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Vowel-Consonant Coalescence in Blackfoot

Mizuki Miyashita

Blackfoot has three variants of a back fricative: palatal [ç], velar [x], and labial-velar [x^w].[1] In this paper, they are referred to as DORSAL FRICATIVES. According to the historical account suggested by Proulx (1989), these dorsal fricatives developed from various consonants before another consonant (i.e., *hp → xp, *tp → xp, *Hm → xp, *nt → xt, *ʔt → xt, *hk → xk, *tk → xk, *łk → xk, *ŝk → xk). In terms of synchronic study, Frantz (2009) and Elfner (2006b) claim that [ç], [x], and [x^w] are surface forms of the same phoneme, /x/, preceded by /i/, /a/, and /o/, respectively. However, to my knowledge, a formal account of these sounds has not been made. The goal of this paper is to provide a formal analysis that depicts the distributions of the dorsal fricative variants with acoustic descriptions of sample recordings and also makes and supports the claim that dorsal fricatives in Blackfoot are examples of typologically rare vowel-consonant coalescence.

Data shown in this paper are from the Blackfoot dictionary (Frantz and Russell 1995) and grammar (Frantz 2009) unless otherwise indicated. The forms in these resources are represented in the orthography; this paper uses orthographic representation except the symbol <x>—which is <h> in the orthography—in order to avoid confusion. Examples that are given in IPA transcription have been

TABLE 1. Blackfoot consonant chart

	LABIAL	DENTAL	PALATAL	DORSAL	GLOTTAL
Plosive	p	t		k	ʔ
Nasal	m	n			
Fricative		s		x	
Affricate		t͡s		k͡s	
Glide	w		j		

confirmed by native speaker consultants, and the transcriptions represent their pronunciation.[2]

The organization of this paper is as follows: In the next section, the Blackfoot sound inventory is given briefly as background. The section after that describes the distribution of the dorsal fricatives in Blackfoot. In the following section, I claim that the dorsal fricatives are the result of vowel-consonant coalescence and provide support for this claim. In the last section, I discuss the significance of this study and the broader implications of the vowel-consonant analysis.

Sound Inventory in Blackfoot

Blackfoot has three vowel phonemes: /i/, /a/, and /o/. All of them have long counterparts: /ii/, /aa/, and /oo/. There are also three diphthongs: /ai/, /ao/, and /oi/ (Frantz 2009), which are realized as various surface forms, including monophthongized segments. The Blackfoot consonants are shown in Table 1. They occur in long and short forms except the glides, back fricative, and glottal stop, which are always short.[3]

Note that the phoneme in question, /x/, although orthographically written as <h>, is not a glottal fricative. This is clear from a number of descriptive sources such as Uhlenbeck (1938), Taylor (1969), and Frantz (2009).

Surface Distribution of /x/

Previously, Frantz (2009) and Elfner (2006b) described [ç], [x], and [xʷ] as surface forms of the same phoneme, /x/, preceded by /i/, /a/, and /o/, respectively. These surface forms occur regardless of morphology as long as the appropriate phonological environment is given. For example, they may be observed within a morpheme, as shown in (1a–c), or across morphemes, as in (1d–f).[4]

(1) a. [piçksso]
pi**ix**ksso
'nine'

b. [pa**x**tómˀxk͡sikimi]
pa**ax**t-omaxk-ikimi
inside-big-water
'Waterton Lake'

c. [po**x**ʷsapoot]
po**ox**sap-oo-t
toward.speaker-go-IMP
'Come here!'

d. [nit͡siomani**ç**pinnaan]
nit-ii-omaan**ii-x**pinnaan
1-PST-be.right(AI)-1PL
'We (excl.) were right.'

e. [nit͡siomiçk**ax**pinnaan]
nit-ii-omiixk**aa-x**pinnaan
1-PST-catch.fish(AI)-1PL
'We (excl.) caught fish.'

f. [nit͡sitap**ox**ʷpinnaan]
nit-itap**oo-x**pinnaan
1-go.there(AI)-1PL
'We (excl.) went there.'

