UNIVERSITY OF CALGARY

The Mora in Blackfoot

by

Emily Jane Elfner

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF ARTS

DEPARTMENT OF LINGUISTICS

CALGARY, ALBERTA

AUGUST, 2006

Abstract

Blackfoot is an Algonquian language spoken in southern Alberta and northwestern Montana. While the language has seen a fair amount of descriptive work (e.g. Frantz 1991), very little has been devoted to studying its phonological system. This thesis represents a preliminary systematic analysis of several topics relating to the phonotactics of the language. Particular attention is paid to the role of contrastive weight in shaping both the consonant system and the vowel system. It is shown that the assumption of underlyingly specified moraic associations is key to understanding the phonotactics of the language, as in the distribution of certain segments, the syllabification of the language's typologically unusual preconsonantal geminates, and in predicting the correct resolution strategy for vowel hiatus. Of particular interest to phonological theory is the role of contrastive weight in producing contrastive syllabification patterns, and an Optimality Theoretic analysis of Blackfoot's complicated vowel hiatus resolution system.

Acknowledgements

There are many people who have contributed to this thesis in many different ways.

First of all, I'd like to offer my thanks to Rachel Ermineskin, a native speaker of Siksika Blackfoot, for taking the time to teach me about her language, and for allowing me to record her speech.

My greatest debt is to my supervisor, Darin Howe, for his patience, encouragement, and enthusiasm throughout all the years I've known him, and especially during the writing of this thesis. He deserves a lot of credit not only for introducing me to Blackfoot but also for all that he's taught me about phonological theory—starting with my very first phonology class as an undergrad.

I'd also like to thank my thesis committee, John Archibald and Douglas Walker, for taking the time to read my thesis and for all of their helpful comments. Thanks also to Amanda Pounder for serving as the neutral chair during my defense, and to Suzanne Curtin, for being willing to help out during the confusion that came with trying to schedule a defense during the summer months.

Great thanks to all of the other professors in the Linguistics Department at the University of Calgary who introduced me to linguistics and whose friendly and supportive atmosphere have made the department a great place to study—these include Betsy Ritter, Robert Murray, Michael Dobrovolsky, Martha McGinnis, Hotze Rullmann, Kimiko Nakanishi, and Susanne Carroll.

Thanks to all of the students in the department for making my time here enjoyable, and for contributing to this thesis both directly and indirectly. I'd especially like to thank my classmates—Kyumin Kim, Rachel Klippenstein, Masako Shimada, and Wing Yee So—as well as other students I've had the honour of knowing—Karen Jesney, Corey Telfer, Heather Bliss, Elham Rohany Rahbar, Ilana Mezhevich, Fumiko Summerell, Ashley Burnett, Antonio Gonzalez-Poot, Christine Shea, Aili You, and Mahdi Ahmadi.

I'm also grateful for the support of many people outside of the department—especially those who have only the vaguest notion of what I am actually studying but have taken the time to ask questions and listen to my attempts to explain it. Great thanks to my parents for supporting my decision to study linguistics; to my sister, Alison, for being the first non-linguist among my friends and family to take a linguistics class and for being a welcome distraction; and to my grandparents, Uncle Allen, my extended family, and all of my non-linguist friends for their interest and support.

Finally, I'd like to acknowledge that this thesis has been generously supported by grants from the Social Sciences and Humanities Research Council of Canada, including a CGS Masters scholarship.

Table of Contents

List of Figures and Illustrations

List of Abbreviations

Symbol	Definition
1SG	1st person singular
3SG	3rd person singular
AN.S	animate singular
DUR	durative
IMP	imperative
INST	instrumental
INV	inverse
PAST	past tense
REFL	reflexive

Chapter One: Introduction

While Blackfoot phonology has received some attention as the subject of descriptive study (e.g. Taylor 1969; Frantz 1978, 1991), very little work has focussed exclusively on the language's phonological system. Some contemporary work has dealt with the accentual system (e.g. Kaneko 1999, Van Der Mark 2003, Stacy 2004); however, with the exception of Frantz' comprehensive work on the phonemic system and orthography design (Frantz 1978), very little attention has been paid to other aspects of the phonology. This thesis treats a variety of topics related to phonotactics, syllable structure and syllable weight, and represents the first systematic investigation of its kind in Blackfoot. It is hoped that the research, both descriptive and theoretical, will help to lay the groundwork for future study of the language. This work therefore serves first and foremost as an important step toward developing an understanding of the Blackfoot phonological system.

This thesis provides a preliminary study of Blackfoot phonotactics, with a particular emphasis on the role of the mora: many of the phonotactic patterns discussed here crucially depend on the assumption that segment weight, formally represented as moraic affiliation, can be specified underlyingly. The goal of this thesis is not to provide a comprehensive overview of the Blackfoot phonological system; rather, detailed analyses of specific phenomena are offered which serve to illustrate the role of contrastive weight in the language's phonology. Of particular interest to phonological theory are the discussion of the typologically unusual preconsonantal geminates and contrastive syllabification (chapter 5) and a comprehensive analysis of vowel hiatus resolution patterns, where it is shown that the many apparently conflicting strategies utilised by Blackfoot speakers are well-motivated phonologically (chapter 6).

While united by the common goal of illustrating the role of underlying moraic contrasts, the body of this thesis (chapters 4, 5, and 6) may be divided into two sections that can be viewed as independent and disparate analyses: chapters 4 and 5 treat consonant weight, while chapter 6 treats vowel hiatus. This being said, it is hoped that the thesis taken together as a whole will provide a valuable step toward a unified analysis of Blackfoot phonotactics, and a better understanding of Blackfoot phonology in general.

Chapters 2 and 3 are intended to provide the reader with enough background to contextualise the analyses presented in the body of the thesis. Chapter 2 provides background on the language, situating it historically, geographically, and sociolinguistically, as well as providing brief discussions of such linguistic issues as dialectal variation, phoneme inventory, abstractness in the vowel system, prominence, the polysynthetic nature of the language, and the orthographic system. Chapter 3 introduces the concept of syllable weight and the theories assumed in this thesis. The chapter discusses syllable weight, its basis in phonetics, its relationship to sonority and the syllable, and its formal representation (including discussion of skeletal slot models and the moraic model). Also introduced is Optimality Theory (OT), the theoretical framework assumed in this thesis.

Chapters 4 and 5 analyse several issues related to consonant weight in Blackfoot. Chapter 4 provides an initial overview of consonant weight in the language. First, intervocalic geminates are discussed, including their representation under moraic theory, the motivation of the representation under OT, and the historical development of contrastive consonant weight in the language. This is followed by an examination of the restricted distribution and moraic status of /x/ and /ʔ/, two consonants which are exceptional in Blackfoot by their lack of contrastive length.

Chapter 5 discusses the syllabification and moraic representation of preconsonantal geminates. It is shown that these length contrasts are best analysed on the surface as contrasts in syllabification, where it is argued that Blackfoot fills a typological gap with respect to predictions inherent in moraic theory. However, it is proposed that these syllabification contrasts arise from underlying weight contrasts, and therefore do not require syllabification to be contrastive. Also discussed are the various pieces of evidence supporting the proposed analysis, including weight neutralisation for preconsonantal nasals. The chapter closes with a discussion of the theoretical and typological implications of the syllabification/weight contrasts in Blackfoot, including a discussion of similar issues in Swedish and English.

Chapter 6 turns away from the discussion of consonant weight, and examines the various strategies for vowel hiatus resolution found in Blackfoot, where the language exemplifies many of the possible strategies found crosslinguistically. The comprehensive OT analysis developed in this chapter argues that even a complicated vowel system as found in Blackfoot, apparently riddled with exceptions, is, in fact, well motivated phonologically. The chapter begins by discussing the representation of vowels under optimality theory, and introduces vowel hiatus resolution as a problem of syllabification and mora preservation. The constraint *HIATUS is proposed, including a discussion of its relationship to ONSET, the constraint traditionally evoked in analyses of hiatus resolution. The body of the chapter is divided into two sections. The first examines coalescence, the preferred strategy for vowel sequences of decreasing sonority, and motivates exceptions with reference to constraint ranking. The second section examines rising diphthongs, which arise from underlying vowel sequences increasing in sonority. Exceptions are similarly accounted for using OT constraints, and the system as a whole is also discussed.

Chapter 7 concludes the thesis, reviewing the findings of the analyses and identifying topics relevant for future research.

Chapter Two: Language Overview

This chapter provides an overview of the Blackfoot language, touching on a number of issues. The goal of this chapter is to provide the reader with information relating to the historical and sociolinguistic status of the language, as well as an introduction to several grammatical issues.

2.1 Genetic Affiliation

Blackfoot is the westernmost member of the Algonquian language family. Languages in this family are spoken across Canada from Labrador to British Columbia, and in the United States as far south as North Carolina (Mithun 1999). Two distantly related languages, Wiyot and Yurok, are spoken in California, and form with Algonquian the larger Algic family. The map in Figure 1 illustrates the wide area covered by languages of this family:

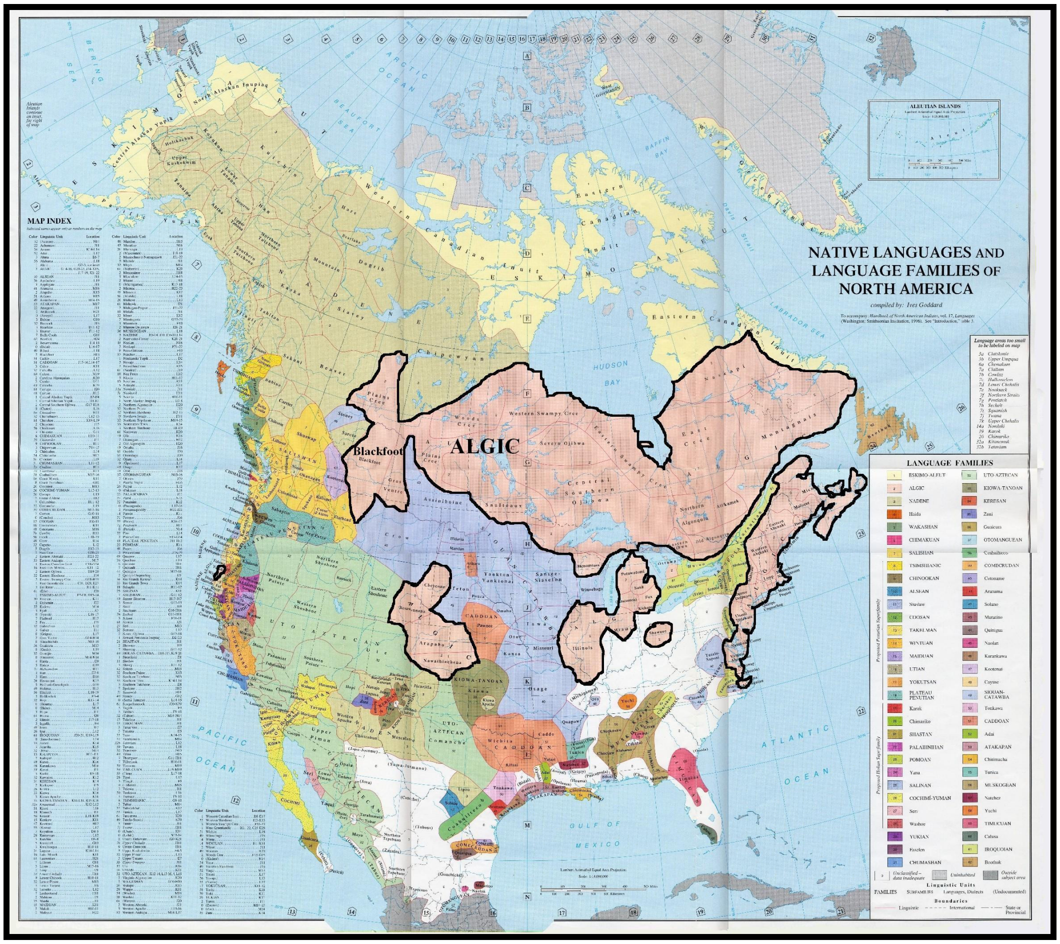


Figure 1. Map showing geographic distribution of Algic languages

(Source: Goddard 1996)

Within Algonquian, only one genetic subgrouping has been identified: Eastern Algonquian contains several languages that were and are spoken in eastern Canada and the eastern United States. Other subgroupings—Central Algonquian and Plains Algonquian, of which Blackfoot is a member—are geographical rather than genetic; the languages in these groupings are not more closely related to each other than to the members of other groups, and shared innovations are said to be the result of contact (Mithun 1999). The following chart shows the Algic family tree (Mithun 1999:327):

(1) ALGIC FAMILY

ALGONQUIAN

EASTERN ALGONQUIAN

Micmac, Maliseet-Passamaquody, Etchemin, Eastern Abenaki, Western Abenaki, Loup A, Loup B, Massachusett, Narragansett, Mohegan-Pequot, Quiripi, Mahican, Munsee, Unami, Nanticoke, Powhatan, Pamlico

CENTRAL ALGONQUIAN

Shawnee
Fox
Miami-Illinois
Potawatomi
Ojibwa
Cree
Menominee

PLAINS ALGONQUIAN

Cheyenne
Arapaho-Atsina
Blackfoot

RITWAN

Wiyot, Yurok

Blackfoot is also the most divergent language. Goddard (1974:601) writes, for example:

> To an Algonquianist it is simply astounding that a language with so many familiar Algonquian traits can also have so many that appear utterly peculiar and un-Algonquian (and so few clear-cut cognates). Blackfoot is unquestionably the most different of all the Algonquian languages.

The Plains languages are exceptionally innovative phonologically, and Blackfoot is particularly so. Blackfoot, as the westernmost Algonquian language,[1] is thought to have

[1] Excepting the more distantly-related Ritwan languages spoken in California.

been the first language to break off as Algonquian speakers moved east (Proulx 1989, Goddard 1994), thus avoiding many of the shared linguistic innovations of its closest relatives. Blackfoot's own set of linguistic changes served to further obscure its relationship to other Algonquian languages, and produced its rather unique grammar.

