INTRODUCTION

This paper treats Blackfoot (Siksiká), an Algonquian language spoken in Southern Alberta and in Northwestern Montana. The phonology of this language has not been widely investigated and it is poorly understood. Even the phonemic inventory is still disputed. However, it is assumed that the language has three distinctive vowels, each of which may occur as short or long, or in three types of diphthongs, as shown in 1.

(1) Blackfoot Vowels

Underlying:               Surface phonetics:

Short
/i/        [i] [i]
/o/        [o] [o] [u] [u]
/a/        [a] [a]

Long
/ii/       [ii]
/oo/       [oo] [uu]
/aa/       [aa]

Diphthongs
/ai/       [ai] [e] [æ] [ei] [ee] [ææ]
/ao/       [ao] [au]
/oi/       [oi]

As far as I know, no complete phonemic inventory of Blackfoot consonants is available in the literature. Frantz (1978, 1991) proposes an orthography for Blackfoot based on the identification of contrastive units. Assuming that these units correspond to phonemes, we can interpret Frantz
as proposing the following phonemic inventory of twelve consonants:

(2) Blackfoot Consonants (Frantz 1978, 1991)

<table>
<thead>
<tr>
<th></th>
<th>Labial</th>
<th>Alveolar</th>
<th>Palatal</th>
<th>Velar</th>
<th>Glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stops</td>
<td>p</td>
<td>t</td>
<td></td>
<td>k</td>
<td>?\dagger</td>
</tr>
<tr>
<td>Affricates</td>
<td></td>
<td>t\textsuperscript{s}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fricatives</td>
<td>s</td>
<td></td>
<td></td>
<td>x</td>
<td>h\dagger</td>
</tr>
<tr>
<td>Nasals</td>
<td>m</td>
<td>n</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glides</td>
<td>w</td>
<td></td>
<td></td>
<td></td>
<td>j</td>
</tr>
</tbody>
</table>

\dagger [?] is represented as in the orthography.

\dagger The distribution of [h] is restricted. It only occurs at the start of a few interjections.

Since Frantz represents the velar fricative [x] as [h] and the velar stop [k] as [k] in the orthography, these two segments seem to be different phonemes. It is also supposed in 2 that the language has only one multiply-articulated segment /t\textsuperscript{s}/, which must be classified as an affricate. Thus, sequences of [k] and [s] have been analyzed as involving the phoneme /k/ followed by the independent phoneme /s/. However, as I will show, these assumptions are problematic. I argue that [x] and [k] are variants of a single phoneme /k/, while [ks] is a single multiply-articulated segment /k\textsuperscript{s}/. The proposed phonemic inventory of Blackfoot consonants is presented in 3.

(3) Proposed Blackfoot Consonant Phonemic Inventory

<table>
<thead>
<tr>
<th></th>
<th>Labial</th>
<th>Alveolar</th>
<th>Palatal</th>
<th>Velar</th>
<th>Glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain Stops</td>
<td>p</td>
<td>t</td>
<td></td>
<td>k</td>
<td>?</td>
</tr>
<tr>
<td>Strident Stops</td>
<td>p\textsuperscript{s}</td>
<td>t\textsuperscript{s}</td>
<td></td>
<td>k\textsuperscript{s}</td>
<td></td>
</tr>
<tr>
<td>Fricatives</td>
<td>s</td>
<td></td>
<td></td>
<td></td>
<td>h</td>
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<td>j</td>
</tr>
</tbody>
</table>

VELAR SPIRANTIZATION

The distribution of [x] and [k] is interesting. [x] occurs only in post-vocalic position (Frantz 1991) and is always followed by another obstruent (4a). On the other hand, [k] occurs pre-vocalically (4b). Post-vocalically, [k] occurs either before [s] (4c) or word-finally (4d). Word-final position is the only position in which a single [k] can occur as a coda, while no word-final [x] is attested. Another difference is that [k] can be a geminate while [x] cannot (4e).
(4) Distribution of [k] and [x]²

a. [in.nóx.so.jis] innóhsoyis ‘spoon’
   [óx.po.ta] óhpota ‘it’s raining’

b. [ki.t‘im] kitsim ‘door’
   [síí k‘án] si‘kán ‘blanket’

c. [so.pú.ksi] sopóksi ‘dollar’
   [pi.ksi.tsíi.na] píksiiksíina ‘snake’

d. [is.so.x.t‘ík] issohtsík ‘future’
   [is.skóx.t‘ík] issóihtsík ‘past’ (B)

e. [ni.ták.kaa] nitákkaa ‘my friend’ (B)
   [pák.kiip] pákkiip ‘choke cherry’

These distributional facts suggest that [x] and [k] are in complementary
distribution if we assume that [k] and [ks] have a different character. Thus,
I propose that [k] and [x] are allophones, and [ks] is a single multiply-arti­
culated segment, /k/. Velar stop [k] spirantizes post-vocalically, preceding
an obstruent, except word-finally. It becomes [x] after /a/ and /o/ while it
alternates to [c] after /i/. The examples are shown in 5.