Thus, a morpheme beginning with /x/ (1d–f) surfaces as three allomorphs based on the final vowel of the preceding morpheme.

Phonologically, dorsal fricatives are observed in two major environments. One is the postvocalic environment, where they are preceded by a short vowel and followed by a consonant. The examples in (1d–f) show postvocalic /x/ in inflected forms of three animate intransitive (AI) verb stems: *omanii* 'to be right', *omiixkaa* 'catch fish', and *itapoo* 'go there'.[5] In this environment, only the three combinations in the examples are observed: [iç], [ax], and [oxʷ]. There is no occurrence of other combinations of vowel and dorsal fricative: *[aç], *[oç], *[ix], *[ox], *[axʷ], *[ixʷ], except when the preceding vowel is underlyingly a diphthong. Each variant of the back fricative has its "favorite" vowel, and, notably, they share articulatory features with those vowels: [i] and [ç] are palatal; [a] and [x] are velar; and [o] and [xʷ] are labial-velar.

The other environment in which dorsal fricatives appear is interconsonantal, where the three variants of the dorsal fricative can occur in the same environments. The examples in (2) show forms including interconsonantal /x/ in various environments such as between [n] and [k], [m] and [k], two [k]s, and [ts] and [k]. Note that these environments are not exhaustive.

(2) a. [inˀçkíw]
inixki-wa
sing-3SG
'He sang.'

b. [issímˀçkaa]
issímixkaawa
sniff-3SG
'He sniffed.'

c. [paxtómˀxk͡sikimi]
paaxt-omaxk-ikimi
inside-big-water
'Waterton Lake'

d. [ikxtsíw]
ikaxtsi-wa
gamble-3SG
'He gambled.'

e. [sikxʷkiaajo]
sik-oxkiaayo
black-bear
'black bear'

f. [annˀxʷkḁ]
anno-xka
this-INVS
'now'

Thus, the interconsonantal environments for the three variants overlap, and the overlapping environments may make the dorsal fricatives appear contrastive. If this were true, the statement made by previous authors that [ç], [x], and [xʷ] are phonetic variations of the same phoneme /x/ becomes questionable. However, I do not believe these are separate phonemes, and I instead support the previous studies' claim.

In order to maintain the view that these dorsal fricatives are phonetic variants of the same phoneme /x/, it must be the case that there are three noncontrasting underlying environments. Specifically, in the interconsonantal cases, the three variants [ç], [x], and [xʷ] must be underlyingly preceded by [i], [a], and [o], respectively. Such environments are supported by the complementary distribution of postvocalic /x/: If the interconsonantal dorsal fricatives [ç], [x], and [xʷ] are independently occurring, it is difficult to explain why these variants have favorite vowel pairs in their postvocalic counterparts.

Vowel-Consonant Coalescence

Both postvocalic and interconsonantal dorsal fricatives can be observed at morpheme boundaries. The final vowel of a morpheme plus a following /x/ that is the initial consonant of the subsequent morpheme create the environment for coalescence. The examples in (3) show coalescence across a morpheme boundary between a short vowel and a dorsal fricative. At the surface, the short vowels are no longer realized as full vowels. Instead, we see a merging of the underlying vowels and the following /x/.

(3) a. [sik**x**ʷkiaajo]
sik-**ox**kiaayo
black-bear
'black bear'

b. [annˀ**x**ʷkḁ]
ann**o-x**ka
this-INVS
'now'

The next examples, in (4), show the merging of sounds between a long vowel and a dorsal fricative across a morpheme boundary. Long vowels surface as short vowels followed by the variants of the phoneme /x/.

(4) a. [nit͡siomaniçpinnaan]
nit-ii-omaan**ii-x**pinnaan
1-PST-be.right(AI)-1PL
'We (excl.) were right.'

b. [nit͡sitap**ox**ʷpinnaan]
nit-itap**oo-x**pinnaan
1-go.there(AI)-1PL
'We (excl.) went there.'

