-inflectional suffix *-hka* (*-sska* after [i]). We propose that an [i] becomes strident between two moraic /s/’s and that the long /sː/ in [V_C] only occurs in this type of derived environment.

(51) Coda position (monomoraic) versus super long

a. [ʔɪs$^{\mu}$.póm$^{\mu}$.ʔç$^{\mu}$.taːt] *isspómmihtaat* ‘help out!’

b. †[ʔó.ss$^{\mu\mu}$.kạ] *óssska* ‘his son-in-law (invs.)’

The syllabification of long /sː/ in the environment [V_C] is unclear. Goad & Shimada (2014a,b) argue that <sss> forms a syllable on its own, where /s/ is parsed to an onset and a bimoraic nucleus. This is represented in (51b). Another hypothesis is that the superlong <sss> closes the preceding syllable, which would predict that the preceding vowel length is neutralized. Although we do not know whether this is true, this is a testable prediction. It is possible that these differences could be probed by asking speakers for their judgments. A preliminary study of syllable tapping in Blackfoot supports an analysis where /s/ is at least sometimes syllabic and suggests that this methodology could be utilized in the future to probe for speaker intuition of syllabification (Anghelescu 2012).

Our hypotheses about the syllabification of [s] are summarized in Table 10. The schemas marked by a dagger (†) do not occur in our dataset.

Table 10 Syllabification of Blackfoot phonologically short and long [s] by environment

Env.	short		long	
	Orthography	Syllabification	Orthography	Syllabification
#_V	<#sV>	[#sV…]	†<#ssV>	†[#s$^{\mu}$.sV…]
#_C	<#sC>	[#s$^{\mu}$.C…]	<#ss>	[#s$^{\mu\mu}$.C…]
_#	<s#>	[…s#]	<ss#>	[…s$^{\mu}$#]
V_V	<VsV>	[…V.sV…]	<VssV>	[…Vs$^{\mu}$.sV…]
C_C	<CsC>	[.Cs$^{\mu}$.C…]	<CssC>	[.Cs$^{\mu\mu}$.C…]
C_V	<CssV>	[.Cs$^{\mu}$.sV…]	<CsssV>	[.Cs$^{\mu\mu}$.sV…]
V_C	<VssC>	[…Vs$^{\mu}$.C…]	†<VsssC>	†[…V.ss$^{\mu\mu}$.C…]

The syllable structures in Table 10 are based on a binary phonological length contrast in all positions, as well as preliminary data on the acoustic duration of both lengths in different positions. Our analysis explains durational differences through a combination of the position of /s/ in a syllable, the moraic status of the /s/, and whether it is “flopped” onto a following syllable or not. This type of analysis is more comprehensive than previous proposals. The analysis in Goad & Shimada (2014a,b) was based on the distribution of orthographic <s>’s in Blackfoot as well as typologically motivated assumptions about syllable structure. The analysis in Elfner (2006a) was based on the distribution of vowel length contrasts. Our proposal takes all of these facts into account and more.

7. Prosody

Each word in Blackfoot has at least one prominent syllable, and sometimes more than one. Prominence is signaled primarily with a relatively higher f0 than surrounding syllables, as well as greater intensity and duration (Van Der Mark 2003), a pattern shared by many languages with stress systems. Previous research disagrees on whether prominence is better understood as stress (Weber 2016a,b, 2020), pitch accent (Kaneko 1999; Van Der Mark 2003; Glougie 2009; Miyashita 2011; Frantz 2017: 3), or tone (Stacy 2004). Still other aspects are not well

understood, including the frequently unpredictable stress on nouns (Kaneko 1999; Stacy 2004; Weber and Allen 2012). With so many remaining questions, this section is necessarily descriptive and preliminary. We discuss some of the acoustic properties of prominence, as well as lexical and morphological properties affecting the location of prominence. We also show that the shape of the pitch contour across long vowels is partly phonologically predictable.

Our data show the pitch peak is produced at a fundamental frequency 28.7 cycles/second (Hz) higher than the other vowels within a phrase. Any syllable may be prominent, except for syllables with voiceless nuclei. Not every syllable has a phonological pitch target, and instead the pitch contour of the word is interpolated between the left edge of a word and the pitch peak on the leftmost prominent syllable. As a result, pitch rises to a pitch peak and falls steeply after the pitch peak (Weber and Allen 2012; Miyashita and Weber 2020; Weber & Shaw 2022). Blackfoot speech has standard declination within a phrase, such that the leftmost prominent syllable in a phrase has the highest f0 maximum and each subsequent prominent syllable has a progressively lower f0 (Taylor 1969: 49*ff*; Frantz 2017: 3–4; Miyashita and Weber 2020). All prominent syllables are marked identically in the orthography with an acute accent over the vowel.

Several prefixes, such as the perfect *ákaa-*, are written with accents in the underlying forms (in Frantz 2017) or dictionary entry headers (in Frantz & Russell 2017), suggesting that these have an underlying lexical accent. However, there are instances in our corpus which complicate this picture. The perfect prefix *akaa-* has accent on the first syllable in (52a), but the second syllable in (52b). We do not know if this is free variation or predictable in some way.

(52) a. [ʔákɔxʷtɛːtskçpiji] *ákaohtaitskihpiyi* ‘she has danced past’
b. [ʔakɔ́ːmɐtɐpɐkːíspoː] *akáómatapakkísspoo* ‘she has started to get much higher’

The difference in location of the f0 pitch peak in both words is clearly visible in Figure 28. Pitch declination occurs from that pitch peak to the right edge of the word in both cases.

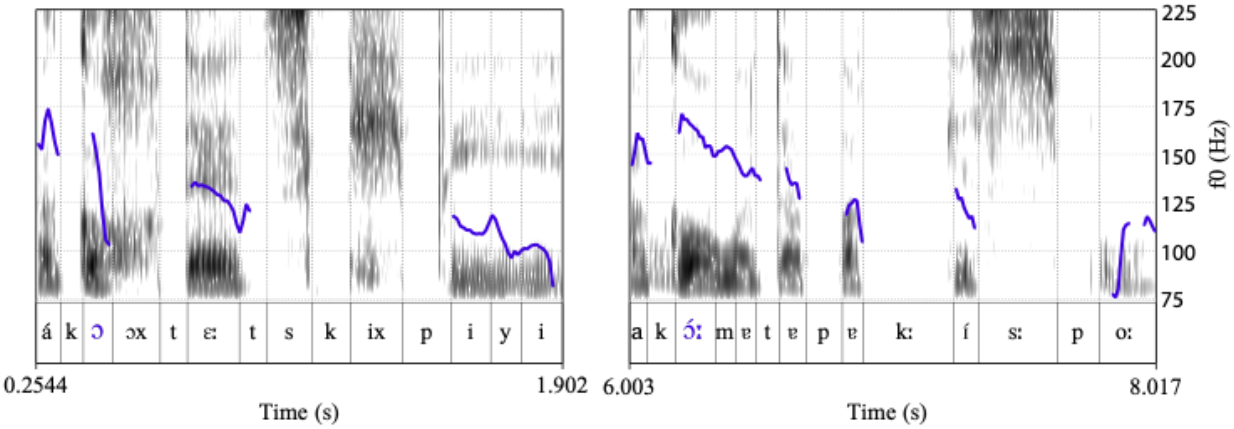

Figure 28 Spectrogram and pitch track for [ʔákɔxʷtɛːtskçpiji] *ákaohtaitskihpiyi* ‘she has danced past’ (left) compared to [ʔakɔ́ːmɐtɐpɐkːíspoː] *akáómatapakkísspoo* ‘she has started to get much higher’ (right). Comparison of stressed and unstressed second vowel highlighted in blue. Dynamic spectrogram range = 45 dB.