(5) Velar Spirantization

a. x [nií.tax.taann] niíhtaann ‘river’ (B)
   [mox.pi.kin] mobpiikin ‘tooth’

b. ç [meig.stúu] maihstóó ‘crow’ (B)

Here, I analyze this problem by two different approaches: syllable-
based analysis and phonetic-based analysis. The Blackfoot velar spirantiza­
tion seems to be sensitive to syllable structure in that this alternation can
be expressed as follows: the velar stop [k] spirantizes in coda position,
except word-finally. Adopting Feature licensing constraint proposed by
Lombardi (1991), the Blackfoot velar spirantization is formalized as in 6.
6a states a positive licensing constraint which should be read as follows:
the feature [+continuant] is only licensed in coda position. 6b is a negative
constraint which should be read as follows: the feature [-continuant] may
not be licensed in coda position. However, this syllable-based analysis has

² The data in this paper are elicited from native speakers of Blackfoot. They are
presented in IPA and in the Blackfoot orthography. In the orthography, [x] is
described as h, and [?]is as . As for vowels, broad phonetic transcription is adopted,
since the allophonic differences do not seem to be relevant to the analysis. The
designation A or B is given when the speakers gave me different forms for the same
words (A = Speaker A, B = Speaker B). Unmarked forms are those provided by both
speakers. A dot between segments represents a syllable break.
VELAR SPIRANTIZATION AND VELAR PHONEMES

a crucial problem. It cannot distinguish word-final codas with non word-final codas. Thus, it is not satisfactory enough.

(6) Feature licensing constraints (cf. Lombardi 1991)

\[
\begin{array}{c|cc}
\text{a. Positive } \sigma & \text{b. Negative } * \sigma \\
\hline
[+\text{cont}] & \text{root node} & [-\text{cont}] \\
0 & \text{place node} & 0
\end{array}
\]

[\text{[DOR]} \quad \text{[DOR]}]

Reading:

[+\text{continuant}] is only licensed
in coda position.

[-\text{continuant}] may not be
licensed in coda position.

On the other hand, phonetic-based analysis gives us a better solution. In this analysis, the phonetic components interpret phonological representations. Steriade (1991a, 1991b) suggests that closure/release portions of consonants be represented geometrically by aperture portions within the feature geometry:

The values of aperture

\begin{align*}
A_0 & \text{ (full closure)} = [-\text{cont}] \\
A_f & \text{ (frication)} = [+\text{cont}, -\text{son}] \\
A_{\text{max}} & \text{ (maximal aperture)} = [+\text{cont}, +\text{son}]
\end{align*}

(a) unreleased stop \quad (b) (released) stop \quad (c) fricative

\[
\begin{array}{c|c|c|c|c}
0 & 0 & 0 & \text{root node} \\
A_0 & A_0 & A_{\text{max}} & A_f
\end{array}
\]

Steriade recognizes three kinds of aperture nodes and characterizes them by the appropriate feature values. In 7, stops are divided into unreleased ones and released ones. An unreleased stop consists of $A_0$, which means a total absence of airflow. A released stop consists of $A_0$ followed by $A_{\text{max}}$, which is a maximally open release. A fricative consists of $A_f$, which is a release sufficient to produce a turbulent airstream.

Cross-linguistically, feature contrast is often preserved in word-final position but it is neutralized in other coda positions. For example, the voicing contrast is frequently preserved word-finally, but not before obstruents. One of the phonetic explanations is that word-final stops are more likely to be audibly released than stops in word-internal stop-obstruent
clusters (Steriade 1997:43). There is nothing impeding or masking audible release. In the model proposed by Steriade (1991), these stops are represented by different structures; word-final stops are represented by 7b while stops in word-internal stop-obstruent clusters are represented by 7a.

In Blackfoot velar spirantization, it is analyzed that the contrast of continuancy is preserved word-finally, but not before obstruents. Applying Steriade (1997) to the Blackfoot case, word-internal /k/ is assumed to be an unreleased stop. It becomes a fricative counterpart [x] which is released. On the other hand, word-final /k/ does not spirantize. It is important to note that released stops and fricatives have [+cont] in common. The word-final /k/ is as continuant as the fricative. Therefore, it does not have to spirantize to [x].