The examples in (5) have no coalescence because the consonants following the vowels are not dorsal fricatives. The vowels remain short, in (5a–c), and long, in (5d–f).

(5) a. [ajimmiw]
á-yimmi-wa
DUR-laugh(AI)-3.SG
'He/She is laughing.'

b. [ponokáw]
ponoká-wa
elk-3.ANIM
'It is an elk.'

c. [natájow]
natáyo-wa
lynx-3.ANIM
'It is a lynx.'

d. [iiman**ii**w]
ii-oman**ii**-wa
PST-be.right(AI)-3SG
'He was right.'

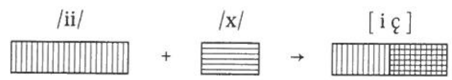
e. [ejpott**aa**w]
á-ipott**aa**-wa
DUR-fly(AI)-3SG
'He is flying.'

f. [áakitap**oo**w]
áak-itap**oo**-wa
FUT-go.there(AI)-3SG
'He is going there.'

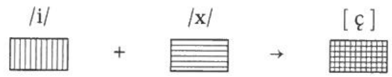
The examples above show that vowel change is observed only when /x/ is involved. This peculiarity, thus, is a phonological, not morphological requirement.

Based on the observation above, I propose the analysis that the phoneme /x/ always underlyingly follows a vowel and that the fricative sound surfaces with shared features from the preceding vowel. During the process of feature-sharing, vowel-consonant coalescence must occur. The term COALESCENCE refers to a phonological phenomenon in which two successive segments merge into a single segment, usually maintaining some characteristics of the original segments (Trask 1996). Under this analysis, the back fricative merges with a vowel or part of a vowel. When an underlying long vowel is followed by the phoneme /x/, the consonant and part of the long vowel merge into one, forming a diphthong-like unit, as illustrated in (6a). Similarly, a back fricative between consonants is developed by the merging of an entire short vowel and a back fricative, as illustrated in (6b).

(6) a.



b.



This analysis is supported perceptually by the fact that the coalesced segments [ç], [x], and [x^w] are phonetically more complex than the symbols reflect (Donald Frantz, personal communication, 2015). I agree with this view because the vowel qualities of [i], [a], and [o] are quite audible in the fricatives [ç], [x], and [x^w] in spite of their voicelessness, as the frication in the vocal tract is radically loud. Below, I describe other supporting factors for the coalescence analysis.

Length of the Preceding Vowel

Vowels preceding dorsal fricatives are always short. That is, sequences such as *[iiç], *[aax], and *[oox^w] do not occur.[6] One could argue that it is natural for the preceding vowel to be shortened, assuming that the sound /x/ is a syllable coda, as vowel shortening always occurs before a coda consonant. This is described as a phonological phenomenon by Elfner (2006a, 2006b), referring to the general process that vowels followed by a consonant cluster are shorter than those in other contexts. However, as shown in (7), not all long vowels are shortened in this context. They remain long before consonant clusters and geminates.[7]

(7)	a. iikkamí'niwa	'he fainted'
	b. nitsiinnohkatsimmoka	'she found me burdensome'
	c. iippotsi'kiniisiwa	'he became winded on impact'
	d. nitsimmsowaakka	'she muddied waters for me'
	e. ksikksinaattsiwa	'it is white'
	f. nitaapsstsitsikini	'I took off my shoes'
	g. ikookssiwa	'he regretted'
	h. otahkoottsiiksi	'prickly pear cacti'
	i. koonsskoyi	'snow covered area'

On the other hand, long vowels never retain their length before /x/. Thus, the shortening of long vowels before /x/ needs its own explanation and cannot be

categorized with the shortening phenomena previously analyzed. This peculiarity of /x/—that its preceding vowel is never long—is explained when coalescence is assumed.