2.2 Sociolinguistic Status

2.2.1 Location

Blackfoot is spoken on the prairies east of the Rocky Mountains in southern Alberta and northwestern Montana. Traditionally, the Blackfoot tribe has been made up of four bands: the Siksiká (Blackfoot), the Aapátohsipikani (North Piikani), the Kainai (Blood), and the Aamsskáápipikani (South Piikani). Today, the majority of speakers live on the four reserves and reservations corresponding to the original bands. Three are located in southern Alberta: the Siksika Reserve near Gleichen (approximately a hundred kilometres east-southeast of Calgary), the Piikani Reserve at Brocket, west of Fort MacLeod, and the Blood Reserve, north of Cardston and south-west of Lethbridge. The South Piikani (sometimes Pikuni) or Blackfeet of Montana occupy an area east of Glacier National Park in northwestern Montana. The map below shows the locations of the four groups:

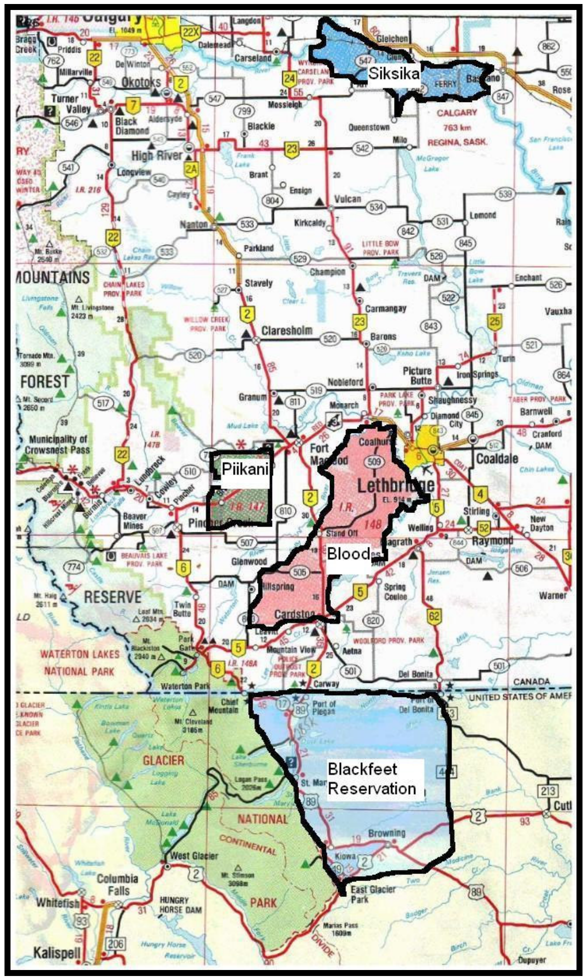


Figure 2. Current Distribution of Blackfoot Reserves and Reservations

(source: http://people.uleth.ca/~frantz/blkft.html)

2.2.2 Status

The leading Blackfoot language specialist, Donald Frantz (n.d.), estimates that in the mid-1990's there were between 5000 and 8000 speakers of Blackfoot, broken up as follows:

- under 100 in Montana
- ⅓ to ½ of 6000 ethnic Siksika
- ⅓ to ½ of 7500 ethnic Kainai
- ¼ to ½ of 4500 ethnic Piikani

Like many indigenous languages spoken in North America, Blackfoot's status is fragile. While some children are being taught Blackfoot alongside English, few, if any, are now learning Blackfoot as a first language (Frantz n.d.). However, Blackfoot language programs are being developed and implemented in schools at various levels. Notably, fulltime Blackfoot immersion for children aged five to twelve is offered by the Piegan Institute on the Blackfeet Reservation.[2]

2.2.3 Dialectal Variation

Blackfoot is spoken in four dialects, corresponding to the geographical/political divisions described above. They are mutually intelligible and the differences among the dialects do not present a barrier to communication. However, while there is sufficient variation to set up the dialect divisions on linguistic as well as political grounds, there is as much variation within dialects as between them (Frantz n.d.).

---

[2]The Piegan Institute's website is available at: www.pieganinstitute.org

Dialectal variation can be found in a number of areas. Lexically, differences are most prevalent in different words for recent lexical acquisitions, both where a single word can have a different meaning in different dialects (e.g. *pikkiáákssi* is 'porridge' on the Blood reserve, but 'ground beef' on the Piikani reserve) and where different words are used to denote the same word (e.g. the word for 'tea' is *áísoyoopoksiikimi* to the Blackfeet of Montana and *siksikimí* to the Canadian reserves). Grammatically, differences are also fairly minor: for example, dialects vary in terms of gender specifications for certain nouns. Phonological variation is found, for example, in the generalisation of certain processes (e.g. /ix/ assibilation, see 4.1.3).

2.3 Linguistic Structure and Representation

This section provides a brief introduction to the language, with the goal of familiarising the reader with the linguistic information necessary to understand the analyses presented in this thesis. For a more complete descriptive overview of the language, see Frantz (1991).

2.3.1 Phoneme Inventory

Blackfoot has a relatively small phoneme inventory, containing only twelve consonants (including glides), and three vowels. Blackfoot lacks voicing or aspiration contrasts; all of its obstruents are voiceless with little or no aspiration, and all of its sonorants are voiced. Liquids are completely absent in Blackfoot as in its relative Plains

Cree, even though Proto-Algonquian reportedly had at least one liquid.[3] As will be a major focal point in this thesis, contrastive length plays a large role in the language, and expands the otherwise small phoneme inventory. The complete phoneme inventory is given below:

(2) Blackfoot Phoneme Inventory

	Labial	Coronal	Dorsal	Glottal
Stops	p pː	t tː	k kː	ʔ
Fricatives		s sː	x	
Affricates		t͡s tː͡s	k͡s kː͡s	
Nasals	m mː	n nː		
Glides	w	j		

Vowels
i iː
o oː
a aː

Of the consonants, only /x/, /ʔ/, and the glides do not contrast for length. As will be discussed below and in subsequent chapters, /x/ and /ʔ/ have extremely limited distributions as compared to the other consonants in the language, and the absence of contrastive length for these consonants will similarly be accounted for.[4]

[3] PA *l generally became Blackfoot /t/ (Proulx 1989:49).

[4] Unfortunately, further discussion of the exceptional nature of glides with respect to gemination is excluded from this thesis. One possibility is that highly sonorous segments are less prone to ambisyllabicity. Under an OT analysis, this could be represented by expanding the constraint *AMBISYLL proposed in 4.1.2 into a family of constraints dependent on sonority, such that some consonants are more likely to geminate than others. However, such an analysis is not developed at present, and is left for future research.

2.3.2 Vowels

The degree of abstractness which should be used to account for the Blackfoot vowel system is unclear. Minimally, the vowel system can be derived via the assumption of three underlying vowels, each contrasting for length:

(3) Vowel inventory

i iː		
		o oː
	a aː	

Phonetically, the number of vowels is much greater.[5] The following chart shows Frantz' (1978) phonetic inventory:

(4) Phonetic Vowel inventory[6]

i iː					u (uː?)
	ɪ			ʊ	
eː		ə			o oː
	ɛ ɛː				
	æː	a aː	ɔ ɔː		

However, as Frantz (1978:311-312) notes, the additional vowels are predictable as variants either of /i, a, o/ or combinations of these vowels. For instance, [u] and [o] are free-variants in Blackfoot, where /o/ is traditionally assumed to be the underlying form

---

[5] To further complicate matters, the phoneme /i/ patterns differently with respect to certain phonological processes, depending on the historical origin of the vowel. It may therefore be necessary to introduce two forms of underlying /i/ which differ phonologically but correspond to the same phonetic output. Frantz (1978, 1991), for example, assumes two underlying forms for [i], /i/ and /I/. This topic is not considered in this thesis. See also Kinsella (1972).

[6] Slightly modified.

(cf. Lowery 1979). Short vowels are realised as lax in closed syllables: /i/ is realised as [ɪ], /a/ as [ə] and /o/ as [ʊ]. The vowels [eː], [ɛː] and [æː], which are always long, are the surface outputs of underlying sequences of /a + i/, while [ɛ] is the realisation of this sequence when it is followed by a coda consonant.[7] Similarly, [ɔː] is the surface realisation of /ao/, which is shortened to [ɔ] in closed syllables. Variation among speakers is common, even within a dialect; for instance, Lowery (1979) notes that "[ay] varies from [əy] to [ey] to [ɛ], depending on the speaker". Further research regarding the reflexes of vowels in Blackfoot, including several speakers from different dialects, will be necessary for a more complete understanding of the vowel system. See also Kinsella (1972) for some discussion of the vowel system.

2.3.3 Prominence

Blackfoot is a pitch accent language (Frantz 1978, 1991; Van Der Mark 2003; Stacy 2004). Unlike stress, accent placement in Blackfoot is virtually unpredictable, although some generalisations exist (Frantz 1978, 1991). However, while the pitch accent system is likely linked to the weight system, it is at present not well understood. Rather than make unqualified stipulations regarding prominence in Blackfoot, this topic is left for future research.

---

[7] I transcribe /ai/ sequences as [ɛː].

2.3.4 Morphosyntax

Blackfoot is a polysynthetic language capable of combining a large number of morphemes with a single stem. Many Blackfoot words are morphologically complex, and word compounding is especially productive in the language. For example, consider the following recent lexical acquisitions (Frantz & Russell 1989[8]):[9]

(5) a. iːxtɛ́ːt͡sinikjoʔp ‘telegraph’ (lit: what one relates stories with)
iːxt-á-it͡siniki-oʔp
INST-DUR-relate.a.story-INST

b. ɛ́ːk͡sisːtoːmatomaːxkaː ‘automobile’ (lit: starts travelling without reason)
á-ik͡sisːto-iːmat-omaːxkaː
DUR-without.reason-start.to-travel

Many other words are clearly complex morphologically but have become opaque through numerous morphophonological processes. Because of its unusually productive morphological system, morphophonological processes are numerous and often complex. These processes are sometimes used in this thesis to illustrate how illicit phonotactic patterns are remedied.

2.3.5 Orthography

The standard orthography used at present is that designed by Donald Frantz (e.g. 1978, 1991), although the Blackfeet of Montana use a slightly different orthography. This orthography is alphabetic, and assumes virtually the same phonemic inventory as

---

[8] Data for this thesis is taken from Frantz & Russell 1989 unless otherwise indicated. The majority of the examples used in this thesis have been confirmed by a native speaker of the Siksika dialect.

[9] All transcriptions are phonological unless otherwise indicated.

this thesis. The phonemes /p, t, k, s, n, m, w/ are represented orthographically as they are in a typical roman alphabet. Some alterations as compared to the IPA transcription used in this thesis include the representation of /x/ as *h*, /ʔ/ as *'*, and /j/ as *y*. The affricates /t͡s, k͡s/ are represented as simple sequences of *ts* and *ks*. Length contrasts are represented as double graphemes: *pp*, *tt*, *kk*, and so on. Long affricates are represented as *tts* and *kks*. Length contrasts are represented orthographically both intervocalically and pre- and post-consonantally.

The vowels /i, a, o/ are represented as *i*, *a*, and *o*, with doubled graphemes once again used to represent contrastive length. Combinations of vowels, even those resulting in coalesced vowels (e.g. /a + i/ > [ɛː], see section 2.3.2, as well as chapter 6) are represented as sequences of vowels: [ɛː] is represented as *ai*, [ɔː] is represented as *ao* and [oj] as *oi*. Rising diphthongs are similarly written as sequences of vowels: [ja] as *ia* and [jo] as *io*. With respect to chapter 6 of this thesis, it is interesting to note that Blackfoot speakers are comfortable with the representation of [ɛː] and [ɔː] as orthographic diphthongs.

This orthography replaced a syllabary designed by missionaries John Williams Tims and Harry W. Gibbon Stocken, as well as unknown Blackfoot, in the 1890's (Tims 1890, Stocken ca. 1890). While the use of this system has become obsolete, it does provide some insight into matters such as syllabification (Ermineskin & Howe 2005). This will be discussed briefly in 5.3.

Chapter Three: Theoretical Background

This chapter introduces the concept of weight, and outlines the theories assumed in this thesis.

3.1 Syllable Weight

In a traditional sense, syllable weight is best understood as the dichotomy present in many languages between so-called *heavy* and *light* syllables. The relative 'weight' of a syllable has long been known to play a crucial role in prosodic phonology, affecting such phenomena as stress assignment, compensatory lengthening, and minimal word requirements—heavy syllables often attract stress or prominence over light syllables, the deletion of a weight-bearing segment is often compensated for, and words are often of a minimal weight. A well-known example is its role in stress assignment in languages such as English. For instance, consider the following examples (Chomsky & Halle 1968:81):

(1) a. rígorous, máximal, vígilant
    b. mediéval, desírous, decórous
    c. relúctant, abýsmal, moméntous

In English, stress regularly falls on the antepenultimate syllable as in (1a). However, stress preferentially falls on syllables containing either a long vowel (1b) or a coda consonant (1c), even if it is not in antepenultimate position. In English, long vowels and coda consonants add salience to the syllable, making the syllable a better candidate for stress; in this sense, stress in English is 'quantity-sensitive'. By contrast, some languages (e.g. French) assign stress regularly without any consideration of syllable weight. Other languages present variations on these two systems; for example, some languages consider long vowels but not closed syllables heavy, while others offer more complicated systems where some coda consonants add weight while others do not, or where some vowels are considered heavier than others (see Gordon 1999 for a detailed weight typology).

Many studies of syllable weight concentrate on languages with weight-sensitive tonal or stress systems. The language under present investigation utilises a prosodic system that falls under neither category: Blackfoot has a pitch-accent system. Pitch accent systems show similarities to both tone and stress systems, and yet form a category of their own. For example, pitch accent systems share with tonal systems the primary phonetic correlate of prominence as fundamental frequency (pitch), and cumulativity with stress systems. While Blackfoot's prominence system may be, in some way, weight-sensitive, the details of this system are, in general, not well understood (see Stacy 2004). This thesis makes no attempt to investigate the pitch accent system, leaving further study of this system, and its relationship to syllable weight, to future research.

Instead, the investigation of syllable weight in Blackfoot presented in this thesis is based on phonotactic patterns rather than prominence assignment. I use evidence such as segment distribution, segment length, vowel quality, and segment coalescence (merging) to develop an understanding of the role segment weight plays in Blackfoot.

3.2 The Phonetics-Phonology Interface

Of the many possible phonetic correlates for segment weight, intensity and duration have been singled out as those which most closely correlate with the patterns for weight assignment. These phonetic characteristics correspond to the two phonological measures of segment weight: sonority, which also correlates with intensity (Parker 2002 and section 3.3.1 below), and phonological length. This section briefly discusses two issues related to the phonetic manifestation of syllable weight—its phonetic correlates and, particularly, its relationship with duration. While this thesis is primarily concerned with the phonological aspects of syllable weight, some of the conclusions made in this thesis relate directly to the phonetic characteristics of the segments in question.

3.2.1 The Phonetic Correlates of Syllable Weight

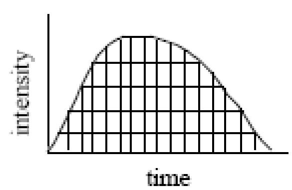
Gordon (1999) conducted a typological study of weight systems, and investigated both the phonetic and phonological motivations for weight systems cross-linguistically. He argued that the particular manifestations of weight systems are the result of compromise between phonetic effectiveness and phonological simplicity. In other words, any syllable weight distinction must first of all be significant in terms of its phonetic factors; however, the number of effective distinctions are in turn constrained so as to avoid the creation of an overly-complex phonological system. Gordon uses the simplicity factor to account for the fact that greater than binary weight systems are relatively rare among the world's languages, and that greater than quaternary systems are virtually non-existent.

Syllable weight in terms of its role in phonological processes such as stress assignment is primarily concerned with the division of syllable types into two or more groups. Gordon argues that phonetic factors are primarily responsible for the determination of which weight divisions are effective enough to be encoded in the phonological system. An effective division is one in which the distribution of the phonetic data for two syllable types contains minimal overlap.

Gordon centred his investigation on two phonetic factors, ‘total energy’ and duration. ‘Total energy’ is defined as the area under the curve when intensity is plotted against time, as shown in the graph below, reproduced from Gordon (1999:164):

(1) Total Energy Graph (Gordon 1999:164)

Total energy



It is this measurement which Gordon found to be most effective in predicting the types of syllable weight distinctions present in languages. Duration was found to be a much less successful predictor of syllable weight, an effective measure only in languages where long vowels are considered heavier than other syllable types, contrary to findings such as those presented in Broselow et al. (1997), which will be discussed in the next section. Interestingly, Gordon’s use of ‘total energy’ as opposed to average energy or other measurements takes into account duration as well as intensity. It is thus not surprising that ‘total energy’ predicts divisions of weight based on duration as effectively as it predicts other divisions.