The location of accent is affected by the morphological structure of the word in ways that are not fully understood. This can be seen in the paradigmatically related words in (53), which both

contain the multimorphemic stem *sskohkot-* ‘give back’. The accent falls within the stem if it has no prefixes, (53a), but falls on the prefix *nit-* ‘1’ when it is present, (53b).

(53)	a.	[ʔɪskxʷkóʊɐwɛː]	*isskohkótawayi*	‘he was given it back’
	b.	[níʊsːkxʷkʊkːɛː]	*nítsskohkokkayi*	‘he gave back to me’

Figure 29 shows a side-by-side spectrogram and pitch track comparision of (53a) on the left and (53b) on the right, highlighting the difference in pitch contour between these words. The pitch peak for (53a) occurs late in the word, while the peak for (53b) is on the initial syllable.

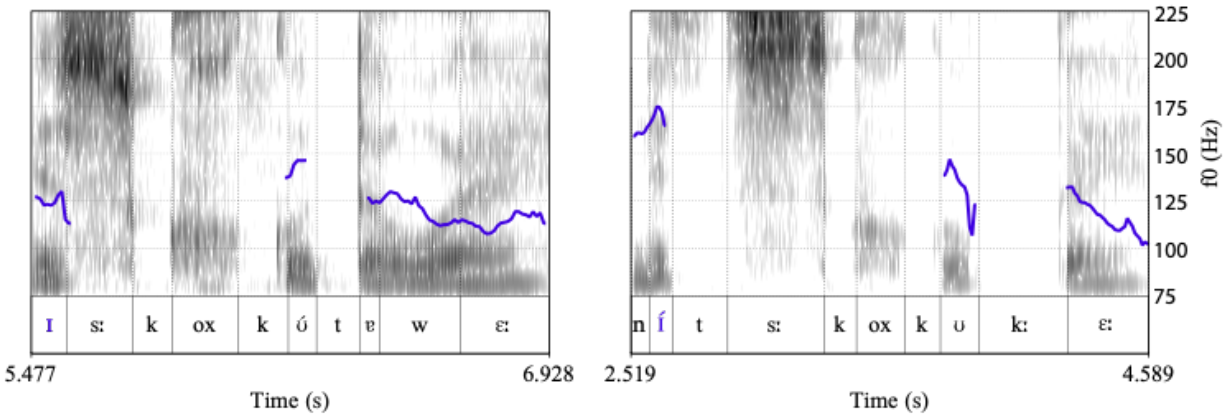

Figure 29 Spectrogram and pitch track for [ʔɪskxʷkóʊɐwɛː] *isskohkótawayi* ‘he was given it back’ (left) compared to [níʊsːkxʷkʊkːɛː] *nítsskohkokkayi* ‘he gave back to me’ (right). Stressed vowels highlighted in blue. Dynamic spectrogram range = 50 dB.

Weber (2016a,b, 2020) finds evidence for metrical properties underlying the location of accent, including attraction to a heavy second syllable in prefixless verbs. Our dataset shows that not all long vowels attract stress. Initial long vowels with and without stress are shown in (54).

(54)	a.	[ʔáːpsːki]	*áápsski*	‘white face’ (horse)
	b.	[ʔaːpíksːt͡sɪt]	*aapíksstsit*	‘take it out of your mouth’

Finally, there are many words which violate other common metrical properties, especially in nouns. (See also discussion in Stacy 2004.) The two words in (55) have multiple accents on adjacent syllables, violating clash.

(55)	a.	[ʔɛ́mːóniːsi]	*áímmóniisi*	‘otter’
	b.	[môːtókɪs]	*móotókis*	‘hide’, ‘skin’

A few recent papers derive the pitch contour across a word from the interaction of phrasal pitch accents and word-level stress (Miyashita and Weber 2020; Weber & Shaw 2022). We contribute to this line of research by describing the phonetic realization of f0 on accents syllables as level high or falling in different positions across the word. In transcriptions, we mark stress with tonal diacritics: [á] for a level high tone, and [â] for a falling tone.

The pitch peak is realized as a level high pitch on short vowels, (56).

(56)	a.	[ʔaʔpsːkít]	*a’psskít*	‘chase it!’

b. [kɛ̰nik͡sɪm:] *kánniksimm* ‘stump’, ‘big branch’
c. [ʔɛ́m:óni:si] *áímmóniisi* ‘otter’

The pitch peak on a long vowel in the middle of the word can be realized as either a level high, (57), or a falling tone, (58). As far as we can tell, the high and falling realizations are not contrastive and are free variants of one another.

(57) a. [ʔɪst͡sá:pinat͡:si] *isstsáápinaattsi* ‘it looks bright’
b. [ʔiçtɛ́:sitoko:] *iihtáísitokoo* ‘he went through the center’
c. [ʔiçtó:kspɛn:ɪkjoʔpa̰] *iihtáókspainnikio’pa* ‘glue’
d. [ʔɪˢt:sks:kjú:mita:] *isttskskskióómitaa* ‘slim faced dog’, ‘grayhound’
e. [ʔɪsksí:na:] *isskssíínaa* ‘insect’

(58) a. [nɪt͡sɪnâ:n] *nitsináan* ‘my belonging/possession’
b. [mô:tókɪs] *móotókis* ‘hide’, ‘skin’
c. [ʔɔ:áxt͡sî:kaʔsi] *aoááhtsíika’si* ‘he acted daring’

Figure 30 shows a side-by-side spectrogram and pitch track comparision of (57a) and (58a), highlighting the difference between the level tone and falling tone accents on long vowels.[10]

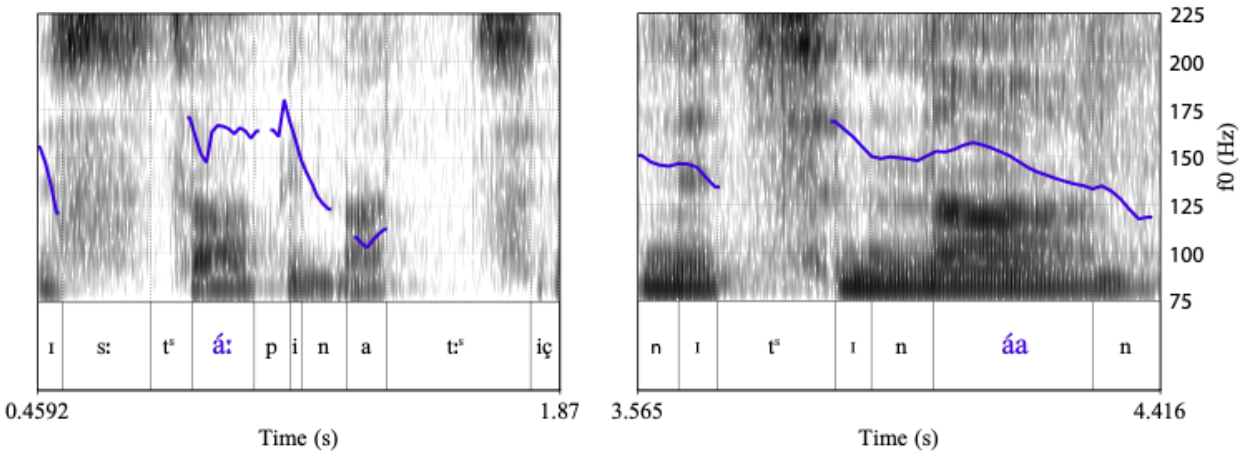

Figure 30 Spectrogram and itch track for [ʔɪst͡sá:pinat͡:si] *isstsáápinaattsi* ‘it looks bright’ (left) compared to [nɪt͡sɪnâ:n] *nitsináan* ‘my belonging/possession’ (right). Stressed vowels highlighted in blue. Dynamic spectrogram range = 50 dB.