Diphthongs

The case of the postvocalic environment when the vowel is a diphthong also provides strong support for the vowel-consonant coalescence analysis. I mentioned above that there is no occurrence of a vowel and a dorsal fricative with mixed articulatory features: *[aç], *[oç], *[ix], *[ox], *[ax^w], and *[ix^w] do not occur. However, the sequence [eç] is attested when the vowel preceding /x/ is underlyingly the diphthong /ai/.

Frantz (1978, 2009) states that the diphthong /ai/ is often realized as a front, nonhigh vowel: [ɛ], [ej], and [æ:].[8] The diphthong /oi/ is pronounced [oj] or [y], and /ao/ is [ɔ] or [aw]. Thus, some are realized as monophthongs. The cases that usually surface as diphthongs present important evidence for coalescence, because when the diphthongs are followed by the dorsal fricative /x/, the off-glide element [j] is not realized, and the sound [ç]—a variant of /x/—surfaces instead. For example, as shown below, /aix/ surfaces as [eç] (8a) and /oix/ as [oç] (8b).

(8) a. [niteçpiyi]
nit-a-ixpiyi
1-DUR-dance
'I am dancing.'

b. [ɛsoçtaa]
Ø-a-isoixtaa
3-DUR-place.one's.own.food.on.a.dish
'He is placing his own food on a dish.'

This can be analyzed as the second element of the diphthong, /i/, merging with the following /x/. Note that while the first example could be analyzed as the spreading of a [front] feature from the preceding vowel, the latter example does not support this analysis. This, in turn, supports the idea that the last half of a long vowel merges with a following dorsal fricative /x/, assuming that diphthongs and long vowels are alike in terms of quantity (i.e., vowel length).

Duration of Coalesced Segments

As a result of vowel-consonant coalescence, an interconsonantal dorsal fricative has the duration of a short vowel and a postvocalic dorsal fricative plus its preceding vowel has the duration of a long vowel. This observation is shown below using phonetic measurements.

The sound samples in (9) and (10) are taken from the recording supplement for the *Basic Beginning Blackfoot* teaching material. This is a 12-page, unpublished document consisting of vocabulary and conversations developed in 2008 by an instructor at the Cuts Wood School (a Blackfoot immersion school) in the Piegan Institute. The sample utterances were produced by the developer of the materials, who is a native speaker from the Kainai reserve in Alberta and regularly uses the language. She was in her mid-50s at the time of recording.

The image in (9) is a spectrogram of the word /omaxkinaa/ [omˀxkinaa] 'old man' along with the values of the segments' durations. As shown in Table 2, the duration of the interconsonantal coalesced segment, a velar fricative [x], is 149ms. This is close to the duration of the word's short vowels: 138ms for [o] and 110ms for [i]. On the other hand, the duration of the long vowel [aa] is 304ms, twice as long as [x]'s. This durational fact is explained by the coalescence analysis.

(9) Spectrogram of /omaxkinaa/ [omˀxkinaa] 'old man'