3.2.2 Phonetic Duration and Syllable Weight

The relationship between phonetic duration and syllable weight is a complicated one. One of the most common weight divisions employed by languages is one which recognises open syllables with long vowels (CVV) as heavy. While languages vary as to whether CVV syllables are heavier or of equal weight compared to closed syllables (CVC), CVC syllables are never heavier than CVV. Gordon (1999:180) recognises this observation as an implicational hierarchy, reproduced below:

(2) Weight hierarchy for syllable types

VV VC V

$\longleftrightarrow$

Heaviest Lightest

Long vowels, therefore, appear to provide direct evidence that duration is important in the determination of syllable weight systems. Gordon (1999), as discussed above, argued that duration is effective only with respect to the determination of long vowels as heavy, and not with respect to other divisions. Broselow et al. (1997), on the other hand, argue that segment duration and segment weight interact in complex and subtle ways. Some of their findings are discussed in this section.

Broselow et al. (1997) investigate the extent to which phonologically-determined moraic representations (see discussion of moraic theory below) can be predicted by the phonetic duration of the composite segments. They examine three languages (Hindi, Mayalayam, and Levantine Arabic), for which coda consonants are treated differently with respect to stress assignment: in Hindi, CVC syllables are always considered heavy; in Mayalayam, CVC syllables are always considered light; in Levantine Arabic, coda consonants sometimes contribute weight or not, depending on the weight of the preceding vowel.

Broselow et al. assume that the difference between Hindi and Mayalayam coda weight is reflected in their moraic representation: coda consonants in Hindi are associated with their own mora, while coda consonants in Mayalayam share their mora with the preceding vowel. This is illustrated below:

(3) Moraic Representation of Hindi syllable types:

a. μ
C V (light)

b. μ μ
C V (heavy)

c. μ μ
C V C (heavy)

(4) Moraic representation of Mayalayam syllable types:

a. μ
C V (light)

b. μ μ
C V (heavy)

c. μ
C V C (light)

Broselow et al. provide phonetic measurements that they claim support the above representations. For example, they show that the vowel sharing a mora in (4c) is significantly shorter than its counterpart in (4a), which does not share a mora. Conversely, the unshared vowel in (3c) is found to be of equal duration with the unshared vowel in (3a).

Similar studies have both supported (e.g. Hubbard 1995, Ham 2001, Cohn 2003) and questioned (e.g. Gordon 1999) the close relationship between the mora and phonetic duration as envisioned by Broselow et al. In sections 5.3 and 5.4, I discuss the possibility that duration is relevant in determining the moraic and syllabic representations of geminates.[10] This follows in the tradition of studies such as Ham (2001), which argue that the phonological representation of geminates (as either a consonant associated with two timing slots or as a moraic ambisyllabic consonant) and their phonetic duration should reflect one another.

3.3 Sonority and Syllable Weight

The sonority sequencing principle (SSP) has long been cited as one of the guiding principles of phonotactics. It can be formulated as below:

(5) Sonority Sequencing Principle (SSP) (Selkirk 1984:116, etc.)
In any syllable, there is a segment constituting a sonority peak that is preceded and/or followed by a sequence of segments with progressively decreasing sonority values.

The SSP makes two assumptions of phonotactic theory—the first is in the existence of the sonority scale, which is universally defined and ranked, and the second is in the defining role of the syllable in determining phonotactics. These concepts are discussed below.

The traditional concept of sonority has recently become a topic of debate since the proposal of the 'Licensing-by-Cue' approach to phonotactics (e.g. Steriade 1997, Wright 2004), which claims that phonotactics are determined based on the saliency and retrievability of perceptual cues. Proponents of this theory generally claim that sonority is circular and ultimately makes the wrong predictions in certain cases—circular because it is used to motivate typological patterns even though sonority patterns were

---

[10] However, no concrete phonetic data will be presented in this thesis.

originally determined via typological generalisations, and simply wrong in certain matters such as its inability to predict the versatility of sibilant consonants in phonotactics. This thesis assumes a traditional approach to phonotactics, and makes reference to sonority throughout. This approach is assumed for the following reasons. First of all, much of this thesis hinges on moraic theory, especially with respect to underlying contrasts, and its relationship to the phonetic properties of syllable weight. Based on independent studies by Gordon (1999) and Parker (2002), the phonetic properties associated with syllable weight (intensity and, to a lesser extent, duration) also correlate with the phonetic properties associated with sonority. In addition, the relationship between moraic associations and sonority has also been well-documented (e.g. Zec 1988, 1995, Morén 1999), whereas little or no work (to my knowledge) has been done relating Licensing-by-Cue to contrastive weight or to segment weight in general.

This section introduces the concept of sonority and discusses its relevance to syllable weight and phonotactics.

3.3.1 Sonority

Sonority can be defined roughly as the relative perceptibility of segments. Even though the concept of sonority is well-motivated phonologically, it is only recently that much attention has been focussed on motivating it phonetically. Parker (2002) investigates correlations of sonority with various phonetic factors, and found the traditional notion of the "sonority scale" to be correlated with intraoral air pressure, F_1 frequency, air flow, segmental duration and particularly intensity. Parker proposes the following sonority scale for speech segments, which he claims to be motivated both phonetically and phonologically:

(6) Universal Sonority Scale (Parker 2002:240, slightly simplified)

Most Sonorous ↑	Low vowels
	Mid Vowels (except [ə])
	High Vowels (except [ɨ])
	[ə]
	[ɨ]
	Glides
	Liquids
	Nasals
	[h]
	Voiced Fricatives
	Voiced Stops and Affricates/Voiceless Fricatives
Least Sonorous ↓	Voiceless Stops and Affricates

Strikingly, Parker's phonetically-constructed sonority scale is essentially identical to the early formulations, dating from Sievers (1881). Additional support for the phonetic reality of sonority comes from Gordon (1999), discussed above, who correlates essentially the same phonetic factors (intensity and duration) with syllable weight. Syllable weight has, in turn, been shown to correlate with the sonority of segments—i.e. highly sonorous segments (e.g. vowels) are most likely to be moraic. The combination of these two studies suggest not only that sonority has a real phonetic basis, but also that sonority is relevant in the determination of phonotactics and syllable weight. If it is accepted that sonority has a phonetic basis, its use in motivating phonotactics ceases to be circular.

Some of the proposed problems with the sonority scale and the SSP—such as the flexible patterning of sibilant fricatives—clearly remain. While the present study does not attempt to provide a solution for this problem at this time, some elements of Blackfoot phonotactics do shed light on this issue. For example, the sibilant fricative /s/ patterns relatively freely in the language, forming SSP-violating consonant clusters and possibly acting as a syllabic consonant. However, independent evidence in the language does suggest that /s/ patterns like a voiceless fricative in terms of sonority. See 5.6, for some discussion of this problem.

3.3.2 The Syllable

The SSP additionally assumes the existence of the syllable, one of the most intuitive and useful prosodic constituents and yet also one of the most debated. Its intuitiveness is evident from the use of the syllable in such language-oriented pastimes as poetry, song, and language games, and its usefulness in accounting for prosodic phenomena such as segment weight and stress assignment (e.g. Blevins 1995). However, strikingly, it is not used as a constituent in any linguistic processes—for instance, no language is known to use the syllable as a reduplicant (i.e. reduplicative affixes never copy actual syllables, as in CV-CV.CVC vs. CVC-CVC.CVC; see Moravcik 1978). A second argument against the psychological reality of the syllable has been its absence as a means of contrast among languages—tautosyllabic contrasts of the type *a.ta* with *at.a*, and *ak.la* with *a.kla* are thought not to exist (e.g. Blevins 1995, McCarthy 2003). The implications of such contrasts in Blackfoot are discussed in chapter 5, where it is argued that contrastive syllabification is best accounted for by assuming that moras are the means of contrast, rather than syllables.

Are syllables extraneous? This thesis assumes that they are not—on the contrary, I argue that syllables play an important role in organising segments: the syllabic tier is in part responsible for determining whether or not segments are associated with moras, and for which types of sequences are allowed in the language. I assume that syllables are constructed by taking into account moraic associations and sonority, and that the language's phonotactics are derived in this way.

3.4 Formal Theories of Weight

Of the various attempts to represent segment weight formally, moraic theory (Hyman 1985, Hayes 1989) has gained the widest acceptance among linguists, and is the framework used in this thesis. In this section, I provide a brief overview of some of the moraic model's predecessors (CV and X-slot models) and discuss the basic assumptions and claims, as well as the advantages and disadvantages, of moraic theory.

3.4.1 Skeletal Slot Models

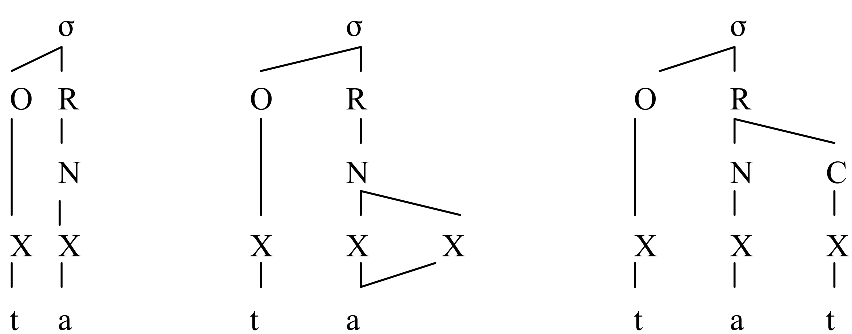
Skeletal slot models, unlike moraic models, associate prosodic timing slots one-on-one with segments. One variation, the X-slot model (Levin 1985), assumes that timing units are of one type which can associate indiscriminately with any type of segment.

The X-slot model was proposed as an improvement over the CV model (Clements & Keyser 1983), as it eliminated the perceived redundancy of specifying consonants as *C* and vowels as *V*. Proponents of these models essentially proposed that issues related to timing (such as compensatory lengthening) should be considered separate from other considerations such as syllable structure or phonotactics in general.

The skeletal tier of the X-slot model immediately dominates the segmental tier and is dominated itself by syllable structure. Because the X-slot model loses the advantage of the CV model in being able to account (at least to a certain extent) for sonority sequencing considerations, X-slot theory requires positing several subsyllabic components in order to account for phonotactic constraints. Minimally, this consists of the onset (O) and the rhyme (R); additionally, the nucleus (N) and the coda (C) are usually assumed as well. Examples of basic syllable types under X-slot theory are given below:

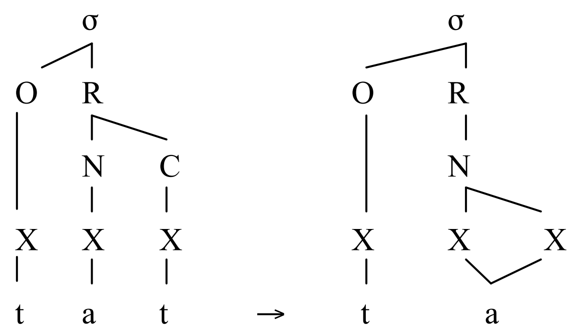
(7) X-slot representation of three syllable types

a. [ta] b. [taː] c. [tat]



Possibly the greatest advantage of the X-slot model is its relative ease in accounting for phonological processes directly related to timing such as compensatory lengthening. X-slots are equivalent for each segment and are therefore fully transferable. This is illustrated below:

(8) Compensatory lengthening under X-slot theory



While the timing unit is easily transferred under this model, the above representation requires a change in syllable structure: the input sequence has a coda consonant, while the derived sequence has a complex nucleus. This is not considered problematic given the assumption that syllabification can be applied at any point in the derivation, thus avoiding unwanted syllable structures.

However, X-slot theory is ultimately a theory of timing and has little to say about segment weight. Like the CV model, X-slot assumes that onsets and nuclei/codas are treated equally with respect to timing/weight. The X-slot model circumvents this problem by referring to its syllable structure specifications. If onsets never contribute to weight or timing in processes such as compensatory lengthening, then this occurs because onsets are considered transparent in these processes; in other words, phonological processes simply ignore onsets in the calculation of weight. This rule is quite arbitrary under this theory, though it is very intuitive given that X-slots are timing units and not weight units: onset consonants contribute to the duration of the syllable; they are pronounced and therefore should be associated with timing units. However, their invisibility in these processes suggests that the processes are not crucially associated with timing after all, even though increased duration is their consequence.

The successor to the X-slot model, the moraic model (Hyman 1985, Hayes 1989) proposes that weight units should replace timing units. Crucially, segments are not required to associate with weight units under this model—for example, onset segments may be associated directly with the syllable node. See 3.4.2 for further discussion.

The moraic model does, however, lose some of the advantages of the skeletal slot models. For instance, X-slot models are capable of providing an explanation for contrasts in duration that are not related to syllable weight. In Blackfoot (see discussion in 5.5), as well as in languages such as Polish (Rubach 1984) and Oowekyala (Howe 2000), contrasts between affricates and segment sequences are not easily accounted for under moraic theory because the length contrast is not due to weight. For example, consider the following examples from Blackfoot; the orthographic representations (in italics) serve to illustrate where the length contrast is manifested:[11]

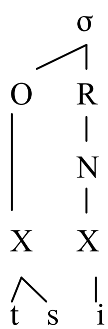
(9)	a.	nítsiʔkaki	'I kicked'	*nítssi'kaki*
		niːt͡sít͡sikín	'mocassin'	*niitsítsikín*
	b.	kaːxtsín	'game'	*kaahtssín*
		kaːxt͡sít	'gamble'	*kaahtsít*
	c.	aksín	'bed'	*akssín*
		áak͡sikamiʔniwa	'he will faint'	*áaksikami'niwa*
	d.	ninixksini	'song'	*ninihkssini*
		ipaxk͡sikɛːmo	'stink like feet'	*ipaxksikaimo*
	e.	amɛ́ipsi	'belt'	*amáíipssi*
	f.	saːxpsit	'boil it'	*saahpssit*
		*p͡s		

[11] Note: very few minimal pairs exist in Blackfoot, owing perhaps to the rather complex morphological system. Minimal pairs will be considered where available; however, this is not always possible.

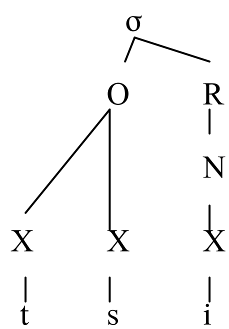
Because stop-/s/ sequences are syllabified as complex onsets in Blackfoot (see 5.5 for further discussion), the contrast in duration for /s/ following stops cannot be attributed to a contrast in weight because onsets are always non-moraic. Using the skeletal slot model, the difference can be attributed to a difference in timing slot associations: affricates consist of two segments associated with a single timing slot, while sequences involve two segments associated with two timing slots, as illustrated below:

(10) The representation of affricates (a) versus segment sequences (b)

a.



b.



Under a moraic account, the difference between the two sequences is assumed to be featural, rather than prosodic. Because timing is generally a prosodic phenomenon, an X-slot account is advantageous in being capable of providing a prosodic explanation for the contrast.

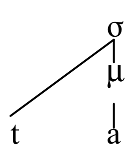
Similarly, a skeletal slot account is advantageous in accounting for languages where geminates are long in duration but do not contribute to syllable weight. While not useful in accounting for Blackfoot, where geminates are always heavy, languages with this type of geminate might benefit from a model where length contrasts for geminates are represented using timing slots rather than a model where length contrasts are represented using moras. In this thesis, it will be assumed that geminates are derived from underlying moraic contrasts (see 4.1.1); however, it is possible that languages differ with respect to which account provides a more accurate representation. Ham (2001), for example, notes that both the X-slot account of geminates and the moraic account of geminates are equally useful in representing geminates phonologically.