However, falling tone is not a free variant of a level high tone in all positions. Specifically, word-final prominent vowels are predictably long with a falling tone. There are examples of four of the five long vowels in this position, (59). Our dataset did not contain any final accented /ɔ:/.

(59) a. [s:popî:] *sspopíí* ‘hawk owl’
b. [pɪˢt:ô:] *pisttóó* ‘common night hawk’

[10] The pitch track in (58a) looks like the pitch maximum is on the vowel immediately prior to [â:], even though the final vowel is perceived as more prominent. This is likely an artefact of PRAAT’s pitch tracker or the preceding voiceless [t͡s].

c.	[pʊnokâː]	*ponoká*	'elk'
d.	[ʔomɛːɛ̂ː]	*omaiáí*	'he took off his robe'

Frantz (2017: 4) claims "there are also sequences of a long vowel or diphthong … followed by an accented vowel". As discussed in §6, these words contain two adjacent syllables, rather than a single syllable. The pitch can therefore be analyzed as a level high on the second syllable, rather than a rising tone across a super long vowel, as seen in (60).

(60)	a.	[naː.áx.sɪk͡s]	*naaáhsiksi*	'my grandparents'
	b.	[nɛː.ɛ́ː.wa]	*naiáíwa*	'my robe'
	c.	[saː.áː.mi]	*saaáámi*	'medicine'

There are clearly open questions regarding accent and pitch contours in Blackfoot, and the data here shows that the extent of lexical, morphological, and metrical factors is still largely unknown. We focused on the phonetic realization of accent within our dataset and showed that word-final accented vowels are predictably long with a falling tone.

8. Conclusion

We presented an acoustic description of Káinai Blackfoot based on awordlist recorded with a single speaker. Our goal was to summarize the previous phonetic and phonological research on Blackfoot – an understudied language – and to show whether or not the previous claims applied to our dataset. Throughout the paper we point out areas that require further research.

The data here exhibit several patterns that are not described in previous literature. For example, we show that centralized vowels occur as systematic allophones of short vowels in several phonological environments for this speaker, and that word-final voiceless vowels arise from final devoicing as well as epenthesis. We also find that pitch contour shape is partially predictable: word-final accented vowels are predictably long with a falling tone. In other sections our acoustic analysis augments previous studies. For example, devoiced but fricated vowels before the dorsal fricative /x/ are completely distinct in spectrograms from word-final devoiced vowels. Additionally, our preliminary study of the various durations of [s] helps inform a phonological analysis of length contrasts for /s/ and /sː/ as well as how these segments syllabify. We hope that this papers helps contextualize the many open questions about segmental and prosodic structure in Blackfoot, as a guide to future research.

References

Anghelescu, Andrei. 2012. Perceptual salience of Blackfoot syllabic /s/. Ms., Paper presented in Ling 531/532 Field Methods, University of British Columbia.

Armoskaite, Solveiga. 2006. Heteromorphemic assibilation of k in Blackfoot. Qualifying Paper, Department of Linguistics, University of British Columbia.

Armoskaite, Solveiga & Mario E. Chávez Peón. 2005. Assibilation in Blackfoot. Ms., Paper presented in LING 431/531 Field Methods, University of British Columbia.

Áístainskiaakii, Isaapóíkoan, Áínnootaa & David Osgarby. 2013. *Aakíípisskani 'the women's buffalo jump'*. In Dunham, Joel, Patrick Littell, and John Lyon (eds.), *Papers of the*

International Conference on Salish and Neighbouring Languages 48, 1–21. (UBCWPL 35.) Vancouver, BC: University of British Columbia. https://lingpapers.sites.olt.ubc.ca/files/2018/01/2013_Aistainskiaakii.pdf

Berman, Howard. 2006. Studies in Blackfoot prehistory. *International Journal of American Linguistics* 72(2): 264–284. https://doi.org/10.1086/507167

Bliss, Heather. 2013. *The Blackfoot configurationality conspiracy: Parallels and differences in clausal and nominal structures*. PhD Thesis, University of British Columbia.

Bliss, Heather & Bryan Gick. 2009. *Articulation without Acoustics: 'Soundless' Vowels in Blackfoot*. In Mailhot, Frédéric (ed.), *Proceedings of the 2009 annual conference of the Canadian Linguistic Association*, np. Ottawa: Carleton University. https://cla-acl.ca/pdfs/actes-2009/CLA2009_Bliss_Gick.pdf

Bliss, Heather & Bryan Gick. 2017. Blackfoot Final Vowels: What Variation and its Absence can Tell us about Communicative Goals. *University of Pennsylvania Working Papers in Linguistics* 23(2): 1-6. https://repository.upenn.edu/handle/20.500.14332/45174

Bliss, Heather & Jennifer Glougie. 2010. Speaker variation and the phonetic realization of Blackfoot obviation morphology. In *Proceedings of the 13th and 14th Workshop on the Structure and Constituency of Languages of the Americas (WSCLA 13 and 14)*, Bliss, Heather and Raphaël Girard (eds.), 70–83. (UBCWPL 26). Vancouver, BC: University of British Columbia. https://lingpapers.sites.olt.ubc.ca/files/2018/01/UBCWPL26-WSCLA1314-BlissGlougie.pdf

Chávez Peón, Mario E. 2015. Disimilación en teoría de la optimidad: Efectos de bloqueo en la asibilación del Blackfoot. In Rodrigo Gutiérrez Bravo, Francisco Arellanes Arellanes, Mario Ernesto Chávez Peón Herrero (eds.), *Nuevos estudios de teoría de la optimidad: sintaxis, estudios fónicos y lingüística computacional*, 105–132. El Colegio de Mexico AC. http://www.jstor.org/stable/j.ctt1h64krt.7

Davidson, Lisa. 2021. Effects of word position and flanking vowel on the implementation of glottal stop: Evidence from Hawaiian. *Journal of Phonetics* 88: 101075. https://doi.org/10.1016/j.wocn.2021.101075

Denzer-King, Ryan. 2009. *The Distribution of /s/ in Blackfoot: An Optimality Theory Account.* Master's Thesis, University of Montana, Missoula, MT. https://scholarworks.umt.edu/etd/981/

Denzer-King, Ryan. 2012. The status of Blackfoot /s/ analyzed in Optimality Theory. In Hele, Karl S. and J. Randolph Valentine (eds.), *Papers of the Fortieth Algonquian Conference*, 97–135. Albany, NY: SUNY Press. https://ojs.library.carleton.ca/index.php/ALGQP/article/view/1275/1164

Derrick, Donald. 2006. Duration of Blackfoot /s/: A comparison of Assibilant, Affricate, Singleton, Geminate and Syllabic /s/ in Blackfoot. In *Proceedings of the Workshop on*

Structure and Constituency in the Languages of the Americas (WSCLA) XI, Fujimori, Atsushi and Maria Amélia Reis Silva (eds.), 53–60. (UBCWPL 19). Vancouver, BC: University of British Columbia. https://hdl.handle.net/10092/18007

Derrick, Donald. 2007. Syllabification and Blackfoot /s/. In *Proceedings of the Northwest Linguistics Conference (NWLC) 22*, 62–76. Vancouver, BC: Simon Fraser University Working Papers in Linguistics.

Derrick, Donald and Weber, Natalie. 2024. Káínai Blackfoot. Open Science Foundation. <https://osf.io/hyzcd/?view_only=1ca61a150e454471a187761645245d6e> ,

Elfner, Emily. 2006a. *The mora in Blackfoot*. MA thesis, University of Calgary.