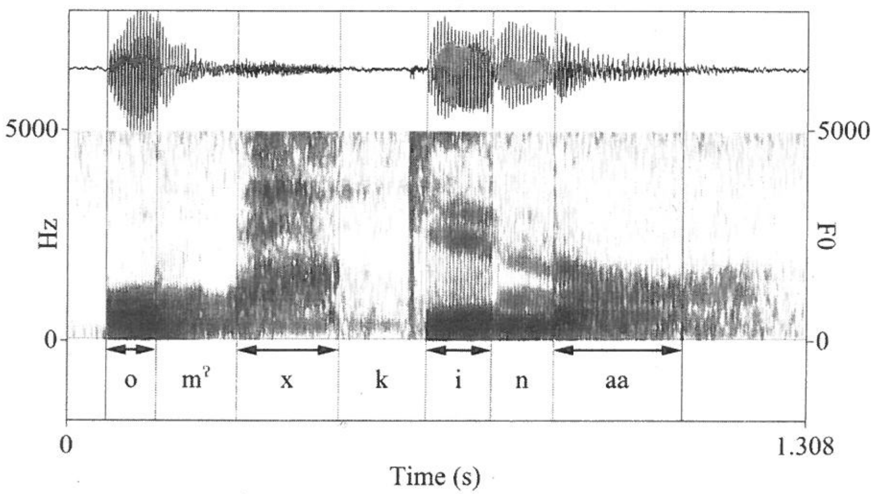


TABLE 2. Vowel durations

vowels	[o]	[x]	[i]	[aa]
ms	138	149	110	304

Turning to a postvocalic coalesced segment, the duration of a coalesced segment with its preceding vowel, V[x], is similar to that of a long vowel. The image in (10) shows a spectrogram of the word /saaxkomaapiiwa/ [saxkʊmaapiiwḁ] 'boy'. As shown in Table 3, the total duration of the coalesced segment with its preceding vowel is 221ms, which is close to the 248ms duration of the long vowel [aa] in the same word. (The duration of the postvocalic [x] is only 143ms.) Again, this durational correspondence is explained by the coalescence analysis that /x/ is fused with the last half of a long vowel, even though the coalesced portion is longer than exactly half of the vowel-plus-coalesced-segment combination.

(10) Spectrogram of /saaxkomaapiiwa/ [saxkʊmaapiiwḁ] 'boy'

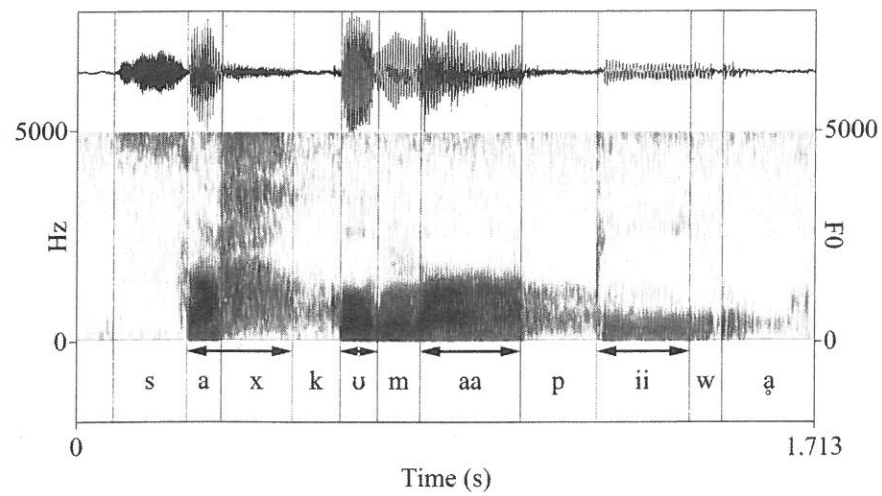


TABLE 3. Vowel durations

vowels	[ax]	[ʊ]	[aa]
ms	221	75	248

Thus, coalescence across morpheme boundaries, the length of preceding vowels, diphthongs, and the duration of coalesced segments all support the idea of a "merger," with /x/ having coalesced with a vowel.

Implications of the Coalescence Analysis

Coalescence Typology

This study is typologically significant. In the phonological literature, the majority of the coalescence examples reported occur between two vowels or two consonants. For example, monophthongization of [ɔ] from /a/ and /o/ in Blackfoot is an occurrence of vowel-vowel coalescence (Frantz 2009). The Kpokolo vowel system also shows a case in which a vowel feature matrix is a result of fusing two separate vowel matrices (Kaye et al. 1985). Odden (1994) shows an example of two vowels that fuse into one syllable in Kikuyu. Bámisilè (1994) reports vowel coalescence in Yoruba. As for consonantal coalescence, Avery and Rice (1989) present fusion as an example of coronal underspecification. Additionally, Indonesian's nasal substitution is shown as an example of coalescence (Pater 1999; Kager 1999).