3.4.2 The Moraic Model

The moraic model differs from the skeletal slot models by associating segments with units of weight (referred to as moras), as opposed to timing units. The obvious advantage of this adjustment is that it eliminates the required association between segments and timing units—under moraic theory, it is possible to represent some segments as either weightless (and thus associated directly to the syllable node) or as sharing a weight unit with another segment. The representation of weightless segments has been the topic of some debate since the inception of moraic theory (e.g. Hyman 1985, Hayes 1989). In this thesis, however, I adopt the widely held assumption that onset consonants associate directly with the syllable node. Examples of moraic representations of three syllable types are given below:

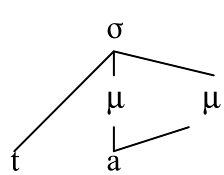
(11) Moraic representations of three syllable types

a.



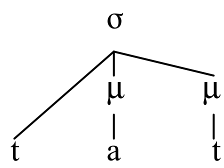
[ta]

b.



[taː]

c.



[tat]

Moraic theory solves a major problem of previous theories by assuming that segments that are 'invisible' in certain processes are simply non-moraic, and preserves their primary advantage by remaining capable of accounting for timing phenomena, such as compensatory lengthening. Note that in the above representations, long vowels are associated with two moras while short vowels are associated with one: in this sense, moras account for length. However, a closed syllable also contains a total of two moras: one is associated with the short vowel and the second with the coda consonant. Moraic theory is thus able to account for weight systems where CVV and CVC are treated equally. The association of long vowels with two moras should therefore not necessarily be considered a representation of length; rather, their bimoraic status simply indicates that it contributes two units of weight to the syllable. While the relationship between segment weight and segment duration has been the topic of some recent research (e.g. Broselow et al. 1997 and discussion above), it is perhaps useful to note at this point that moraic theory itself makes no claims in this regard: moras are units of weight, not time. However, this is not to say that duration is not reflected in moraic representations to some extent. For example, the discussion of consonant length in this thesis argues that the correct representation of ambisyllabic segments as opposed to tautosyllabic segments can be predicted from their duration (see 5.3 and 5.4).

Given the theory's ability to deal directly with weight phenomena, moraic theory is the framework adopted in this thesis. Since the advent of Optimality Theory, many constraints have been proposed to generate the types of representations predicted by moraic theory. I argue that moraic representations are dependent on two types of constraints—moraic faithfulness constraints and syllable structure constraints, which make demands on which segments within a syllable must be moraic. The next section introduces Optimality Theory, the framework assumed in this thesis.

3.5 Optimality Theory

The analyses presented in this thesis are set within the framework of Optimality Theory (Prince & Smolensky 2004, McCarthy 2004). This framework is adopted owing to its facility in working with non-uniform patterns, which is especially useful in the discussion of vowel hiatus resolution in chapter 6. This section provides a brief introduction to the basic principles of the theory. Specific constraints adopted in this thesis will be introduced as required.

Optimality Theory (OT) assumes the existence of a universal set of well-formedness constraints. These constraints conflict with each other within a given language; the satisfaction of all constraints in a given language is therefore assumed to be impossible. According to OT, all constraints are in principle violable, and languages deal with conflicting constraints by ranking them into a strict hierarchy. Given a choice between two possible candidates, languages choose the candidate which best satisfies the highly-valued constraints, regardless of the number of violations to low-ranking constraints; in other words, attested linguistic forms represent the ‘optimal’ candidate, not the flawless candidate in terms of constraint violations. Languages are not expected to be uniform and without exceptions; on the contrary, forms which would be considered exceptions under other frameworks are predicted under OT on the basis of constraint interaction.

In addition to a universal set of constraints, OT assumes two levels of representation: an underlying representation (the input) and a surface representation (the output). The input consists of the phonemes, their features, and other contrastive elements that are present in the speaker's grammar. The information in the input is mapped to an infinite number of surface or 'output' representations. Non-contrastive prosodic information—including syllable structure and the formation of feet and larger constituents—is applied to the input form in all possible ways. These output forms are then evaluated in terms of which constraints are violated and to what extent, and the optimal candidate is chosen. While all languages contain the same set of constraints, it is the ranking of these constraints which determines which is the optimal form—it is thus predicted that this will differ from language to language. All pronounced forms are considered 'optimal', while no form is free from constraint violations.

OT recognises two basic types of constraints: markedness constraints and faithfulness constraints. Markedness constraints militate against dispreferred structures by assigning violation marks to output candidates guilty of these structures. For example, syllables without onsets are considered 'marked' structures cross-linguistically; the constraint ONSET assigns violation marks to all candidates with onsetless syllables. Faithfulness constraints, on the other hand, require that output candidates be faithful to the input. Violation marks are assigned to output candidates which have in some way altered the input form. Faithfulness constraints are generally assumed to be of two types:[12] DEP constraints, which prohibit the addition of new information, and MAX constraints, which prohibit the loss of information. DEP and MAX constraints may be further specified depending on the particular 'information' in question—for example, faithfulness constraints may be formulated in terms of faithfulness to features, segments, moras or any other information present in the input. However, information not present in the input is not subject to faithfulness constraints. For example, current theory often assumes that syllabification is not specified in the input and is therefore not subject to faithfulness constraints. See chapter 5 for further discussion of this topic.

Markedness constraints and faithfulness constraints necessarily compete against one another. For example, imagine that two languages have as an input the sequence /ata/. Language A pronounces this sequence as it is in the input [ata]. Language B pronounces the sequence as [tata], where initial [t] is an epenthetic segment. Two constraints are involved in this particular case:

(12) a. ONSET: syllables must have onsets.[13]

b. DEP: segments present in the output must be present in the input.

In language A, DEP outranks ONSET; in other words, language A will put up with a marked structure in order to preserve input information. In language B, ONSET outranks

[12] However, in this thesis, MAX and DEP will sometimes be collapsed into a FAITH constraint, e.g. FAITHμ.

[13] This constraint could be written as *NOONSET. However, the traditional formulation ONSET is used in this thesis.

DEP; language B prefers altering the input structure in order to avoid a marked structure. These points are illustrated in the following tableaux:

(13) Language A: DEP » ONSET

/ata/	DEP	ONSET
☞ata		*
tata	*!	

(14) Language B: ONSET » DEP

/ata/	ONSET	DEP
ata	*!	
☞tata		*

Both languages ultimately reject the optimal candidate of the other language. Conversely, the winning candidates both violate one of the two constraints considered in this example. The above tableaux illustrate the conflict at the heart of OT between faithfulness and markedness, a topic that will be addressed repeatedly throughout this thesis.

Chapter Four: Moraic Contrasts in Blackfoot: Their Development and Representation

This chapter provides a preliminary overview and analysis of consonant weight in Blackfoot. The representation and development of intervocalic geminates, as well as the phonotactic and moraic behaviour of /x/ and glottal stop, are discussed.

4.1 Geminates in Blackfoot

4.1.1 The Formal Representation of Geminates

Moraic theory assumes that segments receive moras in one of two ways: either they are specified in the underlying representation and preserved on the surface, or they are acquired on the surface due to some markedness constraint (e.g. weight-by-position, Hayes 1989). Under moraic theory, contrastive vowel or consonant length is represented formally as the surface manifestation of underlyingly specified moraic associations—in other words, length contrasts are assumed to arise from underlying weight contrasts. This analysis of contrastive length has long been an integral aspect of moraic theory (e.g. Hayes 1989, Morén 1999), and is widely accepted as an accurate interpretation of phonological length contrasts (e.g. Ham 2001).

Blackfoot contrasts consonant length both intervocalically and preconsonantally in certain environments. In this section, only intervocalic geminates are considered; preconsonantal geminates are discussed in the next chapter. First, consider the following examples of intervocalic consonant length contrasts:

(1)	a.	ikaxt͡siwa	‘he gambled’	ikːaminiwa	‘he fainted’
	b.	ipaxk͡sikɛːmo	‘stink like feet’	ipːataːwa	‘he is shy’
	c.	itan	‘daughter’	itːaxsiwa	‘he was triumphant’
	d.	it͡sinikiwa	‘he told a story’	itː͡si	‘belly’
	e.	ik͡sinima	‘he touched it’	ikː͡sisit͡siʔt͡sima	‘he understood it’
	f.	isinaʔsiwa	‘he was busy’	isːapjaʔtsis	‘telescope/binoculars’
	g.	ninaː	‘man/chief’	ninːa	‘my father’
	h.	imitaː	‘dog’	imːiwa	‘it was deep’

Under a traditional moraic analysis (Hayes 1989), intervocalic geminates in Blackfoot receive the following representations. Note also the representation of contrastive vowel length:

(2) Underlying and surface representations of [ninaː] ‘man/chief’

a. Underlying Representation b. Surface Representation

(3) Underlying and surface representations of [nɪnːa] ‘my father’

a. Underlying Representation b. Surface Representation

The ambisyllabic status of intervocalic geminates as in (3) reflects a compromise between the desire to preserve the mora in a weight-bearing position (in this case coda position) as well as the desire to avoid an onsetless syllable. While this analysis generally works well in terms of phonological properties, it remains a matter of debate whether it is the geminate's mora which is responsible for its increased duration, or its ambisyllabic structure. While not a primary goal of this thesis, the analysis proposed for Blackfoot, as well as the proposed alterations based on phonotactic and phonetic facts, supports the assumption that both aspects play a role.

The moraicity of intervocalic geminates is supported by phonotactics. The clearest piece of evidence comes from their effect of preceding vowels, which are always affected in closed syllables. Before geminates, as before most coda consonants in Blackfoot (cf. /x/ and /ʔ/, sections 4.2 and 4.3), long vowels are shortened and short vowels are realised as lax: /i/ > [ɪ], /o/ > [ʊ], /a/ > [ə]. Additionally, Blackfoot geminates, while they can occur preconsonantally, always follow a vowel and generally do not cooccur with other moraic consonants or form complex codas. The one exception to this rule is the occurrence of non-moraic /s/ before geminate /tː/ as in /istːoan/ 'knife'. This occurs as a result of a preassibilation process (Frantz 1991:152), whereby non-moraic /s/ is inserted following certain instances of the vowel /i/ and preceding /t/.[14] A moraic analysis of preconsonantal /s/ is offered in chapter 5.

4.1.2 OT Account of Intervocalic Geminates

In terms of Optimality Theory, the ambisyllabic structure for geminates is motivated by two considerations: the preservation of the underlying mora in the output, and the avoidance of word-medial onsetless syllables. These can be accounted for with reference to the constraints FAITHμ and ONSET:

---

[14] This process, as well as /k/-assibilation, are only triggered by /i/ whose origin is PA */i/ (Proulx 1989).

(4) FAITHμ: the number of moras present in the output must be equal to the number of moras present in the input.

(5) ONSET: syllables must have onsets.

These constraints are ranked above NOCODA. The simplest formulation of this constraint is as follows:

(6) NOCODA: syllables must not have codas.

I assume in this thesis that any consonant tautosyllabic with a preceding vowel constitutes a violation of NOCODA; as such, this constraint is equally violated by simple coda consonants as by ambisyllabic consonants.

The ranking of the constraint FAITHμ over NOCODA results in the preservation of the underlying mora in the output, while ranking ONSET over NOCODA results in the ambisyllabic structure. This denotes the ranking FAITHμ, ONSET » NOCODA, as illustrated in the following tableau:

(7)

n i_μ n_μ a_μ	FAITHμ	ONSET	NOCODA
$_\sigma$[n i_μ] $_\sigma$[n a_μ]	*!		
$_\sigma$[n i_μ n_μ] $_\sigma$[a_μ]		*!	*
☞ $_\sigma$[n i_μ n_μ] $_\sigma$[n a_μ][15]			*

One problem remains to be discussed. As it stands, the above analysis does not require any constraint specifically militating against the ambisyllabicity of geminates. Instead, I have so far assumed that geminates are marked because they are moraic coda consonants. As Morén (1999) argues, an analysis such as the one presented here offers advantages in the unified treatment of geminates with coda consonants and word-final geminates in languages such as Hungarian (e.g. Morén 1999, Ham 2001), neither of which is ambisyllabic. However, such an analysis also assumes that the ambisyllabic structure of intervocalic geminates is a natural consequence of their moraicity, and that all languages with an intervocalic weight distinction will realise this distinction as an ambisyllabic segment. This consequence is counterintuitive, given that ambisyllabicity adds complexity to the syllable structure, and that a less-complex alternative is readily available. As will be discussed in chapter 5, moraic theory does predict that languages with a contrast between /nin.aː/ and /ni.naː/ could exist, provided that ONSET is ranked lowly enough, and that a constraint rules out ambisyllabicity. In the next chapter, some of typological predictions of the moraic analysis are examined, and I discuss English (e.g. Alcántara 1998) as a language of this type. To account for the English data, it will be necessary to introduce a constraint of the type *AMBISYLL, which works against the linking of segments between two syllables. In the above analysis, *AMBISYLL is ranked below FAITHμ, ONSET, and on par with NOCODA:[16]

---

[15] This short-hand structure is used to represent ambisyllabicity. Even though the geminate is written as two consonants, it should be assumed that the geminate is considered to be a single segment, as discussed above.

[16] Note, however, that there is no evidence from within Blackfoot specifically requiring such a constraint.

(8)

n i_μ n_μ a_μ	FAITHμ	ONSET	*AMBISYLL	NOCODA
$_\sigma$[n i_μ] $_\sigma$[n a_μ]	*!			
$_\sigma$[n i_μ n_μ] $_\sigma$[a_μ]		*!		*
☞ $_\sigma$[n i_μ n_μ] $_\sigma$[n a_μ]			*	*

Any language which allows geminates will allow *AMBISYLL to be violated when it is dominated by a higher-ranked constraint, such as ONSET. However, this analysis predicts that ambisyllabicity will only be used when no other recourse is available, given higher ranked constraints. Introducing the constraint *AMBISYLL allows us to avoid the assumption that ambisyllabicity is in itself unmarked. By assuming that the ambisyllabic structure is a marked one, we predict the existence of languages where underlying moraic contrasts are preserved, but not through the means of gemination.

4.1.3 The Development of Contrastive Weight in Blackfoot

Unlike contrastive vowel length, contrastive consonant length is not reconstructed as a feature of Proto-Algonquian (henceforth PA).[17] Geminates in Blackfoot have a number of origins. According to Thomson (1978), a number of geminates in Blackfoot arose through regressive assimilation of consonant clusters. He proposes that these illicit

---

[17] Proulx (1989) claims that contrastive vowel length in Blackfoot does not correspond to contrastive vowel length in PA. Rather, he argues that PA vowel length contrasts neutralised in Blackfoot, and that the language developed its own quantity system, possibly through initial change (see Costa 1996 for Algonquian, Proulx 1989, 2005 for Blackfoot).

consonant clusters arose through a syncope rule. Evidence for this rule comes from a number of stems in Blackfoot whose word-initial form is without a geminate and whose word-medial form[18] begins with a geminate. The so-called ‘snake stems’ are given below:

(6) Word-initial	Expected word-internal	Actual word-internal	
pik͡sík͡siːnaː	*-i-pit͡siːk͡siːnaː	-i-tː͡siːk͡siːnaː	‘snake’
kipita	*-i-kipita	-i-pːita	‘elderly’
kiːpó	*-i-kiːpó	-i-pːo	‘ten’
ponoká	*-i-ponoká	-i-nːoka	‘elk’
ponopaːni	*-i-ponopaːni	-i-nːopaːni	‘quiver’
pinaːp-	*-i-pinaːp	-i-nːaːp-	‘east’
ninaː	*-i-ninaː	-i-nːa	‘man’

Thomson proposes that the word-internal form arose through syncope of the first vowel in the word-initial forms. This was followed by regressive assimilation of the stop-stop or stop-nasal sequence, resulting in the geminate:[19]

(7) Original Word-medial	Syncope	Regressive Assimilation	
*-i-pit͡siːk͡siːnaː	*-i-pt͡siːk͡siːnaː	-i-tː͡siːk͡siːnaː	‘snake’
*-i-kipita	*-i-kpita	-i-pːita	‘elderly’
*-i-kiːpó	*-i-kpó	-i-pːo	‘ten’
*-i-ponoká	*-i-pnoká	i-nːoka	‘elk’
*-i-ponopaːni	*-i-pnopaːni	-i-nːopaːni	‘quiver’
*-i-pinaːp	*-i-pnaːp	-i-nːaːp-	‘east’
*-i-ninaː	*-i-nnaː	-i-nːa	‘man’

[18] Consonant-initial stems are preceded by the connective-/i/ affix when in word-medial position (e.g. Frantz 1991).