Elfner, Emily. 2006b. Contrastive syllabification in Blackfoot. In *Proceedings of the 25th West Coast Conference on Formal Linguistics*, Baumer, Donald and Montero, David and Scanlon, Michael (eds.), 141–149. Somerville, MA: Cascadilla Proceedings Project. http://www.lingref.com/cpp/wccfl/25/paper1442.pdf

Ermineskin, Rachel & Darin Howe. 2005. On Blackfoot syllabics and the Law of Finals. Paper, *37th Algonquian Conference* at Carleton University, Ottawa, October 22, 2005. http://hdl.handle.net/1880/112322

Fish, Naatosi & Mizuki Miyashita. 2017. Guiding pronunciation of Blackfoot melody. In Reyhner, Jon, Joseph Martin, Louise Lockard, and Willard Sakiestewa Gilbert (eds.), *Honoring our teachers*, 203–210. Flagstaff, AZ: Northern Arizona University. https://jan.ucc.nau.edu/~jar/HOT/HOT-12.pdf

Frantz, Donald G. 1978. Abstractness of phonology and Blackfoot orthography design. In *Approaches to language, anthropological issues: Papers written for the IXth International Congress of Anthropological and Ethnological Sciences, Chicago, 1973*, McCormack, W. and S.A. Wurm (eds.), 307–325. Mouton Publishers.

Frantz, Donald G. 2017. *Blackfoot Grammar*. Third edition. Toronto: University of Toronto Press.

Frantz, Donald G. & Norma Jean Russell. 2017. *Blackfoot Dictionary of Stems, Roots and Affixes*. Third edition. Toronto: University of Toronto Press.

Genee, Inge. 2020. It's written *niisto* but it sounds like KNEE STEW. Handling multiple orthographies in Blackfoot language web resources. *Written Language and Literacy* 23(1): 1–28. https://doi.org/10.1075/wll.00031.gen

Genee, Inge & Fangfang Li. 2023. Voice Onset Time in a language without voicing contrast: An acoustic analysis of Blackfoot oral stops. *Journal of the International Phonetic Association,* 1-19. https://doi.org/10.1017/S0025100323000051

Genee, Inge & Junker, Marie-Odile. 2018. The Blackfoot Language Resources and Digital Dictionary project: Creating integrated web resources for language documentation and

revitalization. *Language Documentation and Conservation* 12: 274–314. http://hdl.handle.net/10125/24770

Gick, Bryan, Heather Bliss, Karin Michelson & Bosko Radanov. 2012. Articulation without acoustics: "Soundless" vowels in Oneida and Blackfoot. *Journal of Phonetics* 40: 46–53. https://doi.org/10.1016/j.wocn.2011.09.002

Glougie, Jennifer. 2009. *The tone pattern of Blackfoot nonaffirmative endings*. Ms, Qualifying Paper, University of British Columbia.

Goad, Heather & Akiko Shimada. 2014*a*. /s/ can be a vocoid. In *NELS 44: Proceedings of the Forty-Fourth Annual Meeting of the North East Linguistic Society*, Iyer, Jyoti and Leland Kusmer (eds.), 135–148. University of Connecticut: Graduate Linguistics Students Association.

Goad, Heather & Akiko Shimada. 2014*b*. In some languages, /s/ is a vowel. In Kingston, John, Moore-Cantwell, Claire, Pater, Joe and Staubs, Robert (eds.), *Proceedings of the 2013 Meeting on Phonology*. Linguistic Society of America, Washington, DC. https://doi.org/10.3765/amp.v1i1.50

Goddard, Ives. 1994. The west-to-east cline in Algonquian dialectology. In Cowan, William (ed.), *Actes du 25e Congrès des Algonquinistes*, 187–211. Ottawa: Carleton University.

Goddard, Ives. 1975. Algonquian, Wiyot, and Yurok: Proving a distant genetic relationship. In *Linguistics and Anthropology: In Honor of C.F. Voegelin*, Kinkade, M. Dale, Kenneth L. Hale and Oswald Werner (eds.), 249–262. Lisse: Peter de Ridder Press. https://doi.org/10.1086/465741

Haas, Mary R. 1958. Algonkian-Ritwan: The end of a controversy. *International Journal of American Linguistics* 24: 159–173. https://doi.org/10.1086/464453

Hayes, Bruce. 1989.

Hyman, Larry. 1985.

Kaneko, Ikuyo. 2000. Velar spirantization and velar phonemes in Blackfoot. In Nichols, John D. (ed.), *Papers of the Thirty-First Algonquian Conference*, 200–210. Winnipeg: University of Manitoba.

Kaneko, Ikuyo. 1999. *A Metrical Analysis of Blackfoot Nominal Accent in Optimality Theory*, MA thesis, University of British Columbia.

Kinsella, Norman George. 1972. The vowel system of Blackfoot. University of Calgary, MA thesis.

Labouriau R (2020). _postHoc: Tools for Post-Hoc Analysis_. R package version 0.1.3, <https://CRAN.R-project.org/package=postHoc>.

Lowery, Brenda. 1979. The phonological system of Blackfoot. In *Contributions to Canadian linguistics*, 67–91. (National Museum of Man, Mercury Series.) Ottawa: University of Ottawa Press.

Miller, Taylor L., & Sande, Hannah. 2021. Is Word-Level Recursion Actually Recursion? *Languages*, *6*(2), 100. Retrieved from https://doi.org/10.3390/languages6020100

Mithun, Marianne. 1999. *The Languages of Native North America*. Cambridge: Cambridge University Press.

Miyashita, Mizuki. 2024. Syllabicity of Dorsal Fricative [X] in Blackfoot: An Empirical Investigation. In Inge Genee, Monica Macaulay, and Margaret Noodin (eds.), *Papers of the Fifty-Third Algonquian Conference*, 161–178. East Lansing, MI: Michigan State University Press.

Miyashita, Mizuki. 2018. Vowel-Consonant Coalescence in Blackfoot. *Papers of the 47th Algonquian Conference*, 217–236. Monica Macaulay & Margaret Noodin (eds.). East Lansing: Michigan State University Press. https://par.nsf.gov/biblio/10394218-vowel-consonant-coalescence-blackfoot

Miyashita, Mizuki. 2011. Five Blackfoot lullabies. *Proceedings of the American Philosophical Society* 155(3): 276–293. http://www.jstor.org/stable/23208685

Miyashita, Mizuki & Chatsis, Annabelle. 2015. Respecting dialectal variations in a Blackfoot language class. In Reyhner, J., J. Martin, L. Lockard, and W.S. Gilbert (eds.), *Honoring our Elders: Culturally appropriate approaches for teaching Indigenous students,* 109–116. Flagstaff, AZ: Northern Arizona University. https://jan.ucc.nau.edu/~jar/HOE/HOE8.pdf

Miyashita, Mizuki and Weber, Natalie. 2020. Blackfoot pitch contour: an instrumental investigation. In Macaulay, Monica and Margaret Noodin (eds.), *Papers of the 49th Algonquian Conference*, 149–166. East Lansing, MI: Michigan State University Press.

Peter, Naoki. 2014. *Hiatus resolution in Blackfoot*. MA thesis, Universität Bern.

Peterson, Tyler. 2004. Theoretical issues in the representation of the glottal stop in Blackfoot. In *Proceedings from the 7th Workshop on American Indigenous Languages [WAIL 7]*, Harper, Lea and Carmen Jany (eds.), 106–121. (Santa Barbara Papers in Linguistics 15). Santa Barbara.

Prins, Samantha Leigh. 2019. Final vowel devoicing in Blackfoot. MA thesis, University of Montana.

Proulx, Paul. 1989. A sketch of Blackfoot historical phonology. *International Journal of American Linguistics* 55(1): 43–82. https://doi.org/10.1086/466104

R Core Team (2024). _R: A Language and Environment for Statistical Computing_. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>.