Examples of coalescence between a vowel and consonant are not uncommon, but they generally involve a consonant that is either nasal or [−consonantal]. The predominant case of vowel-consonant fusion is perhaps the vowel-nasal coalescence observed in French (e.g., Morin 2002) as well as in Choctaw (Lombardi and McCarthy 1991). Examples where the merging segment is [−consonantal] are seen in two other Algonquian languages: Wolfart (1996), for example, describes a contraction in Cree in which interconsonantal [w] followed by [i] or [e] is realized as [o]. Similarly, in Ojibwe [w] and [a] coalesce to [o] (Malone 1997) and [y] and [e] to [ii] (Valentine 2002). In these cases, the merging consonants are glides, which are [−consonantal], and they surface as a vowel with features of the glides. Another example is Capanahua (Elías-Ulloa 2009), in which a vowel and a glottal stop (which is also [−consonantal]) coalesce to form a glottalized vowel. Thus, the vowel-consonant coalescence shown in all these examples is the fusion of two [−consonantal] segments or a vowel and a nasal consonant. Since two nonnasal segments with opposite values of the feature [consonantal] merge in Blackfoot, as described in this paper, the present study adds a rare example to the typology of coalescence.

Mora Analysis

The coalescence analysis can be made with reference to moras (Hayes 1989), giving support to this theoretical unit. In the analysis of postvocalic coalescence, the second mora of a long vowel merges with the following /x/. In the case of interconsonantal coalescence, the entire monomoraic short vowel merges with the following /x/. This moraic analysis is shown in (11).

(11) a. $/V_{\mu0}V_{\mu1}x_2/ \rightarrow [V_{\mu0}x_{\mu1,2}]$ $(V_0 = V_1)$

b. $/V_{\mu1}x_2/ \rightarrow [x_{\mu1,2}]$

Thus, in a mora-based analysis, the dorsal fricative /x/ merges with its immediately preceding mora. This analysis unifies the two environments.

Elfner (2006b) notes that if /x/ is assumed to be moraic, then the shortening of the long vowel before /x/ can be analyzed as an avoidance of a super-heavy syllable. With respect to a short vowel merging with /x/, however, she states that "it is less clear how this process can be accounted for under a moraic analysis" (Elfner 2006b:49) and also discusses the difficulty of analyzing it as underlyingly moraic or as the result of weight-by-position. The coalescence analysis in this paper implies that /x/ does not have an inherent or underlying mora but receives one from the preceding vowel.

Place Feature of /x/

The dorsal fricative consonant underlyingly must occur following a vowel. The surface form of /x/ is always a coalesced segment, and it is either [ç], [x], or [xʷ], underlyingly preceded by [i], [a], or [o], respectively. In other words, the place feature of the phonetic forms of /x/ entirely depends on the preceding underlying vowel. This leads to the possibility that /x/ may be placeless. In fact, Goad and Shimada (2014) propose that this consonant is inherently placeless for three theoretical reasons: it does not pattern with other place-bearing lingual consonants (e.g., it does not occur as an onset); it is always a coda, which cannot license its own place features; and it has the same distribution as /ʔ/, which is generally accepted as placeless. The present study provides additional description that supports the idea of the phoneme being /X/, without a place specification.[9]

Syllabic Consonant or Voiceless Vowel?

The interconsonantal coalesced segments are represented as syllabic consonants in Elfner (2006b): [ç̩], [x̩], and [x̩w]. However, it is worth examining whether interconsonantal coalescence results in a syllabic consonant or a voiceless vowel, as this paper's analysis suggests that segments that are heterogenous with respect to the feature [consonantal] merge together.

Vowel devoicing in Blackfoot is a well-known phenomenon (Frantz 2009; Bliss and Gick 2009). Devoiced vowels are observed only in phrase-final position, as in the examples in (12).