[19] The second consonant in the sequence regularly provided the features for the newly produced geminate: e.g. /pt/ > /tː/, /kp/ > /pː/, /pn/ > /nː/.

Regressive assimilation is also attested synchronically, as in the following example from Frantz (1991:150):

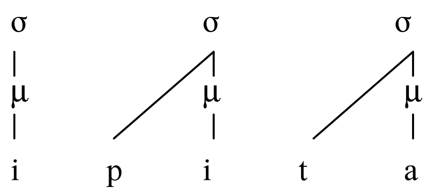
(8) nitánikːa 'he told me'
nit-wanit-k-wa
1-tell-INV-AN.S

This example is productive among words using the inverse suffix; however, to the best of my knowledge, it is the only synchronic environment where geminates are produced. Regardless, the use of this process in environments other than Thomson's snake stems suggests that many of Blackfoot's geminates arose via assimilation.

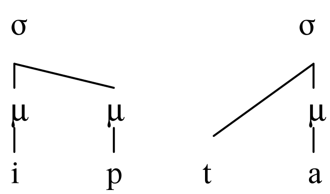
Given that the development of the 'snake stems' above is correct, it is simple to see how syncope and regressive assimilation results in the underlyingly moraic segments present in Blackfoot synchronically. Consider, for example, the progression of /kipita/ 'elderly' under a moraic analysis:

(9) Development of geminates under a moraic analysis

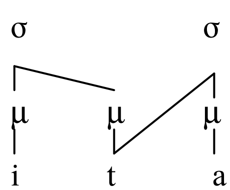
a. Original Form



b. Syncope: /p/ receives a mora by weight-by-position (Hayes 1989)[20]



c. Regressive assimilation of consonant cluster



Even though the two stops are now one segment, the mora is preserved. This assimilation is a form of coalescence (see chapter 6), where the place features of the second segment and the moraic associations of the first segment are preserved.

Geminate /sː/ can additionally be seen to arise synchronically from assimilation in other environments. A common assibilation process is the assimilation of /ix/ to /sː/ (Frantz 1991:153). In the examples below, this results in the intervocalic geminate /sː/ and the preconsonantal geminate /sː/:

---

[20] Alternatively, /p/ could be said to acquire the mora from the lost vowel.

(10) a. pisːini ‘entering’ (Frantz 1991:153)
pi:-xsini
b. isːk ‘pail’ vs. noxk ‘my pail’ (Frantz 1978:312)
Underlying form: /ixk/

This same process also creates consonant clusters:

(11) nitaʔpɛːnaːnsːkaː ‘I am going about acquiring gifts’
nit-aʔp-a-inaːni-xkaː
1S-about-DUR-possess-acquire

The regressive assimilation in (10a) is essentially identical to the other types of geminate assimilation discussed above: moraic /x/ (see discussion in the next section) merges with non-moraic onset /s/, forming an intervocalic moraic segment with the features of /s/. The motivation for the assimilation shown in (10b) and (11) is less clear; variation among speakers and dialects, as well as the effects of fast speech (Frantz n.d.), suggest that sequences of /ix/ are perhaps more easily pronounced as [s]. However, it is at present unclear whether interconsonantal /sː/ is moraic (i.e. syllabic) or whether it is part of a complex onset. These clusters are not discussed in this thesis, and are left to future research.

4.2 /x/

The segment /x/ is exceptional in Blackfoot: unlike most other consonants in Blackfoot, it does not contrast for length. This property can be attributed to its restricted distribution: /x/ is found exclusively in post-vocalic, pre-obstruent position, /VxO/. Historically, this pattern can be derived from a process whereby coda consonants neutralised to /x/ before obstruents. The following examples from Proulx (1989:51) illustrate this development (starred forms are reconstructed):

(12)

PA	Blackfoot	
*-hpani	-o:xpíni	'lung'
*-tpikaji	-o:xpikis	'rib'
*-to:ntani	-otoxtoni	'heel'
*-aʔte:-	ixtsi:	'be located'
*nehk-	ninixk-	'name'
*-tka:tʃi	-o:xkátsi	'leg'
*weθkani	-xkíni	'bone'
*ka:ʃkantamwa	káxtstim	's/he bites it through or off'

As was the case in the development of geminates, this process represents a reduction in the types of consonant clusters available in the language.[21]

Synchronically, /x/ represents one of the few consonants in Blackfoot that can occupy coda position aside from geminates. That the segment does occupy coda position as opposed to forming a complex onset is evident from its effect on preceding vowels, which are always affected in closed syllables. Before /x/, long vowels are shortened while short vowels behave somewhat differently than before geminates and other coda consonants (see section 4.1.1): while they do not become lax, they instead combine with /x/ to form a coalesced segment containing features of both segments: /ix/ > [ç̩], /ox/ > [x̩ʷ], and /ax/ > [x̩]. Moraically, the shortening of long vowels before coda consonants is best analysed as the avoidance of extra-heavy syllables, i.e. those containing three or more moras. The laxing or other alteration of short vowels can similarly be seen as the result of closing the syllable with a consonant, although it is less clear how this process can be accounted for under a moraic analysis.[22] Additionally, perhaps due to its marked nature within the Blackfoot consonant inventory, /x/ is sometimes assimilated to /s/ in certain environments, such as following certain instances of /i/ or preceding /s/ (see discussion in the 4.1).

The other aspect of its distribution—that /x/ only occurs before obstruents—is easily accounted for with reference to the Syllable Contact Law (Murray & Vennemann 1983:520), which is given below:

(9) Syllable Contact Law:

A syllable contact A$B is the more preferred the greater the sonority of the offset *A* and the less the sonority of the onset *B*.

The Syllable Contact Law, as formulated above, does not specifically forbid specific sequences, and different languages may have different thresholds for accepting syllable contact types. For instance, Blackfoot allows sonority to remain level over the syllable boundary (as is obvious from the presence of ambisyllabic geminates); however, the language does not allow sonority to increase over a syllable boundary. Languages such as Korean (Davis & Shin 1999) show similar restrictions, and formalisations of the Syllable Contact Law as an OT constraint often view the constraint as militating against increasing sonority over a syllable boundary (e.g. Davis & Shin 1999, Rose 2000). This topic will be discussed further in 5.4.

---

[21] Note that many of the environments in (12) are identical to those in Thomson's snake stems in (6). These two processes do not contradict one another if it is assumed that they occurred independently at different points in the history of the language.

[22] For example, one possibility would be to assume that the lax vowel and the coda consonant share a mora.

Under moraic theory, the restricted distribution of /x/ in coda position results in a redundancy—the segment is always moraic. As was the case for geminates, the segment /x/ in Blackfoot originated from the neutralisation of coda consonants. In section 4.1.3, I argued that regressive assimilation resulted in an underlyingly specified mora. In the case of /x/, it is unclear whether the segment should be analysed as underlyingly moraic or whether it should be assumed that the segment receives its mora via weight-by-position (i.e. by virtue of being syllabified in coda position). Psychologically, it is logical to assume that the surface manifestation of /x/ as exclusively moraic may have resulted in this redundancy becoming specified in the underlying representation, as is arguably the case for vowels (see discussion in 6.1); however, as the moraicity of /x/ is non-contrastive (as compared to Blackfoot's preconsonantal geminates, see chapter 5), the underlying specification of /x/ is not only impossible to determine, but ultimately of little consequence in understanding of the language.

4.3 Glottal Stop

Glottal stop, like /x/, is also unusual within the Blackfoot consonant inventory because it does not contrast for length and has a restricted distribution. Like /x/, glottal stop is almost exclusively found in coda position, where it can precede any consonant except glottal stop:

(13)	ájoʔka:wa	‘he’s sleeping’
	oʔtakí:wa	‘it is round’
	isákakaʔpiwa	‘it is cherished’
	istawáʔsiwa	‘he grew’
	á:sɛ:ʔniwa	‘he cried’
	kátɔ:ʔmɛ:noawa	‘have you seen him/her yet?’
	aʔpik͡sík:aʔjiwa	‘s/he walked’
	ikoxpiʔwa	‘it swelled’

Unlike /x/, glottal stop’s restricted distribution cannot be attributed to any known historical process, and is most likely due to its inherent phonetic characteristics.[23] Synchronically, in Blackfoot, when glottal stop occurs intervocalically through morphological concatenation, the glottal stop is often ‘moved’ to coda position. This process, termed ‘glottal metathesis’ by Frantz (1991), further suggests that coda position is the preferred position for this segment. Under this process, underlying sequences of /VʔVC/ are realised as [VVʔC], where the VV sequence is subject to the appropriate hiatus resolution strategy (in this case coalescence; for more detailed discussion of vowel hiatus resolution in Blackfoot, see chapter 6):

(14)	Underlying form	Surface form	
	is:kaʔ-iʔtaki	is:kɛ́:ʔtakiwa[24]	‘he was overwhelmed’
	is:kaʔ-omita:-mo:pik:ina:n	is:kɔ:ʔmitɔ́:pik:iniwa	‘she was crazy’
	áʔ-omɛ:ʔtakiwa	ɔ́:ʔmɛ:ʔtakiwa	‘now he believes’

[23] For instance, glottal stop patterns as a sonorant in many languages, both phonetically and phonologically. This seems to be the case in Blackfoot (Elfner 2005), and may contribute to its moraicity (as sonorants are more likely to moraic, e.g. Zec 1995).

[24] A sequence of two glottal stops is realised as a single glottal stop (Frantz 1991:152).

An explanation for this patterning is to assume that glottal stop, like /x/, is preferentially moraic. As such, it is preferentially syllabified in coda position, where its mora can be preserved. If it were syllabified as an onset, its mora would be lost because onsets cannot be moraic. Further arguments supporting this analysis are discussed below.

The behaviour of vowels before glottal stop supports the above claim that /ʔ/ is moraic. Glottal stop behaves like geminates and /x/ by affecting the duration of preceding vowels; however, unlike before geminates and /ʔ/, vowel length is completely neutralised before the segment. It is likely that vowel-/ʔ/ sequences are bimoraic, because compensatory lengthening can occur when /ʔ/ is lost, resulting in a long vowel (Frantz 1991, Van Der Mark 2003, Stacy 2004). Similarly, Frantz (n.d.) notes that the opposite process is common among speakers of the Siksika dialect, whereby long vowels are often replaced by vowel plus glottal stop sequences.

A further testament to glottal stop's moraicity is its incompatibility with /x/, the other consonant in Blackfoot relegated to coda position. When the two consonants are brought together through morphological concatenation, the sequence is remedied either through the deletion of the glottal stop or through vowel epenthesis; this varies among speakers:

(15) Speaker A: kátaʔ-oxtoʔtoːwa > kátɔːʔoxtoʔtoːwa 'did he arrive from there?'
Speaker B: kátaʔ-oxtoʔtoːwa > kátɔːxtoʔtoːwa

Unlike /x/, glottal stop does occasionally occur intervocalically in other environments; however, this is rare. The following list is exhaustive within Frantz and Russell (1989):

(16)	saʔɛ́ː	'duck'
	stáʔɔː	'ghost/spirit'
	niʔíːt͡siʔsaːn	'red ochre'
	ksinaʔoː	'male coyote' (archaic?)
	atóʔaxsim	'sock'
	sáiʔit͡ːsikotoji	'rattlesnake'
	iːʔitːaki	'flay, skin'

Of these, only *duck*, *ghost*, and possibly *red ochre* and *male coyote* (although this word is archaic), are clearly not the result of epenthesis. The word for *sock*, while its morphological division is not clear, is perhaps not subject to metathesis because of the following /x/. Similarly, the words for *rattlesnake* and *flay/skin* are followed by a geminate consonant. Because both geminates and glottal stop are moraic, it is expected that vowel epenthesis might similarly be used to avoid a sequence of moraic consonants.

Presumably, glottal stop is allowed to occur intervocalically only when glottal metathesis is blocked in some way, or perhaps when glottal stop is lexically defined. This appears to be the case for /saʔɛ́ː/ 'duck'; for example, metathesis does not seem to occur even when the word is not in final position, as in /saʔɛ́ːkiʔsomː/ 'duck moon/March'.

The behaviour of /ʔ/ supports the assertion that the segment is underlyingly moraic. However, does /ʔ/ lose its mora in intervocalic position, or does it retain its mora, allowing an onsetless syllable? This question likely cannot be resolved without further research measuring the average length of vowels before glottal stop and determining how these measurements compare to average lengths of short and long vowels in open syllables.

4.4 Conclusion

This chapter provided a preliminary look at segment weight in Blackfoot, providing brief analyses of unquestionably moraic segments. The first segments to be discussed were the intervocalic geminates. They were shown to be well-accounted for under the traditional moraic representation of geminates, which assumes that they are underlyingly moraic and ambisyllabic on the surface. This representation was derived under an OT analysis, where it was argued that the attested representation was motivated by ranking FAITHμ and ONSET above NOCODA and *AMBISYLL. Following this analysis was a brief discussion relating to the origins of geminates in Blackfoot, in order to develop an understanding of how such contrasts came about in the language.

The following sections discussed the distribution and phonotactic behaviour of two exceptional consonants in Blackfoot, /x/ and glottal stop. It was shown in these discussions that the absence of contrastive length in these consonants arises from their restricted distribution, where they occur almost exclusively in coda position. In the case of /x/, this distribution was attributed to its historical origin, while for glottal stop its distribution appeared to be due to its inherent phonetic characteristics, as it was reassigned to coda position when necessary. In both cases, however, the segments behaved as though they were inherently moraic.

Chapter Five: Contrastive Syllabification

Current phonological theory generally assumes that syllabification is absent from underlying representations because it is never used contrastively among the world's languages: tautomorphemic contrasts of the type *a.ka* vs. *ak.a* or *ak.la* vs. *a.kla* have never been convincingly documented (e.g. Blevins 1995, McCarthy 2003). However, it is a matter of debate whether the absence of contrastive syllabification is a universal property of languages, or whether it is simply an empirical problem.

This chapter presents data from Blackfoot which appear to contain tautomorphemic contrasts in syllabification, and discusses the implications of the data for the debate raised above. While apparently filling a typological gap in syllabification patterns, I show that the syllabification contrasts found in Blackfoot do not require the specification of syllable structure in the underlying representation. Instead, I propose that the data can be accounted for by assuming that moras are specified in the underlying representation, and that contrastive syllabification is the means by which Blackfoot speakers retain these underlying moraic contrasts on the surface. By assuming that weight rather than syllabification is contrastive, the analysis fulfills implicit predictions made by moraic theory, which already assumes that moras can be used contrastively. In addition, the moraic analysis accounts for some of the phonotactic and phonetic patterns specific to Blackfoot, patterns which receive only an arbitrary treatment under a syllabic account.