Reis-Silva, Amélia. 2008. Laryngeal specification in Blackfoot obstruents. Ms, Qualifying Paper, University of British Columbia.

Sapir, Edward. 1913. Wiyot and Yurok, Algonkian languages of California. *American Anthropologist* 15(4): 617–646. https://doi.org/10.1525/aa.1913.15.4.02a00040

Sapir, Edward. 1922.The Algonkian affinity of Yurok and Wiyot kinship terms. *Journal de la Société des Américanistes* 14–15(1): 36–74. https://doi.org/10.3406/jsa.1922.3991

Stacy, Elizabeth. 2004. *Phonological aspects of Blackfoot prominence.* MA thesis, University of Calgary.

Statistics Canada. 2017. Blackfoot, UNP [Designated place], Alberta and Canada [Country] (table). Census Profile. 2016 Census. (Catalogue no. 98-316-X2016001.) Ottawa: Statistics Canada. Released November 29, 2017. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E. (Accessed 2018-05-23.)

Statistics Canada. 2011. 2011 census in brief. Aboriginal languages in Canada. (Catalog no.98-314-X2011003.) Ottawa: Statistics Canada. http://www12.statcan.gc.ca/census-recensement/2011/as-sa/98-314-x/98-314-x2011003_3-eng.pdf. (Accessed 2018–20–22.)

Taylor, Allan. R. 1969. *A grammar of Blackfoot*. PhD thesis, University of California, Berkeley.

Tims, John W. 1889. *Grammar and Dictionary of the Blackfoot Language in the Dominion of Canada: For the Use of Missionaries, School Teachers and Others*. London: Society for promoting Christian knowledge.

Tucker, Benjamin V. and Richard Wright. 2020. Introduction to the special issue on the phonetics of under-documented languages. *The Journal of the Acoustical Society of America* 147(4): 2741–2744. https://doi.org/10.1121/10.0001107

U.S. Census Bureau. 2015. Detailed languages spoken at home and ability to speak English for the population 5 years and over for States: 2009–2013. https://www.census.gov/data/tables/2013/demo/2009-2013-lang-tables.html. (Accessed 2018–02–20.)

Uhlenbeck, C. Cornelius. 1938. *A concise Blackfoot grammar based on material from the southern Peigans*. Nieuwe reeks, deel 41, of Verhandelingen der Koninklijke Akademie van Wetenschappen te Amsterdam, Afdeeling Letterkunde. Amsterdam: Noord-Hollandsche Uitgevers-Maatschappij.

Van Der Mark, Sheena C. 2003. *The phonetics of Blackfoot pitch accent*. MA thesis, University of Calgary.

Weber, Natalie. 2016a. Accent and prosody in Blackfoot verbs. In Macaulay, Monica, Margaret Noodin, and J. Randolph Valentine (eds.), *Papers of the Forty-fourth Algonquian Conference*, 348–369. Albany, NY: SUNY Press.

Weber, Natalie. 2016b. Initial extrametricality and cyclicity in Blackfoot accent. In Anghelescu, Andrei, Joel Dunham, and Natalie Weber (eds.), *Proceedings of the Qualifying Papers Mini-conferences 2013–2014*, 234–248. (UBCWPL 42.) Vancouver, BC: University of British Columbia. https://lingpapers.sites.olt.ubc.ca/files/2021/04/QP3-14-Weber.pdf

Weber, Natalie. 2020. *Syntax, prosody, and metrical structure in Blackfoot*. PhD dissertation, University of British Columbia.

Weber, Natalie. 2022. Prosodic word recursion in a polysynthetic language (Blackfoot; Algonquian). *Languages* 7(3): *Phonology-syntax interface and recursivity*. https://doi.org/10.3390/languages7030159

Weber, Natalie. submitted. Undiscovered contrasts and epenthesis in Blackfoot: phonological and corpus evidence.

Weber, Natalie & Allen, Blake H. 2012. Blackfoot prominence: Insights from morpho-phonology. https://circle.ubc.ca/bitstream/handle/2429/43085/Weber_N_et_al_Blackfoot_pitch_accent_paper.pdf

Weber, Natalie, Tyler Brown, Joshua Celli, McKenzie Denham, Hailey Dykstra, Nico Kidd, Rodrigo Hernandez-Merlin, Evan Hochstein, Pinyu Hwang, Diana Kulmizev, Hannah Morrison, Matty Norris, and Lena Venkatraman. 2023. Blackfoot Words: A lexical database of Blackfoot legacy sources. *Language Resources and Evaluation* 57: 1207–1262. https://doi.org/10.1007/s10579-022-09631-2

Weber, Natalie & Mizuki Miyashita. 2024. On diphthongs and digraphs in Blackfoot. In Inge Genee, Monica Macaulay, and Margaret Noodin (eds.), *Papers of the Fifty-Third Algonquian Conference*, 269–287. East Lansing, MI: Michigan State University Press.

Weber, Natalie & Jason Shaw. 2022. Situating Blackfoot within a typology of (mobile) boundary tone grammars. In Peter Jurgec, Liisa Duncan, Emily Elfner, Yoonjung Kang, Alexei Kochetov, Brittney K. O'Neill, Avery Ozburn, Keren Rice, Nathan Sanders, Jessamyn Schertz, Nate Shaftoe, and Lisa Sullivan (eds.), *Proceedings of the 2021 Annual Meeting on Phonology*. Washington, DC: Linguistic Society of America. https://doi.org/10.3765/amp.v9i0.5154

Whalen, Doug H., DiCanio, Christian, Geissler, Christopher, and King, Hannah. (2016). Acoustic realization of a distinctive, frequent glottal stop: The Arapaho example. *The Journal of the Acoustical Society of America*, 139(4), 2212–2213. https://doi.org/10.1121/1.4950615

Windsor, Joseph W. 2017*a*. *From phonology to syntax — and back again: Hierarchical structure in Irish and Blackfoot*. PhD dissertation, University of Calgary.

Windsor, Joseph W. 2017*b*. Predicting prosodic structure by morphosyntactic category: A case study of Blackfoot. *Glossa* 2 (1): 10. https://doi.org/10.5334/gjgl.229

Appendix: Transcriptions

The following is the list of words and transcriptions used to build the charts in this description. Words were prompted by an English translation. In some cases, the word as spoken by Totsinámm differs from the word listed in the dictionary. In those cases, we have noted the differences in footnotes. If the word differed in morphology, we sometimes constructed a free translation which better matches the meaning.