(12) a. *iniiwa* [iniiwḁ] 'buffalo'

b. *apasstaamiinaamma* [apasstamiinaammḁ] 'apple'

c. *aakiikoana* [aakiikoanḁ] 'girl'

The distribution of the devoiced vowels differs from the vowel-consonant coalescence, which occurs phrase-medially, as in (13), and never finally.

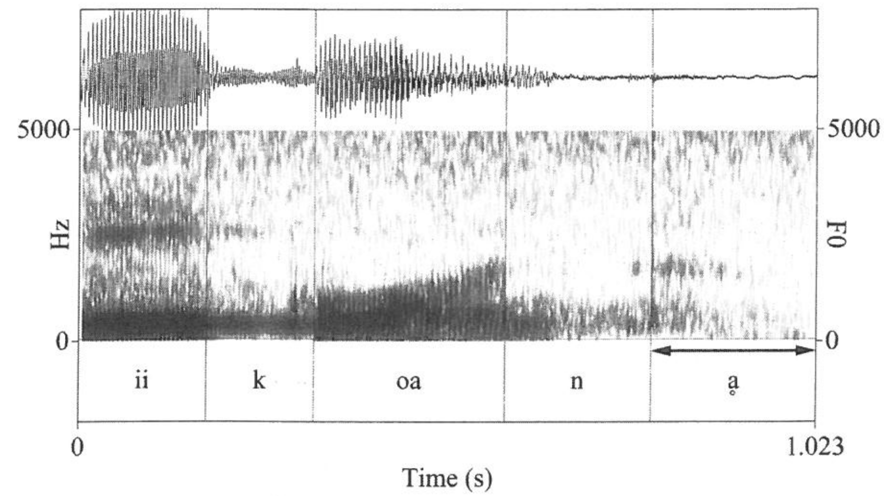
(13) a. *omahkokataa* [omx̩kokataa] 'gopher'

b. *nitaakahkayii* [nitaakx̩kayii] 'I will go home'

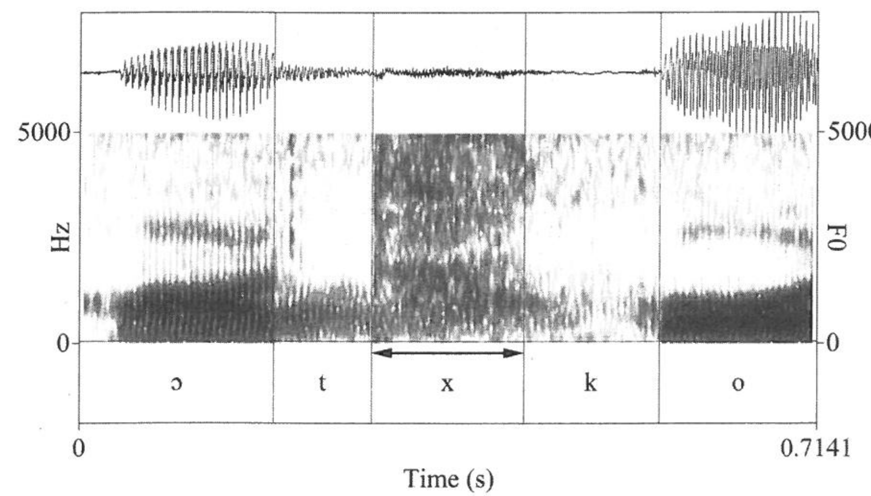
c. *nitssokimmohsi* [nitssokimmx̩ʷsi̥] 'I feel good'

In addition to the fact that the distributions of devoiced vowels and coalesced segments do not pattern together, the noise of the coalesced segments is perceptually and acoustically louder than that of voiceless vowels.[10] Acoustic evidence for this is shown in the spectrograms in (14) and (15). The sound samples are taken from the same source as (9) and (10). The word portion in (14) contains a voiceless vowel at the end, and the noise is hardly detected. On the other hand, (15) contains an interconsonantal coalescence word-medially, and the noise is quite visible as dark scattered prints.