5.1 Preconsonantal Geminates

As discussed previously, Blackfoot's relatively small phoneme inventory is expanded by a large number of length contrasts:

(10) *Blackfoot Phoneme Inventory*

	Labial	Coronal	Dorsal	Glottal
Stops	p pː	t tː	k kː	ʔ
Fricatives		s sː	x	
Affricates		t͡s t͡ːs	k͡s k͡ːs	
Nasals	m mː	n nː		
Glides	w	j		

Vowels		
i iː		
		o oː
	a aː	

Like many other languages, Blackfoot contrasts length intervocalically (see 4.1). More unusually, however, Blackfoot also contrasts consonant length preconsonantally in two environments: /s/ before stops (3) and stops before /s/ (4):

(11)	istawáʔsiwa	'he grew'	isːtatánsiwa	'he bragged'
	ɛ́stokaːsiwa	'he's tripping'	ɛ́sːtaxpikoxkoisːk͡sniʔpawa	'he wants to find out about it'
(12)	ipiksit	'flee'	ipikːsit	'be anxious'
	aksín	'bed'	ikːítstakːsin	'offering'
	nítsikstaki	'I bit'	oxpatótːsin	'appendix'
	otoxsistsínáji	'he is her next youngest sibling'	k͡sistːsit	'be hopeful'
	sit͡sípsat͡sisa	'speak to him'	ikípːsak͡siwa	'he briefly went out'

Phonotactics and phonetic duration suggest that the consonant sequences are treated differently with respect to syllable weight, and are syllabified differently; short segments are syllabified tautosyllabically with the following segment as a complex onset (/i.stawáʔsiwa/ 'he grew', /ipi.ksit/ 'flee'), while their long counterparts are not.

5.2 Contrastive Syllabification in Blackfoot as Mora Preservation

5.2.1 Representations

In chapter 4, both contrastive vowel length and intervocalic gemination in Blackfoot were shown to be well accounted for under a traditional moraic analysis of these phenomena, where underlyingly specified moraic contrasts were assumed. In this section, I turn to the somewhat unusual preconsonantal consonant length contrasts found in Blackfoot, and propose that these length contrasts can be accounted for in precisely the same way as the more commonly found length contrasts—by assuming that these contrasts arise from underlyingly specified moraic associations.

For example, recall the preconsonantal length contrast for the phoneme /s/, as in the following words:

(13)	a.	is:tatánsiwa	‘he bragged’
	b.	istawáʔsiwa	‘he grew’

Under a moraic analysis, these two words contrast underlyingly via the moraic status of /s/ in the underlying representation, as illustrated below:

```
(14)  a.  /is:tatánsiwa/ ‘he bragged’      b.  /istawáʔsiwa/  ‘he grew’

          μ     μ        μ                     μ               μ
          |     |        |                     |               |
          i     s    t   a  …                  i     s    t    a  …
```

As in the analysis of intervocalic geminates, syllabification is applied to the underlying representations with the goal of preserving the underlying moraic structure while creating an unmarked syllable structure. In (14a), underlyingly moraic /s/ is syllabified in a weight-bearing position (coda position), as was the case for intervocalic geminates. However, unlike intervocalic geminates, the syllabification of the moraic consonant in coda position does not create an onsetless syllable: the following consonant fills this role. Because the onsetless syllable was proposed to be responsible for the ambisyllabicity of intervocalic geminates, it is predicted by this analysis that preconsonantal geminates need not be ambisyllabic, and may be syllabified simply as a coda consonant. This representation is illustrated in (15a) below.

On the other hand, underlying non-moraic preconsonantal /s/ as in (14b) must be syllabified in a position where it can preserve its weightlessness. I propose that it is syllabified as part of the onset of the following syllable, forming a complex /s/-stop onset, which is also attested word-initially in Blackfoot (e.g. /stamik/ ‘steer’). This analysis avoids introducing weightless codas to Blackfoot, for which there is no evidence.

The proposed surface representations of the structures in (14) are illustrated below:

(15) Surface representations of underlying representations in (14)

a. /isːtatánsiwa/ ‘he bragged’ b. /istawáʔsiwa/ ‘he grew’

Side by side, these two independently motivated representations result in what is superficially contrastive syllabification, but which are actually derived via underlying moraic contrasts.

5.2.2 OT Analysis

These representations are easily derived via the OT constraints discussed in 4.1.2, where it was argued that the ranking FAITHμ, ONSET » *AMBISYLL, NOCODA was responsible for deriving intervocalic geminates from underlyingly moraic consonants. Owing to the different environment, however, ONSET is less relevant, and an additional constraint is required to forbid the syllabification of both consonants in onset position, *COMPONS:

(16) *COMPONS: onsets must be limited to a single consonant.

As well, to prevent the syllabification of non-moraic consonants in coda position, a constraint denoting the weight-by-position principle (Hayes 1989) is necessary:

(17) WBYP: coda consonants must be moraic.

In the case of preconsonantal non-moraic /s/, *COMPONS is violated to prevent a violation of FAITHμ or WBYP, which are also ranked highly. This tableau shows that *COMPONS is ranked below the three high-ranked constraints (FAITHμ, WBYP, and ONSET):

(18)

i_μ s t a_μ	FAITHμ	WBYP	ONSET	*COMPONS	*AMBISYLL	NOCODA
$_\sigma[i_\mu\ s_\mu]\ _\sigma[t\ a_\mu]$	*!					*
$_\sigma[i_\mu\ s]\ _\sigma[t\ a_\mu]$		*!				*
☞ $_\sigma[i_\mu]\ _\sigma[s\ t\ a_\mu]$				*		

In the case of preconsonantal moraic /sː/, this constraint ranking predicts the correct representation:

(19)

i_μ s_μ t a_μ …	FAITHμ	WBYP	ONSET	*COMPONS	*AMBISYLL	NOCODA
$_\sigma[i_\mu]$ $_\sigma[$s t $a_\mu]$	*!			*		
☞ $_\sigma[i_\mu$ $s_\mu]$ $_\sigma[$t $a_\mu]$						*

In conclusion, it was shown that the contrastive syllabification patterns found in Blackfoot are predicted using commonly-used syllable structure constraints, the same that were used to justify the ambisyllabic representation of intervocalic geminates. Two new constraints were introduced—WBYP and *COMPONS—which were necessary given the different environment of preconsonantal segments as compared to intervocalic segments.

5.3 Evidence

This section considers evidence from orthography, phonotactics, and phonetics which supports the phonological representations of both intervocalic and preconsonantal geminates in Blackfoot. This evidence is organised into two tables: the first compares the various environments in which /s/ can occur, and the second compares the various environments for stops.

The phoneme /s/ can occur in a variety of environments in Blackfoot: intervocalically, preconsonantally, postconsonantally and interconsonantally. Up to this point, two of these environments have been examined: the intervocalic environment and the preconsonantal (postvocalic) environment, where /s/ contrasts in terms of its moraicity. The table presented below compares nonmoraic and moraic /s/ in both of these environments, according to a variety of factors, including orthographic representation, various phonotactic patterns, and its phonetic duration. As is clearly demonstrated by the table, the moraicity of the segment is reflected in these factors, such that segments pattern according to moraic associations, regardless of environment:

(20)

	Pre-C /s/	Intervocalic /s/	Pre-C /sː/	Intervocalic /sː/
Example	/istawáʔsiwa/ ‘he bragged’	/isináʔsiwa/ ‘he was busy’	/isːtatánsiwa/ ‘he grew’	/isːapjáʔtsis/ ‘telescope’
Phonological Representation	non-moraic onset	non-moraic onset	moraic coda	moraic, ambisyllabic
Orthography	<s> *istawá’siwa* ‘he bragged’	<s> *isiná’siwa* ‘he was busy’	<ss> *isstatánssiwa* ‘he grew’	<ss> *issapia’tsis* ‘telescope’
Phonotactics				
a. Vowel length	Vː remain long	Vː remain long	Vː > V	Vː > V
b. Vowel quality	V remain tense	V remain tense	V > lax	V > lax
c. Distribution	Limited distribution: [ist][25], *[ast, ost] ?[isk], *[ask, osk] *[Vsp]	Intervocalic	Equal before all stops: /sːp/, /sːt/, /sːk/	Intervocalic
	Can precede geminate [tː]: /istːoan/ ‘knife’[26]		Cannot precede geminates: */sːCː/	
d. Word-initial	Attested: /stamik/ ‘steer’	Attested: /sik͡siká/ ‘Blackfoot’	Usually preceded by epenthetic /i/: /isːtaːt/ ‘wish’	Usually preceded by epenthetic /i/: /isːiːstsit/ ‘bathe’
Phonetic duration[27]	Shorter than both pre-C /sː/ and intervocalic /sː/	Shorter than intervocalic /sː/	Longer than pre-C /s/, shorter than intervocalic /sː/	Longer than all other varieties of /s/ and /sː/

---

[25] [ist] arises from preassibilation: it > ist

[26] Preassibilation environment.

[27] Evidence relating to phonetic duration is based on a preliminary study undertaken by the author. In this study, average duration of consonants in the four different environments were measured, both for /s/ and the stop /k/ (see below). Three tokens of two words were measured for each environment, where average duration of the tokens were averaged with the measurements of the two words. A full statistical analysis has not been performed, owing to the small number of tokens; however, the average values of the data are as follows: /VsC/: 91.3ms; /VsːC/: 191.9ms ; /VsV/: 169.1ms; /VsːV/: 336.0ms

Additionally, the contrastive syllabification analysis is supported by preliminary work on the Blackfoot syllabic orthography, a writing system which has now been replaced by the roman alphabetic orthography designed by Frantz (see Frantz 1978). Ermineskin and Howe (2005), in a study of Blackfoot documents written using the syllabary, identify what they term the “Law of Finals”, an observation that coda consonants are often omitted in syllabic writing systems. In Blackfoot, they observe that preconsonantal moraic /sː/ (as in /isːtatánsiwa/ ‘he bragged’) is often omitted by Blackfoot speakers using the orthography, while preconsonantal moraic /s/ (as in /istawáʔsiwa/ ‘he grew’) is not omitted. This finding suggests preconsonantal length contrasts are correctly analysed as syllabification contrasts.

As is clear from the above table, there is considerable evidence supporting the differentiation of two types of segments both intervocalically and preconsonantally, and also that this difference is correctly defined as one of contrasting moraicity and syllabification.

Stops can also occur in a variety of environments and preserve underlying moraic contrasts. The following table compares stops in two environments (intervocalic and preconsonantal) and demonstrates the similar patterning of moraic versus non-moraic stops in both environments:

(21)

	Pre-C /p, t, k/	Pre-vocalic /p, t, k/	Pre-C /pː, tː, kː/	Pre-vocalic /pː, tː, kː/
Example	/ipiksit/ ‘flee’	/ɛ́kaxtsiwa/ ‘he is gambling’	/ipɪkːsit/ ‘be anxious’	/ikːamíʔniwa/ ‘he fainted’
Phonological Representation	non-moraic onset	non-moraic onset	moraic	moraic, ambisyllabic
Orthography	<p, t, k> *ipikssit*	<p, t, k> *áíkahtsiwa*	<pp, tt, kk> *ipikkssit*	<pp, tt, kk> *ikkamí’niwa*
Phonotactics				
a. Vowel length	Vː remain long	Vː remain long	Vː > V	Vː > V
b. Vowel quality	V remain tense	V remain tense	V > lax	V > lax
c. Distribution	Can be preceded by moraic coda consonants /ʔ/ & /x/:[28] /kaːx.tsín/ ‘game’ /piːʔksíː/ ‘bird’ /saːx.psit/ ‘boil it’	Can be preceded by moraic coda consonants /ʔ/ & /x/: /iːxtɛːpiːʔpojoʔp/ ‘telephone’ /isːpaxko/ ‘hill’ /omaxkoxpokón/ ‘big ball’	Never preceded by either /ʔ/ or /x/: */xpːs, xtːs, xkːs/	Never preceded by either /ʔ/ or /x/: */xpːV, xtːV, xkːV/
	Can occur within C sequences: /kítspsksínimáʔtsoːka/ ‘he taught you at a higher level’	Prevocalic	Only occurs post-V, & at beginning of C sequences: /ikːstskjomitaː/ ‘greyhound bus/dog’	Prevocalic
Phonetic duration[29]	Shorter than both pre-C [pː,tː,kː] and interV [pː,tː,kː]	Shorter than pre-V [pː,tː,kː]	Longer than pre-C [p,t,k], same as interV [pː,tː,kː]	Longer than [p,t,k], same as pre-C [pː,tː,kː]

As was the case for /s/, it is clear that there is support for identifying a preconsonantal moraic contrast. One point in the above table deserves some consideration. If indeed

[28] /x/ occurs exclusively in coda position, /ʔ/ almost exclusively; both are moraic. See previous chapter.

preconsonantal moraic stops receive the same representation as preconsonantal /sː/, as a tautosyllabic coda consonant, it is unexpected that preconsonantal moraic stops should be equal in duration to their intervocalic counterparts, while preconsonantal moraic /sː/ was shorter in duration. I propose in the next section that representing preconsonantal moraic stops as ambisyllabic rather than as tautosyllabic coda consonants, as was the case for moraic preconsonantal /sː/, can provide a possible explanation for this asymmetry.

5.4 Gemination in Stop-/s/ Sequences

Above, it was argued that the contrastive syllabification patterns in Blackfoot can be derived from the assumption that superficial length contrasts originate from underlying moraic contrasts. I proposed that preconsonantal geminates need not be specified as ambisyllabic owing to the fulfillment of the onset constraint by the following consonant. However, the analysis did not exclude the possibility that ambisyllabicity could indeed arise in these environments if it were motivated by some other constraint. This section discusses the phonetic properties of the two types of preconsonantal geminates found in Blackfoot, /sː/ followed by a stop and geminate stop followed by /s/, and argues that the longer duration of preconsonantal geminate stops as compared to preconsonantal /sː/ can be captured by assuming different syllable structures.

---

[29] These phonetic generalisations are also based on a similar preliminary phonetic study undertaken by the author, using the same method. The average values for /k/ are as follows:/VkC/: 134.7ms; /VkV/: 119.8ms; /VkːC/: 320.4ms; /VkːV/: 288.5ms

The difference in representation between the non-ambisyllabic structure of preconsonantal geminate /sː/ as given above in (15a) and the ambisyllabic structure of intervocalic geminate /sː/ (section 4.1) is corroborated by durational evidence: the duration of preconsonantal geminate /sː/ is intermediate between non-moraic preconsonantal /s/ and the intervocalic geminate /sː/. That the different phonological representations motivate the durational difference seems a reasonable explanation, especially when the duration of preconsonantal geminate stops are considered.

While no detailed phonetic studies have been performed investigating this question, my preliminary study (see fn. 27 and 29 above) suggests that the duration of preconsonantal geminate stops in Blackfoot (e.g. /ipikːsit/ 'be anxious') is roughly equal to their duration intervocalically (e.g. /ikːamíʔniwa/ 'he fainted'). Above, it was argued that the phonological representation of preconsonantal geminate /sː/ differed from the phonological representation of intervocalic geminate /sː/, and that this difference was corroborated by durational evidence. In contrast to preconsonantal geminate /sː/, the durational evidence suggests that preconsonantal geminate stops are not simple coda consonants but true geminates, being both moraic and ambisyllabic. This is illustrated in the following representations of /ipikːsit/ 'be anxious':

(22) Underlying and surface representations of /ipikːsit/ 'be anxious'

a. Underlying Representation b. Surface Representation

However, unlike intervocalic geminates, the ambisyllabic structure of (22b) cannot be motivated by a dispreference for onsetless syllables. As discussed above, the preconsonantal nature of the preconsonantal geminates eliminates the need for ambisyllabicity owing to the avoidance of onsetless syllables: in (22b), the syllabification of /s/ in onset position presumably fulfills this constraint.