1.	[aʔpsːkít]	*a'psskít*	'chase it!'
2.	[axkójɪnːɪmaːn]	*aahkóyinnimaan*	'pipe'
3.	[áːkɛːˢtaːpik͡sɪmmɛː]	*áákaistaapiksimayi*	'he will throw it'
4.	[áːkituʔtaʔpɛsːi]	*áákito'ta'paissiwa*	'she will associate with him'
5.	[áːkitʊpɐkɪˢtóːpiːjaː] [áːkitɐpʊk͡sɪˢtóːpiːjaː]	*áákitopakistóópiiyaawa* *áákitapoksistóópiiyaawa*[11]	'they will sit side by side'
6.	[áːkxʷtoʔtst͡siː]	*áákohto'tstsiiwa*	'it came from there'
7.	[áːkxʷtsɪtokoː]	*áákohtssitokoowa*	'she will go through the center'
8.	[áːk͡sɪk͡sɪkːsːiːˢtstaki]	*ááksiksikksssiiststakiwa*	'she will have a white wash'
9.	[áːk͡sɪskɐnɔːtoni]	*áákssikskanáótoniwa*[12]	'it will become morning'
10.	[áːksɛsksimaː]	*áákssaisskssimaawa*	'she will grow (plants)'
11.	[áːksːt͡siːjuʔpa̰]	*áákssstsiiyoo'pa*	'he will use a sweat lodge'
12.	[áːksːt͡sɪmaː]	*áákssstsimaawa*	'he will light it'
13.	[aːpíksɪn]	*aapíkssin*	'sores'
14.	[aːpíksːt͡sɪt]	*aapíksstsit*[13]	'take it out of your mouth!'
15.	[áːpsːki]	*áápsski*	'white face' (horse)
16.	[aːsíːkukiː]	*aasíikokii*[14]	'bear grass'
17.	[ɛ́ːkɪmʔxʷsi]	*áíkimmohsiwa*	'he is pitying himself'
18.	[ɛ́kːatoʔpa̰]	*áíkkatoo'pa*	'balloon'
19.	[ɛ́ːk͡sɪsɪˢtstaː], [ɛ́ːkɪsɪˢtstaː]	*áíksisiststaawa* *áíkisiststaawa*	'he is sharpening (a knife)'
20.	[ɛ́mːóniːsi]	*áímmóniisi*	'otter'
21.	[ɛ́ːpɐkːɪtɐkaʔsi]	*áípakkitaka'siwa*[15]	'motorcycle'
22.	[ɛ́ːpoxʷsápaːpik͡sɪmːɛː]	*áípoohsápaapiksimmayi*	'he is throwing it towards me'
23.	[ɛ́ːsokɐtːsːɐmːiːwɛː]	*áísokattsssammiiwayi*	'she looked at him frequently'
24.	[ɛ́sk͡sɪnimaʔtstxʷki]	*áíssksinima'tstohkiwa*	'he teaches'
25.	[ɛ́skskaʔtaki]	*áíssska'takiwa*	'he is thinking about it'
26.	[ɛ́ˢtːsíkɐtːsi]	*áísttsíkattsiwa*	'it looks shiny'
27.	[ákɛsːakɪmːiːwɛː]	*ákaissakimmiiwayi*	'he has stopped mourning for her'
28.	[ákɔxʷtɛːtskçpiji]	*ákaohtaitskihpiyiwa*	'she has danced past'
29.	[akɔ́ːmɐtɐpɐkːíspoː]	*akáómatapakkísspoowa*	'she has started to get much higher'

[11] Frantz and Russell (2017) have *áakitopaksikksstóópiiyaawa* 'they will sit abreast there', with an extra syllable. Totsinámm pronounced this word in two different ways. The [a] ~ [o] metathesis in the second pronunciation is probably a speech error.

[12] Frantz and Russell (2017) lists *áákssikskanáótonni* 'it will become morning' with a geminate *n*. The short *n* in this word might be a Káínai pronunciation.

[13] Frantz and Russell (2017) lists *aapíttstsit!* 'empty your mouth of it!' There is known speaker variation in the distribution of *ts* and *ks*.

[14] Frantz and Russell (2017) lists *áíksikkookiyi* 'bear grass'.

[15] In the Piikani dialect, the word for 'motorcycle' is *áípakkohtamma*.

30.	[akájisɛs:api]	*akáyisaissapi*	‘scout’
31.	[aksín]	*akssín*	‘bed’
32.	[ɛ́nʔxʷkạ]	*ánnohka*	‘now’
33.	[anóxʷkaʔt͡sisɪm]	*anóóhka’tsisim*[16]	‘she found it burdensome’
34.	[ɔ:áxt͡sî:kaʔsi]	*aoááhtsíika’siwa*	‘he acted daring’
35.	[ɔ́:ko:jʔs:ka:]	*áókooysskaa*	‘carpenter’
36.	[ɔ́:oweʔtaki]	*áóowai’takiwa*	‘he is asking for a wife’
37.	[ɔ́:ts:ksi:ˢtsta:ni]	*áótssksiiststaani*	‘he kneaded it’
38.	[ápɛsta:minam:]	*ápaisstaaminaamm*	‘apple’
39.	[apó:ts:t͡sɪn] [apó:t͡sɪˢt͡sɪn]	*apóótsstsin*, *apóótsistsin*	‘muscle’
40.	[ápspini:k͡s]	*ápspiniiksi*	‘geese’
41.	[asâ:kɪp:ópi:tạ]	*asáakippópiit*	‘stop and sit!’
42.	[ats:tóxʷkɪn:ɪma:n], [at͡sɪˢtóxʷkɪn:ɪma:n]	*atsstóóhkinnimaan*, *atsistóóhkinnimaan*	‘suspenders’
43.	[awxkɔ́:t͡si:s:ɪn]	*awahkáótsiiyssin*[17]	‘war’
44.	[aja:kóxʷki:ts:kaʔsi]	*ayaakóóhkiitsska’siwa*	‘she is gonna act strange/foreign’
45.	[ájâ:k͡sɪk͡sɪk:s:i]	*áyáaksiksikkssiwa*[18]	‘it (anim.) is gonna be stiff’
46.	[ájâ:ks:pçkaʔsi]	*áyáaksspihka’siwa*	‘she will act snobby’
47.	[íʔks:kɪmʔạ]	*í’ksskimma*	‘metal’
48.	[içpokónʔs:ka:]	*iihpokónsskaawa*	‘he has gotten the ball’
49.	[içtɛ́:kskɪmɔʔpi:ˢt͡s]	*iihtáíkskimao’piistsi*	‘hunting equipment’
50.	[içtɛ́:sɪtoko:]	*iihtáísitokoowa*	‘he went through the center’
51.	[içtɛ́stsɐkjoʔpi]	*iihtáísstssakio’pi*	‘brand iron’
52.	[içtɔ́:kspɛn:ɪkjoʔpạ]	*iihtáókspainnikio’pa*	‘glue’
53.	[i:kít͡sɪk͡sɪnamʔạ]	*iikítsiksinamma*	‘he looks sickly’
54.	[i:kómʔs:pikaʔpsi]	*iikómsspika’pssiwa*	‘he is hard to take care of’
55.	[i:k͡sínakstsɪmʔạ]	*iiksínakstssimma*[19]	‘it (anim.) is small’
56.	[í:ksks:tsʊwaʔpi:]	*íiksksstsowa’piiwa*	‘it was a chance happening’
57.	[í:ks:psɪmʔạ]	*íiksspssimma*	‘it (anim.) is tall’
58.	[i:tɛ́nʔçtɔwʔpạ]	*iitáínnihtao’pa*	‘cooking pot’
59.	[i:tóíst͡si:ji]	*iitóísstsiiyiwa*	‘he went to a sweat’
60.	[í:ts:k͡si:ˢtsta:n]	*íítssksiiststaan*	‘dough’
61.	[ikímʔxʷsi:tạ]	*ikímmohsiit*[20]	‘pity yourself!’

---

[16] Frantz and Russell (2017) list a related verb *onnohkatsimmis!* ‘find him burdensome!’ Totsinámm probably used a stem which agrees with a grammatically inanimate object.

[17] Totsinámm normally has an intrustive glottal stop between a glide [j] <y> and a long [s:], but does not in this word. Vowels before geminate consonants are normally neutralized to short, but the vowel in this word remains long. It seems likely this pronunciation is a reflex of fast speech.

[18] Frantz and Russell (2017) list *áaksikkskssiwa* ‘it will be stiff’. Totsinámm uses the imminent future prefix *ayaak-* instead of future *aak-*, but the stem in her pronunciation also has one extra syllable.

[19] Frantz and Russell (2017) has *i’nákstssimma* ‘small’ with a glottal stop. This glottal stop was probably elided in fast speech here. Totsinámm also includes a degree-marking prefix, *iik-*, which occurs on many stative verbs.