(14) Spectrogram of a voiceless vowel: [iikoanḁ] < *aakiikoana* [aakiikoanḁ] 'girl'



(15) Spectrogram of an interconsonantal coalescence: [ɔtxko] < *aotahkoinamm* 'yellow'



Thus, the coalesced segment shows characteristics that are distinct from voiceless vowels in the language, supporting the idea that the coalesced segment is better analyzed as a consonant.

Further Topics for Research

This study suggests several topics for further research. For example, since the three variants of /x/ are distinct in the case of interconsonantal coalescence, there must be vowel features retained from the underlying vowel. The retaining vowel features in coalescence may be [+high] for [ç], [+back] for [x̩], and [+back] and [+round] for [x̩ʷ]. Also, according to the universal sonority scale, fricatives are lower than nasals in sonority, and this is true in Blackfoot (Elfner 2005). If the dorsal fricatives can be syllabic, this presents a typologically interesting instance because nasals in Blackfoot do not occur as syllabic. Thus, implicational universals regarding syllabic sonorants and fricatives would need to be revisited. Additionally, this may suggest that sonority may not be the only measure for syllabification (cf. Clements 1992).

Conclusion

The three variations of the dorsal fricative in Blackfoot occur interconsonantally and postvocalically. They never surface after a long vowel, as other consonants do. The variants are examples of V-C coalescence, which is typologically rare. This coalescence analysis offers an explanation for the peculiarity of the dorsal fricatives. It also leads to other interesting phonological questions regarding, for example, moras, segment status, and syllabicity. Further research is needed.

NOTES

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2. The symbol <a> is used instead of <ɑ> for the low vowel to be consistent with the orthography, as this is not a main concern of the analysis.

3. The sound in question, /x/, is represented as h in the orthography. The same symbol represents a glottal fricative. The glottal fricative /h/ is excluded here because it only occurs in discourse markers such as *hannia* 'really?', *hoaa* 'wow!', etc., and seems to occur as a word-initial onset filler for these exclamation words. Also, the initial sounds of these words are often very close to onsetless (Donald Frantz, personal communication 2015). For this reason, I hesitate to include /h/ in the set of legitimate phonemes.
4. Abbreviations: DUR = durative, PL = plural, SG = singular, INVS = invisible post-inflectional suffix, ANIM = animate, INAN = inanimative, PST = past, FUT = future, NONAFF = nonaffirmative, REFL = reflexive, IMP = imperative.
5. Note that the forms given in the dictionary (Frantz and Russell 1995) for (1d–e) are slightly different from the forms produced by the consultant, of which expected forms based on the dictionary are [nitsíímaniçpinnaan] and [nitsíímiçkaxpinnaan], respectively.
6. Note that *naaáhs* 'my grandparent' is not an example of VV+/x/. Instead, this is an example of vowel hiatus. This is evident from the location of accent: the first vowel is long, immediately followed by an accented vowel, [na:.áxs]. I do not discuss Vx when the vowel is short but accented.
7. General vowel shortening may be a phonetic phenomenon rather than phonological. Further investigation is necessary regarding this topic.
8. [aj] is also documented as a dialectal variation found in North Piegan. It is [ej] in other Blackfoot-speaking bands.
9. Goad and Shimada (2014) represents the sound as /h/, without specifying a gestural feature, which may imply that it is a glottal sound. The traditional and impressionistic view, however, is that its phoneme is a velar fricative /x/ (Frantz 2009; Elfner 2006b). My analysis still holds the traditional view that this sound is a dorsal fricative, with the difference that there is no underlying place feature.
10. There is also a phonetic difference. Bliss and Gick (2009) report their finding that Blackfoot devoiced vowels are articulatorily present but acoustically null and posit an interaction between an articulatory speech sound and morphosyntactic distinction strategy. In my own experience working with several native speakers of Blackfoot, I observed similar articulatorily positive but soundless vowel production as well as vowels that were fully voiced, aspirated, and completely deleted (with and without the gestures). However, it is unknown whether these phonetic variations are conditioned.

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