I propose that the structure in (22b) is motivated by another syllable structure consideration, namely, the 'Syllable Contact Law' (Murray & Vennemann 1983:520), repeated from section 4.2:

(23) Syllable Contact Law:
A syllable contact $A^{\$}B$ is the more preferred the greater the sonority of the offset *A* and the less the sonority of the onset *B*.

Placing the syllable boundary between /k/ and /s/ as in /ipik.sit/ results in a suboptimal syllable contact because sonority increases over the syllable boundary. Blackfoot improves syllable contact by geminating the stop such that sonority remains level across the syllable boundary.[30] This analysis is supported by evidence throughout the phonotactics of the language which demonstrate that syllable contact is never violated in the language (see Elfner 2005).

In terms of OT, this representation is predicted if a new constraint is introduced reflecting the preferential structures of the syllable contact law. There has been some debate as to the best way to formulate this law as a constraint, and there has been considerable variety in the interpretation of this law in terms of OT (Davis & Shin

[30] See Murray & Vennemann (1983) for a similar analysis in Germanic.

1999, Rose 2000, etc.). The preference law, as it is formulated by Murray and Vennemann (1983), denotes a scale where some violations of the contact law are deemed “worse” than others. It also suggests that different languages will have different degrees of tolerance for various syllable contact patterns. Blackfoot, for instance, disallows any syllable contact patterns where sonority increases over the syllable boundary, but will allow sonority to remain level across the syllable boundary, as occurs with geminates.

The most correct OT formulation of the syllable contact law as it is put forth in Murray and Vennemann (1983) might be one in which a ranked family of constraints is assumed, with the worst contacts universally ranked more highly than other contacts. Rose (2000), for instance, proposes two versions of the syllable contact constraint, one more stringent in its demands than the other. For the purposes of this thesis, I will simply assume that the syllable contact patterns found in Blackfoot form the essence of the constraint:

(24) SYLLCON: sonority cannot increase over a syllable boundary.

This particular formulation may not accurately predict the patterns found in other languages. In addition, it makes no assertion as to whether certain violations are ‘worse’ than others. It is, however, sufficient for the discussion of the Blackfoot patterns at hand.

I argued above that a violation of SYLLCON in a stop-/s/ sequence forces gemination and an ambisyllabic structure. SYLLCON must therefore be ranked above the lowly ranked constraints, *COMPONS, *AMBISYLL and NOCODA:

(25)

… p i_μ k_μ s i_μ …	FAITHμ	ONSET	WBYP	SYLLCON	*COMPONS	*AMBISYLL	NOCODA
$_\sigma$[p i_μ] $_\sigma$[k s i_μ]	*!				*		
$_\sigma$[p i_μ k_μ] $_\sigma$[s i_μ]				*!			*
☞ $_\sigma$[p i_μ k_μ] $_\sigma$[k s i_μ]					*	*	*

The next section discusses the syllabification of non-moraic preconsonantal stops.

5.5 Non-moraic Preconsonantal Stops

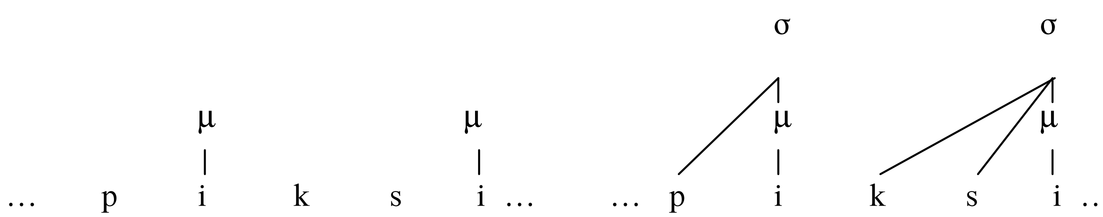
It is now a simple matter to extend the analysis developed above to propose representations of short preconsonantal stops, as in /ipiksit/ 'flee': in contrast to their long counterparts (/ipɪkːsit/ 'be anxious'), they are underlying non-moraic. Additionally, in parallel to non-moraic preconsonantal /s/, phonotactic evidence, as well as the syllable contact law (see section 5.4) and weight-by-position (Hayes 1989), argue in favour of syllabifying non-moraic preconsonantal stops as part of a complex onset rather than as a weightless coda:[31]

---

[31] However, while stop-/s/ complex onsets are (arguably) legitimate onsets word-medially, they do not appear to occur word-initially. While many words begin with /t͡s/ and /k͡s/ affricates (see discussion below, in this section), sequences containing a stop followed by longer /s/ are not listed in Frantz and Russell (1989). The solution to this problem is not apparent at the present; however, it is interesting to note that Blackfoot does demonstrate edge-effects in other parts of the grammar (e.g. deletion of word-initial glides, see 6.2.2). This problem remains an intriguing topic for future research.

(26) Underlying and surface representations of /ipiksit/ ‘flee’

a. Underlying Representation b. Surface Representation



Interestingly, the tautosyllabification of the stop and /s/ as in (26b) creates a contrast between complex stop-/s/ onsets, and Blackfoot’s /t͡s/ and /k͡s/ affricates. Phonetically, this is manifested as a post-consonantal length contrast, where the segmental /s/ is longer in duration than affricate /s/ (see also 3.4.1):[32, 33]

(15)	a.	nítsiʔkaki	‘I kicked’	*nítssi’kaki*
		niːt͡sít͡sikín	‘mocassin’	*niitsítsikín*
	b.	kaːxtsín	‘game’	*kaahtssín*
		kaːxt͡sít	‘gamble’	*kaahtsít*
	c.	aksín	‘bed’	*akssín*
		áak͡sikamiʔniwa	‘he will faint’	*áaksikami’niwa*
	d.	ninixksini	‘song’	*ninihkssini*
		ipaxk͡sikɛːmo	‘stink like feet’	*ipaxksikaimo*
	e.	amɛ́ipsi	‘belt’	*amáíipssi*
	f.	saːxpsit	‘boil it’	*saahpssit*
		*p͡s		

This contrast serves the dual purpose of supporting the claim that stop-long /s/ clusters are legitimate onsets in Blackfoot, as well as the assertion that /k/-short /s/ clusters are

[32] Orthographically (e.g. Frantz 1978, 1991; Frantz & Russell 1989), stop-/s/ sequences are transcribed with long *ss*, while stop-/s/ affricates are transcribed with short *s*.

[33] This contrast is found in several word-medial environments: intervocalically, following moraic or non-moraic /s/, following /x/ and /ʔ/.

best analysed as affricates. It further eliminates the possibility that stop-long /s/ clusters can be analysed as affricates.

In terms of OT, the representation in (26b) is once again predicted by the constraint ranking discussed in previous sections, and no new constraints need be proposed:

(27)

… p i_μ k s i_μ …	FAITHμ	ONSET	WBYP	SYLLCON	*COMPONS	*AMBISYLL	NOCODA
$_\sigma$[p i_μ k_μ] $_\sigma$[s i_μ]	*!			*!			*
$_\sigma$[p i_μ k] $_\sigma$[s i_μ]			*!	*!	*		
$_\sigma$[p i_μ k_μ] $_\sigma$[k s i_μ]	*!				*	*	*
☞ $_\sigma$[p i_μ] $_\sigma$[k s i_μ]					*		

In this case, the candidate with the weightless coda (/ipik.sit/) not only violates WBYP but also SYLLCON. This provides additional support for the contrastive syllabification analysis proposed in this chapter.

5.6 Preconsonantal Nasals: Neutralisation of Underlying Moraic Contrasts

The discussion to this point has proposed that word-medial stop-/s/ and /s/-stop clusters preserve underlying moraic contrasts by employing contrastive syllabification on the surface. The usefulness of contrastive syllabification as a means of mora preservation arises from the language-specific phonotactics of Blackfoot, which allow such clusters to be syllabified either heterosyllabically or as complex onsets, with the modification of gemination for stops. The strong prediction arising from this analysis is that no preconsonantal length contrasts will be found in environments where contrastive syllabification is ruled out by phonotactic constraints forbidding the syllabification of the cluster as a complex onset.

This prediction is manifested within Blackfoot when another environment is considered: nasals followed by /s/. Contrary to their behaviour intervocalically, where geminate nasals contrast with non-geminate nasals, no length contrast is found preconsonantally:

(28)	a.	ninaː	'man/chief'	ninːa	'my father'
	b.	imitaː	'dog'	imːiwa	'it was deep'
(29)	a.	isˑtatán.siwa	'he bragged'		
		sim.sin	'drink'		
	b.	*/V.ns/, /Vnːs/, etc.			

In accordance with the analysis developed in this chapter, I propose that no length contrast is possible in this preconsonantal environment because the sequence nasal-/s/ does not form a legitimate complex onset in Blackfoot, presumably because it does not adhere to the SSP (see 3.3). As such, the nasal is uniformly syllabified in coda position whether it is underlyingly moraic or not. It follows that the nasal becomes uniformly moraic in this environment: if it is underlyingly moraic, the mora is preserved in coda position; if it is not, the mora is added to the surface representation via weight-by-position (Hayes 1989).

Pre-consonantal nasals demonstrate that underlying moraic contrasts are neutralised if "contrastive syllabification" is not a possibility; in other words, if the sequence in question cannot be syllabified both heterosyllabically and as a complex onset. The neutralisation of moraic contrasts for preconsonantal nasals therefore serves to support the assertion that contrastive syllabification is used to preserve these contrasts for pre-consonantal stops and /s/, as opposed to a contrast in coda weight.

The neutralisation of nasals preconsonantally can be derived using the constraint hierarchy for Blackfoot discussed in this chapter, provided that a constraint is introduced to rule out nasal-/s/ onsets. An obvious way to rule these out would be to introduce an OT constraint formalising the SSP, as in Morelli (2000:22):

(30) SSP: Sonority increases towards the syllable peak and decreases towards the syllable margins.

However, a problem arises when it is considered that /s/-stop onsets also violate the SSP, and it is difficult to determine how this should be addressed. Morelli (2000) suggests dividing the SSP constraint in two separate constraints, *REVERSAL and *PLATEAU:

(31) a. *REVERSAL: sonority reversals are disallowed in onsets (i.e. sonority cannot decrease)
b. *PLATEAU: sonority plateaus are disallowed in onsets (i.e. sonority cannot be level)

Morelli (2000) uses these two constraints to provide a sonority-based argument in favour of the relative typological unmarkedness of /s/-stop onsets. However, her analysis crucially assumes that stops and fricatives are considered to be of equal sonority, meaning that obstruent clusters violate *PLATEAU and not *REVERSAL. Such an analysis would solve the problem of onsets in Blackfoot, were it not for the discussion in the previous section where it was argued that underlyingly moraic stops geminate before /s/ because of the difference in sonority between the two segments results in a suboptimal syllable contact.

If a similar analysis is to be applied to Blackfoot, it will be necessary to make some assumptions regarding the relative sonority of segments. First of all, recall that sonority is a relative term, and based on general phonetic properties rather than a single feature. The 'sonority' of a segment may therefore be dependent on a number of different factors. Consider /s/, for example, which is voiceless, resulting in its relatively low sonority (i.e. when it is included with other voiceless fricatives). In Blackfoot, this voicelessness helps to create a clear division between the less sonorous obstruents and the more sonorous sonorants. However, /s/ is also a sibilant, with a relatively high intensity when compared to other obstruents; its internal phonetic perceptual cues are therefore stronger, as well. In this way, /s/ is more likely to occur in environments where other consonants are too weak to occur—word-initially as part of a complex obstruent cluster, for instance, as argued by proponents of the licensing-by-cue approach (Steriade 1997, Wright 2004).

It is perhaps not contradictory, therefore, to suggest that /s/ and stops, while differing in sonority, are perhaps close enough in sonority that onset clusters of these segments are not judged as harshly by Blackfoot speakers as are true sonority reversals, such as a sonorant-obstruent onset.[34] As a temporary solution to the problem at hand, I therefore propose incorporating Morelli's (2000:27) constraint *REVERSAL, and

---

[34] Interestingly, Blackfoot *only* allows complex onsets consisting of obstruents. Blackfoot does not allow so-called 'core clusters', i.e. SSP-friendly complex onsets such as obstruent-sonorant clusters. This thesis does not attempt to offer an explanation for this gap.

assuming that sequences of obstruents do not violate this constraint, even if they do differ in sonority to some extent. To account for nasal weight neutralisation, it is sufficient to rank *REVERSAL above FAITHμ:

(32)

… a_μ n s i_μ …	ONSET	SYLL CON	*REVERSAL	WBYP	FAITHμ	*COMP ONS	*AMBISYLL	NOCODA
$_\sigma[a_\mu]$ $_\sigma[$n s $i_\mu]$			*!			*		
$_\sigma[a_\mu$ n$]$ $_\sigma[$s $i_\mu]$				*!				*
☞ $_\sigma[a_\mu$ $n_\mu]_\sigma[$s $i_\mu]$					*			*

5.7 Theoretical Implications

5.7.1 Contrastive Weight vs. Contrastive Syllabification

This chapter has argued that while Blackfoot does show superficial contrastive syllabification, the data can be accounted for using moraic theory, where contrasts in syllabification arise as a strategy to preserve underlyingly specified moras. In other words, the above analysis has proposed that the phenomenon in question is actually a surface manifestation of contrastive syllable weight, and is not true contrastive syllabification. However, the differences in typological predictions between the moraic account proposed here and a theoretical syllabic account, where syllabification is specified in the underlying representation and subject to faithfulness constraints, have not yet been discussed. This section makes clear some of the different predictions made by the two theories in terms of possible typological systems.

As discussed above, moraic faithfulness in Blackfoot interacts with two syllable structure preferences/constraints, both of which are highly ranked. These included a constraint preferring syllables to have onsets and the syllable contact law. Under an OT analysis, the moraic account predicts the following systems should be possible under different constraint permutations, given that moraic faithfulness is highly ranked in the language:

(33) Possible "contrastive syllabification" systems as predicted by moraic theory, given ranking of constraint (high vs. low); underline indicates a moraic segment (see section 5.7 for possible interpretations of Swedish and English).

	ONSET = high		ONSET = low	
SYLLCON = high	i.ka i.ksa i.ska	i$\underline{k}$.ka i$\underline{k}$.ksa i$\underline{s}$.ka = Blackfoot	35	
SYLLCON = low	i.ka i.ksa i.ska	i$\underline{k}$.ka i$\underline{k}$.sa i$\underline{s}$.ka = Swedish?	i.ka i.ksa i.ska	i$\underline{k}$.a i$\underline{k}$.sa i$\underline{s}$.ka = English?

As in Blackfoot, the moraic account predicts that underlying moras are retained by syllabification in coda position, while a segment's ambisyllabicity changes depending on language-specific syllable structure preferences.

A possible complication arises when it is considered that other constraints may come into play, such as weight-by-position. For example, as is shown in the Swedish data discussed below, some languages allow weightless codas, meaning that contrasting weight in coda position may be preferable to contrastive syllabification. However, this development is ultimately not problematic, as it is a language-specific preference. If it is indeed moraic faithfulness which is crucial, and not syllabic faithfulness, such languages should still be considered a part of the predicted typology if the preserved moras contrast pre-consonantally on the surface.