[20] Within this sound file, the first repetition is [ɛ́:kɪmʔxʷsi] *áíkimmohsiwa* ‘he is pitying

62.	[ɪk:st͡sóxʷkɪn:]	*ikkstsóóhkinn*	‘sharp necklace’
63.	[ik͡sísta::psi]	*iksístaaapssiwa*	‘she is lazy’
64.	[ik͡sɪstóts͡ɪm:ɛ:]	*iksistótsimmayi*	‘he wasted it’
65.	[ik͡sístspiʔtakɪtạ]	*iksístspi’takit*	‘be eager!’
66.	[íkst͡síʔpʊji]	*íkstsí’poyiwa*[21]	‘she implied’
67.	[imitâ:]	*imitáá*	‘dog’
68.	[imitóʔkomi]	*imitáó’komi*	‘flea’
69.	[ɪm:ɪst͡sî:]	*immisstsíí*	‘grease/cooking oil’
70.	[imʔs:ká:n]	*imsskáán*	‘doggie bag’
71.	[imʔs:ká:t]	*imsskáát*	‘save a portion!’
72.	[ɪn:óxʷk͡sɪsi]	*innóóhksisi*	‘long nose’, ‘elephant’
73.	[ɪp:ot͡sípɪsta:n],	*ippotsípistaan*,	‘braid’
	[ɪp:ot͡síps:ta:n]	*ippotsípsstaan*	
74.	[isɛ́st:u:]	*isáísttoowa*	‘he announced’
75.	[isatɛ́s:i]	*isatáíssiwa*	‘he became offended’
76.	[ɪs:akím:ɪs]	*issakímmis*	‘get over him!’
77.	[ɪs:ɔ́:ka:si]	*isssáókaasiwa*	‘she tripped’
78.	[ɪskxʷkótɐwɛ:]	*isskohkótawayi*	‘he was given it back’
79.	[ɪsksk͡sínʔhka:]	*isskskínihkaawa*	‘she broke glass’
80.	[ɪsksí:na:]	*isskssíínaa*	‘insect’
81.	[ɪspómʔçta:t]	*isspómmihtaat*	‘help out!’
82.	[ɪst͡sá:pinat͡:si]	*isstsáápinaattsiwa*	‘it looks bright’
83.	[ɪst͡sí:ʔs:ka:n]	*isstsíiysskaan*	‘sweat lodge’
84.	[ɪstskí:ststa:]	*isstskíststaa*	‘bay’
85.	[ɪst:sks:kjú:mita:]	*isttsksskióómitaa*[22]	‘slim faced dog’, ‘grayhound’
86.	[ɪst:s:ú:tạ]	*isttssóót*	‘go into the forest!’
87.	[ɪst:st͡sá:pikɪm:]	*isttstsáápikimm*	‘barbed wire’
88.	[i:t͡síʔtsksoji]	*iitsí’tsksoyi*	‘picnic’
89.	[kɐk:ô:]	*kakkóó*	‘pigeon’
90.	[kɛ́nik͡sɪm:]	*kániksimm*	‘stump’, ‘big branch’
91.	[kjɛ́:kitumʔs:tskɪst͡s]	*kiáákitoomsstskisstsi*[23]	‘you will lie face down’
	[kitá:kitumʔs:tskɪst͡s]	*kitáákitoomsstskisstsi*	
92.	[ki:píp:o]	*kiipíppo*	‘hundred’
93.	[kím:ataʔpsíja:pi:kʊɐn]	*kímmata’pssíyaapiikoan*[24]	‘poor walker’
94.	[kɪp:itâ::ki:]	*kippitáaakii*	‘elderly woman’

himself’.The second two repetitions are as we have transcribed here.

[21] Frantz and Russell (2017) list *itsksi’poyiwa* ‘she implied’ instead. There is known speaker variation in the distribution of *ts* and *ks*.

[22] Frantz and Russell (2017) list *ikkstsskiomitaa* ‘greyhound’. There is known speaker variation in the distribution of *tts* (or *stts*) and *kks*.

[23] Frantz and Russell (2017) has *áakomsstskiihtsiiwa* ‘she will lie face down’ (which lacks the second person prefix *ki-* ~ *kit-*) with a dorsal fricative instead of an alveolar one. There is known speaker variation in the realization of dorsal fricatives after high, front vowels. Totsinámm also includes a prefix *it-* ‘there’.

[24] Frantz and Russell (2017) has *kímmatá’piaapiikoan* ‘hobo, tramp, vagabond’, which includes the inanimate intransitive verb stem *kimmata’pii-*. In contrast, Totsinámm uses a word which begins with an animate intransitive verb stem, *kimmata’pssi-* ‘pitiable one’

95.	[kɪt͡sɪk͡síkːɐkoːmi̥]	*kitsiksíkkakoomi*	‘you married young’
96.	[koxʷpɐ́tːstaːn]	*koohpáttstaan*	‘yeast bread’
97.	[k͡sɪkːokúːwa]	*ksikkokóówa*	‘tent’
98.	[k͡sísksːtaki]	*ksíssksstaki*	‘beaver’
99.	[máːtɛːnʔsːpópiːwaːt͡sɪk͡s]	*máátainsspópiiwaatsiksi*	‘she does not sit still’
100.	[máːtɛpːʊmoxʷt͡sɪmîː]	*máátaippomoohtsimííwa*	‘he does not hear well’
101.	[meːêː]	*maiáí*	‘robe’
102.	[matóípsːtaxkaːt]	*matóípsstaahkaat*	‘go buy cigarettes!’
103.	[miːˢt͡sís]	*miistsís*	‘tree’
104.	[moxʷkínʔsːt͡sɪs]	*moohkínsstsis*	‘elbow’
105.	[môːtókɪs]	*móotókis*	‘hide’, ‘skin’
106.	[motːok͡sís]	*mottoksís*	‘knee’
107.	[mowɐ́psːpɪn]	*mowápsspin*[25]	‘eye’
108.	[naːáxsɪk͡s]	*naaáhsiksi*	‘my grandparents’
109.	[naːmjóːjɪs]	*naamióóyis*[26]	‘bee hive’
110.	[náːtoʔkiːkɪpːiːtɐpíːjaːˈ]	*nááto’kiikippiitapíiyaawa*	‘they are two hundred people’
111.	[neːéːwa]	*naiáíwa*	‘my robe’
112.	[níːpḁ]	*níípa*	‘leaf’
113.	[niːsípːo]	*niisíppo*	‘forty’
114.	[nimuwóxʷt͡si]	*nimowóóhtsi*[27]	‘westward’
115.	[nímʔsḁ]	*nímssa*	‘my daughter-in-law’
116.	[nínːḁ]	*nínna*	‘my father’
117.	[nɪnʔsːpáʔpsi]	*ninsspá’pssiwa*[28]	‘she has a quiet temperament’
118.	[nísːˈ]	*níss*	‘my son-in-law’
119.	[nɪsːísːˈ]	*nissíss*	‘my younger sibling’ (of female)
120.	[nitáːkɛskskɐmːaːˈ]	*nitáákaisskskammaawa*	‘I will watch over him’
121.	[nitáːkʊksɪt͡sɪpsakːḁ]	*nitáákokssitsipssakka*	‘he will talk deceptively to me’
122.	[nitáːkotoːmiçkḁ]	*nitáákotoomiihka*	‘I will go fishing’
123.	[nitáːk͡sɪkːiookḁ]	*nitáákssikkiooka*	‘he will tame me’
124.	[nitáːksːkskoiʔpḁ]	*nitáákssskskoi’pa*	‘I will measure it’
125.	[nitáːksokinokḁ]	*nitáákssokinoka*	‘he will doctor me’
126.	[nitɛ́ːsiʔkiʔpḁ]	*nitáísi’ki’pa*	‘I am covering it’
127.	[nitɛ́ːsɪmɪmːokḁ]	*nitáísimimmoka*	‘he is talking gossip about me’
128.	[nitɛ́ːsokinokḁ]	*nitáísokinoka*	‘he is doctoring me’
129.	[nitɛ́skxʷkʊkːḁ]	*nitáísskohkokka*	‘he always gives back to me’
130.	[nitɛ́skskɐmːaːˈ]	*nitáísskskammaawa*	‘I am watching over him’
131.	[nitɛ́skskoiʔpḁ]	*nitáísskskoi’pa*	‘I am measuring it’
132.	[nitɛ́stḁ]	*nitáísstaa*	‘I am drinking milk’, ‘I am nursing’
133.	[nɪtɐ́nʔḁ]	*nitána*	‘my daughter’
134.	[nitáwatoxʷksːkinaki̥]	*nitáwatoohksskinaki*[29]	‘I bend my back’

---

[25] Frantz and Russell (2017) spell this without a *w*: *moápsspini* ‘eye’.