However, this analysis has a potential problem: Blackfoot stops might be released in word-internal post-vocalic position. Bortolin and McLennan (1995:1) describe the Blackfoot stops as unaspirated but released except those marked. Since they do not show the acoustic analysis, it is not clear whether or not the Blackfoot stops are really released. Further research is required for this point.

**STRIDENT STOP /kʰ/**

Thus, [k] cannot occur before any obstruent. However, it occurs before [s]. This implies that [ks] sequence has a different organization; considering [ks] to be a single segment puts [k] and [x] in complementary distribution. I propose that [ks] is a single multiply-articulated segment /kʰ/. The claim that Blackfoot has a series of multiply-articulated segments — what I call 'strident stops', i.e. /pʰ/, /tʰ/, and /kʰ/ — will be supported by the following arguments.

(8) Blackfoot Syllable Template
The first evidence is related to the Blackfoot syllable structure. The proposed template in 8 is based on the types of attested syllables shown in 9. In Blackfoot, syllables do not necessarily have an onset (9a). If they do, it may be composed of up to two consonantal segments (9b). Within a nucleus, both short and long vowels are allowed (9c). Long vowels do not have to be geminates; they can be diphthongs (9d). Blackfoot is able to have closed syllables, in which the maximum coda is limited to two consonants word-internally, but it may be three word-finally (9e).

(9) Blackfoot Syllable Types

a. Syllable without Onset

V    [u.kü.wan]  okóan  ‘house’
VV   [ii.níí]    iinií ‘buffalo’

b. Syllable with Onset

CV   [ná.pi]    napi  ‘friend’
CCV  [ski.nis.taam]  skinistaan ‘pocket’

C. Single Nucleus and Complex Nuclei

VC  [it.to.wán]  ittoán ‘knife’ (A)
CVV [náá.pi]    náápi ‘old man/trickster’

d. Diphthongs

VV  [éi.ta.ku]  áitako ‘last night’ (A)
[kái.skaax.pá]  káiskaahpa ‘porcupine’ (B)

e. Closed Syllables

CVC [po.kón]  pokón ‘ball’
CVCC [kuʔs]   ko’s ‘dish’ (A)

It is important to note that /kʰ/ is involved in words which appear to contain more than two segments in onset and coda, as shown in 10.

(10) a. [i.nák’té.si]  ináktssi ‘young’ (A)
    b. [nii.téik’skis.tumí]  nütsikssiksístimí ‘I have a healthy body’ (B)

The maximum numbers of onsets and codas may be up to three segments if [ks] is a consonant cluster. The proposal that [ks] is a single segment reduces the maximum onset and coda to the independently motivated two consonants.

In addition to the two multiply-articulated segments, i.e. /tʰ/ and /kʰ/, /pʰ/ is also found in Blackfoot, as given in 11. A multiply-articulated segment /pʰ/ fills a gap in the inventory of Blackfoot consonants: Three kinds of plain stops /p/, /t/, and /k/ correspond to three kinds of multiply-articulated segments, /pʰ/, /tʰ/, and /kʰ/ respectively. This is the third support.
The example in (11), oâ’psp [o.wâ’p’s’p] ‘eye’ has three consonants in word-final coda position, even though we count [ps] as one segment. The word-final syllable does not satisfy the template in 8; it contains one extra coda consonant. Such exceptional segments are observed in a variety of languages only at the edge of the syllabification domain and analyzed as extrasyllabic in that they are invisible to the rules of syllabification. I claim that in Blackfoot, extrasyllabic takes effect on the word-final position. Cross-linguistic generalizations show that if a language allows clusters of \( n \) consonants word-finally, then the clusters of \( n-1 \) consonants are also possible word-internally (Blevins 1995:217). This generalization implies that only one consonant can be extrasyllabic. Unless /p’s/ is construed as one segment, Blackfoot would be an exceptional language in that it could bear more than one extrasyllabic consonant.

Additional support for treating stops followed by /s/ as complex segments comes from the syllabification judgements of my language consultants: they never separate these complex segments in word-internal positions, while other consonant clusters are split into two different syllables.

Multiply-articulated segments, especially /p’s/ and /k’s/, are controversial in the standard feature geometry model (e.g. the Halle-Sagey model and the Clements-Hume model, see Kenstowicz 1994:452 and Clements and Hume 1995:292). Multiply-articulated segments are generally classified into contour segments and complex segments (Sagey 1986). A contour segment is a segment containing sequences (or contours) of articulations. It may branch for terminal features only. No branching class nodes are allowed (Sagey 1986:50). Affricates and prenasalized stops are often regarded as contour segments. The representation of an affricate [tʰ] is given in (12).