[26] Frantz and Russell (2017) 2017 have *naam<u>oo</u>yis* ‘bee hive’, without a glide after the *m*.

[27] Frantz and Russell (2017) have *ní<u>mm</u>oohtsi* ‘westward’, with a geminate *mm* and no glide.

[28] Frantz and Russell (2017) list *insspá’pssiwa* ‘she has a quiet temperament’, without an initial *n*.

[29] Frantz and Russell (2017) lists *nit<u>áó</u>t<u>ohs</u>kíniaaki* ‘I bend my back’. There are two differences here: the stem begins with *o* in the dictionary but with *wa* for Totsinámm; the dictionary has a different medial sequence than Totsinámm.

135.	[nitája:pst͡sa:kḭ]	*nitáyaapstsaaki*	‘I close my eyes’
136.	[nitúʔxʷt͡sɪt͡siʔçkaʔs:pɪn:a:n]	*nitó’ohtsitsi’ihka’sspinnaan*	‘we honored her’
	[nitúʔxʷt͡sɪt͡siʔskaʔs:pɪn:a:n]	*nitó’ohtsitsi’ska’sspinnaan*	
137.	[nit͡sí:kɐjʔs:po:kạ]	*nitsíikaysspooka*	‘she parted my hair’
138.	[nit͡sí:ks:tạ]	*nitsíiksstaa*	‘I want/wish’
139.	[nit͡sí:mak:ạ]	*nitsíimakka*[30]	‘she imitated me’
140.	[nit͡sɪksík:çkíniʔtakḭ]	*nitsiksíkkihkínii’taki*	‘I am sad/depressed’
141.	[nɪt͡sɪnâ:n]	*nitsináan*	‘my belonging/possession’
142.	[nit͡sípɐks:kínja:]	*nitsípaksskíniaawa*	‘I hit him on the back’
143.	[níts:kxʷkʊk:ɛ:]	*nítsskohkokkayi*	‘he gave back to me’
144.	[níts:k͡sínimaʔt͡sookạ]	*nítssksínimaa’tsooka*	‘she taught me’
145.	[níts:pi:ʔji]	*nítsspii’yi*[31]	‘I danced’
146.	[níts:axsi:n]	*nítsssaahssiin*[32]	‘my blurred vision’
147.	[níts:oʔto:kạ]	*nítssso’tooka*	‘he felt me (up)’
148.	[ot͡sikɛ́:sɪna:ksi:ˢt͡s]	*otsikáísinaakssiistsi*	‘his debts’
	[okɛ́:sɪna:ksi:ˢt͡s]	*okáísinaakssiistsi*	
149.	[ʊmʔxkɛ́:sɪpɪspɪk:s:i:]	*omahkáísipisspikkssi*[33]	‘Sharp-shinned hawk’
150.	[ʊ́mʔxkítɛ:sɐps:i:ˢtstɐkjoʔpạ]	*omahkítaisapsssiiststakio’pa*	‘washtub’
151.	[ʊ́mʔxks:k͡sɪsi]	*ómahkssksisi*	‘big nose’
152.	[ʊ́mʔxks:ksi:na:]	*ómahksskssiinaa*	‘big insect’
153.	[ʊ́mʔxks:ɐpjaʔt͡sɪs]	*ómahksssapia’tsis*	‘big field glasses’
154.	[ome:ê:]	*omaiáí*	‘he took off his robe’
155.	[omín:]	*omínn*	‘wing’
156.	[ot͡sɪpí:jɪsko]	*otsipíiyissko*	‘area of trees’
157.	[ot:ɐ́pitoxʷt͡si]	*ottápitoohtsi*	‘behind the house’
158.	[pisɐ́tsɛski]	*pisátssaisski*	‘flower’
159.	[píspɪk:s:i:]	*písspikkssii*[34]	‘sparrow hawk’
160.	[pɪˢt:û:]	*pisttóó*	‘common night hawk’
161.	[pʊnokâ:]	*ponokáá*	‘elk’
162.	[pó:s]	*póós*	‘cat’
163.	[sa:á:mi]	*saaámi*[35]	‘medicine’
164.	[sípst͡sina:n]	*sípstsinaan*[36]	‘tipi flap pole’
165.	[skî:m]	*skíím*	‘female animal’
166.	[sojíˢt:ɐjɪtạ]	*soyísttayit*	‘dive!’
167.	[spɐ́t͡sɪko]	*spátsiko*	‘sand’

---

[30] Frantz and Russell (2017) lists *nitsíiyíimakka* ‘she imitated me’, with an additional syllable at the left edge of the stem.

[31] Frantz and Russell (2017) spell this *nítsspiyi* ‘I danced’; we have given an orthographic representation that closer matches Totsinámm’s pronunciation.

[32] Frantz and Russell (2017) have *nítsssaahsinaa* ‘I had blurred vision’, where the right edge of the verb stem is significantly different. Totsinámm’s version may be a stem nominalization.

[33] Frantz and Russell (2017) have *ómahksipisspsksii* ‘Sharp-shinned hawk’.

[34] Frantz and Russell (2017) has *písspsksi(i)* ‘sparrow hawk’.

[35] Frantz and Russell (2017) spells this with three vowels, *saaámi* ‘medicine’; we have spelled this with four <a> vowels to represent a sequence of two long vowels.

[36] Frantz and Russell (2017) list *saipstsimaan* ‘tipi flap pole’, with a different vowel in the first syllable, and an *m* instead of an *n*.

168.	[sːpóxʷtxkn̥]	*sspóóhtahka*	‘angel’, ‘person in heaven’
169.	[sːpopîː]	*sspopíí*	‘hawk owl’
170.	[stáxt͡sɪt͡si]	*stááhtsitsi*	‘underwear’
171.	[stɛ́mɪkn̥]	*stámika*	‘steer’
172.	[stɛ́míkːsk͡siːs]	*stámíkksksiis*[37]	‘test her knowledge!’
173.	[stɛ́mɪpxʷk͡sɪˢtːskíniːs]	*stámipohksisttskíniis*	‘give her a haircut!’
174.	[stɛ́mɪtsːkɪtn̥]	*stámitsskit*	‘leave it (anim.)!’
175.	[stɛ́motoipstaxkaːt]	*stámotoipstaahkaat*	‘just go buy cigarettes!’
176.	[stɛ́mʔsːaːkonoːs]	*stámsssaakonoos*	‘try to recognize her!’
177.	[tûʔtsːksːkɛ́mːɪs]	*tó’tssksskámmis*	‘watch over her!’

[37] Frantz and Russell (2017) have *isttsksiisa!* ‘test her knowledge!’. There is known speaker variation in the distribution of *tts* (or *stts*) and *kks*. Totsinámm includes a prefix *stam-* ‘just’.