(12) Representation of affricate [tʰ]

\[
[\text{[tʰ]}]
\]

\[
\text{[cont]}
\]

\[
\text{[i cont]}
\]

\[
\text{Place}
\]

\[
[\text{[COR]}
\]
A complex segment, on the other hand, is a segment characterized by at least two different oral articulator features, representing a segment with two or more simultaneous oral tract constrictions. These articulators are phonologically unordered even where phonetically they may be (or seem to be) ordered. The labiovelar stop [kp], found in many West African languages, is an example of a complex segment, and behaves phonologically as both labial and velar with respect to processes both on the left and on the right. The representation of a complex segment [kp] is given in 13.

(13) Representation of labiovelar stop [kp]

\[
\begin{array}{c}
[kp] \\
\text{Root} \\
\text{Place} \\
\phantom{[kp]} \phantom{\text{Root}} \\
\phantom{[kp]} \phantom{\text{Root}} \phantom{[LAB]} \phantom{[DOR]} \\
\end{array}
\]

Given that strident stops are a sequence of a stop plus a fricative, they look like affricates. However, it is impossible to represent them by means of a feature geometry in 12 because [p^s] and [k^s] are not homorganic. A representation in 13 is incomplete for them. They are characterized by two different oral articulators, [LAB] and [COR] for [p^s], and [DOR] and [COR] for [k^s], but the articulators do not share the same continuancy. The feature [continuant] is directly dominated by the root node, so, it is natural that the articulations share the same continuancy.

(14) Representation of strident stops in the Padgett model

a. \[p^s\] 
\[
\begin{array}{c}
\text{Root} \\
\text{Place} \\
\phantom{[p^s]} \\
\phantom{[p^s]} \phantom{[LAB]} \phantom{[COR]} \\
\end{array}
\]

b. \[k^s\] 
\[
\begin{array}{c}
\text{Root} \\
\text{Place} \\
\phantom{[k^s]} \\
\phantom{[k^s]} \phantom{[LAB]} \phantom{[DOR]} \\
\end{array}
\]

Padgett (1991) claims that [cont] is located under the articulators. Examining the unusual segments of Kabardian, known as ‘harmonic clusters’, he argues that they are in fact complex segments which require independent
underlying [cont] values for the articulators. Padgett's model succeeds in representing the strident stops in Blackfoot. However, it is not restrictive enough to exclude a complex segment like \([k^s]\) which is assumed not to exist in natural languages. Since any articulator can bear the feature [cont] individually, his feature geometry incorrectly predicts that representations like 15 should be possible.

(15)  
* \([k^s]\)  
Root  
|  
Place  
|  
[LAB] [DOR]  
|  
[+cont] [-cont]

On the other hand, Shaw (1991) and LaCharité (1993) claim that the feature [strident] is located under the coronal articulator. The feature [strident] has been used to define fricatives and affricates. Thus, it is plausible to propose that this feature is linked under the [COR] node, so that it is restricted to coronal.

(16) Representation of strident stops in the Shaw/LaCharité model

\[
\begin{array}{ccc}
[p^s] & [t^s] & [k^s] \\
\text{Root} & \text{Root} & \text{Root} \\
\text{Place} & \text{Place} & \text{Place} \\
[+strident] & [+strident] & [+strident] \\
\end{array}
\]

The model with the [strident] feature is more restrictive than the model proposed by Padgett in that it correctly excludes a complex segment such as \([k^s]\).

(17)  
* \([k^s]\)  
Root  
|  
Place  
|  
[LAB] [DOR]  
|  
[+strident]
CONCLUSIONS

In this paper, I have discussed the inventory of velar phonemes in Blackfoot. From the orthography, the language has been assumed to have two velar phonemes [k] and [x]. However, I propose that these two sounds are allophones, and they are both the stop in underlying representations, i.e. [k] spirantizes to [x]. I have analyzed this alternation from two different approaches, a syllable-based one and a phonetics-based one. Syllable-based analysis is problematic in that it cannot distinguish word-internal codas and word-final codas although they show different properties. Instead, phonetics-based analysis gave us a reasonable account.

I have also claimed that Blackfoot has a velar strident stop [ks]. This claim is supported by not only the distributional facts, but also the syllable structure. Although the featural representation is controversial, it can be accounted for by adopting Shaw (1991) and LaCharité (1993) who claim that [strident] is located under [COR].

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