On the other hand, the syllabic account makes somewhat different predictions. For instance, we might expect that ambisyllabicity could be encoded in the underlying representation, resulting in not only a two-way syllabic contrast as suggested in the introduction, but a three-way contrast in syllabification (i.ka, ik.a, ik.ka/i.ksa, ik.sa, ik.ksa). Moraic theory predicts that a single language with a three-way contrast in syllabification could not exist, as ambisyllabicity is used as a reparative measure rather than as a contrastive feature.

The moraic account, rather than the syllabic account, correctly predicts the system found in Blackfoot as well as other attested systems (see next section). The above discussion predicts that a language with a three-way contrast in syllabification would provide evidence for true contrastive syllabification, as such a language would be incompatible with the moraic account proposed above. The patterns found in Blackfoot therefore do not provide evidence for true "contrastive syllabification", but do however provide evidence that contrastive syllabification can indeed arise from contrastive weight.

5.7.2 Typological Implications

Even if syllabification is not specified in the underlying structure, Blackfoot still fills a typological gap in terms of what is possible under moraic theory. For example,

---

[35] *ik.a, ik.ksa,* etc. are impossible because SYLLCON must be low for *ik.a,* high for *ik.ksa.*

Morén (1999) notes that moraic theory predicts a system where coda consonants contrast between weight-bearing and weightless:

> ‘There is yet one more pattern that can result from ranking the constraints under discussion… This pattern has distinctive intervocalic consonant moraicity where ambisyllabic codas contribute to syllable weight [i.e. intervocalic geminates], and non-ambisyllabic coda consonants that contribute to syllable weight or not depending on whether or not they are underlyingly moraic… It is an empirical issue as to whether this type of language exists.’ (Morén 1999:388-391)

Similarly, McCarthy (2003) questions whether phonological theory should be altered to make the generation of such languages impossible:

> It is widely though not universally accepted that contrasts of quantity and syllabicity are represented by deploying moras in the underlying representations […] To complete the picture, though, it is necessary to show that faithfulness to underlying moras does not offer a back-door into the non-occurring *pa.ta/pat.a* or *pak.la/pa.kla* contrasts. (McCarthy 2003:60)

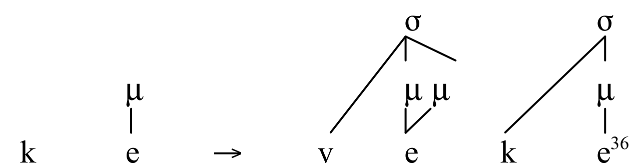
A language like Blackfoot poses the question of whether or not Blackfoot is alone in allowing the preservation of moras to result in contrastive syllabification: have these languages simply not been discovered yet? Or have existing analyses overlooked these possibilities?

While more research remains to be done with the possibility of contrastive weight in mind, I will discuss here two possible language parallels: Swedish (Morén 1999:392-393) and English (Chomsky & Halle 1968:83, Wells 1990, Alcántara 1998, Hammond 1999). Above, I proposed that Swedish and English can be used to fill out the typological table proposed in (33); a brief discussion of these languages is given below.

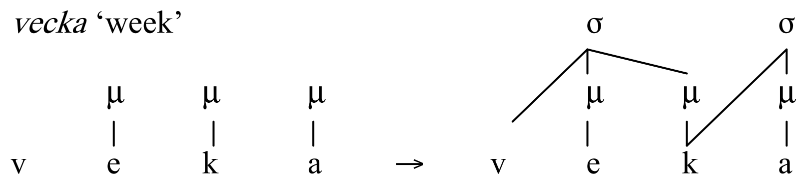
5.7.2.1 Swedish

Swedish, like Blackfoot, contrasts moraicity intervocalically via a geminate/non-geminate contrast (Morén 1999:392-393):

(34) a. *veke* ‘wick’



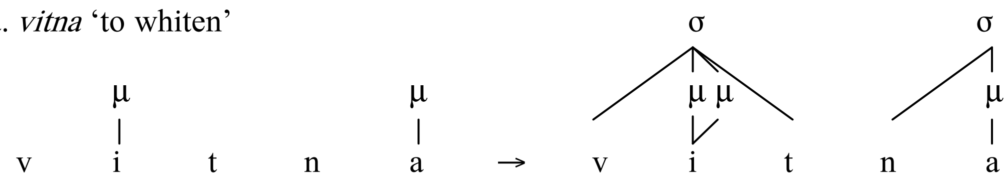
b. *vecka* ‘week’



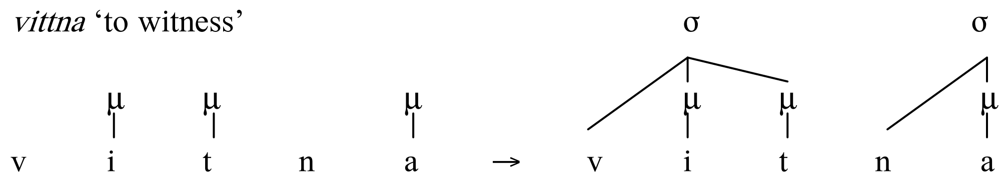
Preconsonantally, moraic contrasts are preserved, but are, however, not subject to gemination, presumably because syllable contact is not ranked highly in the language (cf. Morén 1999:392-393):

[36] Swedish requires stressed syllables to be bimoraic; stressed short vowels are lengthened in the absence of coda weight (Morén 1999:392).

(35) a. *vitna* ‘to whiten’



b. *vittna* ‘to witness’



As discussed in the previous section, Swedish resembles Blackfoot because the language ranks FAITHμ highly.

(36)

v e_μ k_μ a_μ	FAITHμ	ONSET	*AMBISYLL	NOCODA
$_\sigma$[v e_μ] $_\sigma$[k a_μ]	*!			
$_\sigma$[v e_μ k_μ] $_\sigma$[a_μ]		*!		*
☞ $_\sigma$[v e_μ k_μ] $_\sigma$[k a_μ]			*	*

As predicted in the previous section, Swedish lacks preconsonantal geminates because SYLLCON is ranked lowly. As was the case for preconsonantal moraic /s/ in Blackfoot, Swedish preconsonantal moraic consonants are syllabified as simple coda consonants:

(37)

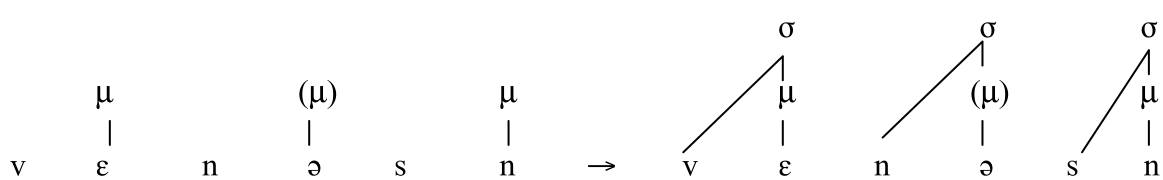
v i_μ t_μ n a_μ	ONSET	FAITHμ	*AMBISYLL	SYLLCON	NOCODA
$_\sigma$[v i_μ t_μ] $_\sigma$[t n a_μ]			*!		*
☞ $_\sigma$[v i_μ t_μ] $_\sigma$[n a_μ]				*	*

The above tableau suggests that intervocalic geminates are avoided due to the ranking *AMBISYLL » SYLLCON. It is, however, possible that the onset /tn/ is avoided in Swedish, which would also eliminate the alternate possibility in the above tableau. A more complete analysis of Swedish is beyond the scope of this thesis; regardless, it is of interest that Swedish avoids preconsonantal gemination even when SYLLCON is violated, offering a contrast to Blackfoot.

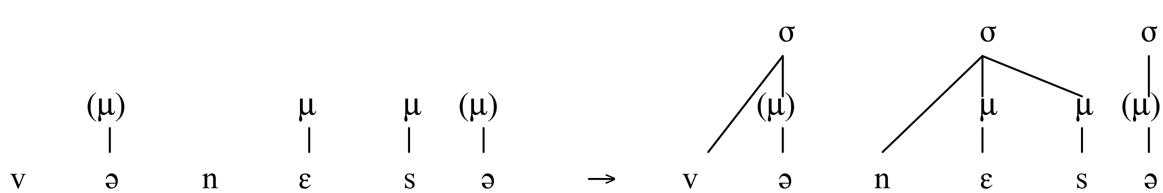
5.7.2.2 English

English, on the other hand, does not geminate consonants either intervocalically or preconsonantally. However, certain alternations in stress patterns can be accounted for if moras are assumed to be underlyingly specified (Chomsky & Halle 1968:83, Wells 1990, Alcántara 1998, cf. Hammond 1999). For example, contrastive weight can be found intervocalically in the contrast between *vénison* and *Vanéssa*:

(38) a. vénison



b. Vanéssa



English stress can be captured using the following set of constraints, as used by Alcántara (1998):

(39) a. NONFIN: No prosodic head of PrWd is final in PrWd, i.e. the final foot in the word cannot be the head (i.e. primary stressed) foot of the word
b. EDGEMOST: Allign(PrWd, R; Ft (Head), R)
c. FTBINμ: a foot must have exactly two moras.
d. FTFORM(TROCHAIC): [σ́ σ]

In a word like *venison*, where only vowels (and perhaps syllabic /n̩/) are specified for weight underlyingly, stress defaults to the first syllable of the word, which forms a trochaic foot containing the first two syllables; the final syllable is considered extrametrical owing to NONFIN:

(40)

v $ε_μ$ n $ə_μ$ s $n_μ$	FTBINμ	NON FIN	EDGEMOST	FTFORM (TRO)	*AMBISYL L	FAITH μ	ONSET
$_σ$[v $έ_μ$] ($_σ$[n $ə́_μ$]) $_σ$[s $n_μ$]	*!						
$_σ$[v $έ_μ$] ($_σ$[n $ə́_μ$] $_σ$[s $n_μ$])		*!	*				*
$_σ$[v $έ_μ$] ($_σ$[n $ə́_μ$ $s_μ$]) $_σ$[$n_μ$]			*			*!	*!
☞ ($_σ$[v $έ_μ$] $_σ$[n $ə_μ$]) $_σ$[s $n_μ$]			*				

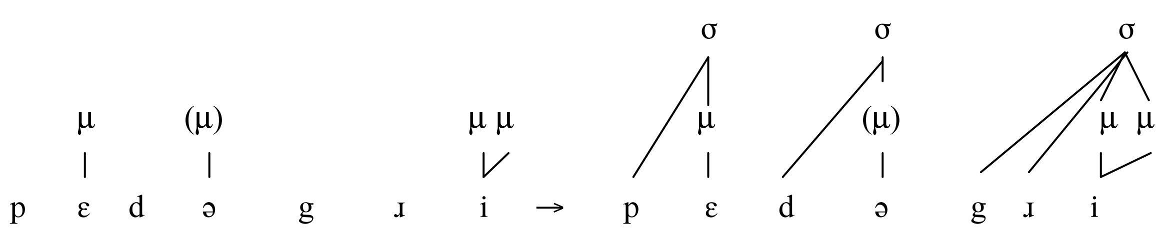
In *Vanéssa*, /s/ is underlyingly moraic. For this reason, stress is attracted to the second syllable rather than the first, as was the case in *vénison*:

(41)

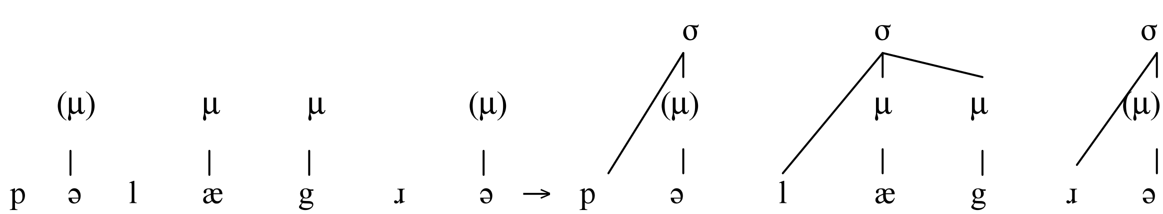
v ə$_{\mu}$ n ε$_{\mu}$ s$_{\mu}$ ə$_{\mu}$	FTBINμ	NON FIN	EDGE MOST	FTFORM (TRO)	*AMBISYLL	FAITHμ	ONSET
$_{\sigma}$[v ə$_{\mu}$] ($_{\sigma}$[n έ$_{\mu}$ s$_{\mu}$]) $_{\sigma}$[s ə$_{\mu}$]			*		*!		
($_{\sigma}$[v ə́$_{\mu}$] $_{\sigma}$[n ε$_{\mu}$]) $_{\sigma}$[s ə$_{\mu}$]			*			*!	
☞ $_{\sigma}$[v ə$_{\mu}$] ($_{\sigma}$[n έ$_{\mu}$ s$_{\mu}$]) $_{\sigma}$[ə$_{\mu}$]			*				*

Preconsonantally, English also preserves underlying contrasts in segment weight. For example, the difference in stress assignment in *pédigree* versus *pellágra* can similarly be attributed to underlyingly specified moraic assignments (Chomsky & Halle 1968:83, Alcántara 1998):

(42) a. pédigree



b. pellágra



In (40a), the first syllable in *pédigree* receives a stress via the constraint ranking in exactly the same way as was the case in *vénison*. The segments /gɹ/ form a complex onset in order to avoid a violation of FAITHμ:

(43)

p $ɛ_μ$ d $ə_μ$ g ɹ $i_{μμ}$	FT BIN(μ)	NON FIN	EDGE MOST	FTFORM (TRO)	*AMBISYLL	FAITHμ	ONSET
$_σ$[p $ɛ_μ$] ($_σ$[d $ə́_μ$]) $_σ$[g ɹ $i_{μμ}$]	*!		*				
$_σ$[p $ɛ_μ$] ($_σ$[d $ə́_μ$] $_σ$[g ɹ $i_μ$])		*!					
$_σ$[p $ɛ_μ$] ($_σ$[d $ə́_μ$ $g_μ$]) $_σ$[ɹ $i_{μμ}$]			*			*!	
☞ ($_σ$[p $ɛ́_μ$] $_σ$[d $ə_μ$]) $_σ$[g ɹ $i_{μμ}$]			*				

On the other hand, /g/ is underlyingly moraic. As was the case for *Vanéssa*, stress is attracted to the second syllable, which is made heavy by the preservation of moraic /g/ in coda position. As in Swedish, this syllabification creates a SYLLCON violation, which is not remedied due to the ranking *AMBISYLL » SYLLCON:

(44)

p $ə_μ$ l $æ_μ$ $g_μ$ ɹ $ə_μ$	FT BIN(μ)	NON FIN	EDGE MOST	FTFORM (TRO)	*AMBISYLL	FAITHμ	ONSET	SYLLCON
$_σ$[p ə] ($_σ$[l $ǽ_μ$ $g_μ$]) $_σ$[g ɹ $ə_μ$]			*		*!			
($_σ$[p $ə́_μ$] $_σ$[l $æ_μ$]) $_σ$[g ɹ $ə_μ$]			*			*!		
☞ $_σ$[p ə] ($_σ$[l $ǽ_μ$ $g_μ$]) $_σ$[ɹ $ə_μ$]			*				*	*

While more complete analyses of these languages with respect to contrastive segment weight are not considered here, the above analyses suggest that the Blackfoot patterns may not be as typologically rare as has been assumed.

5.8 Conclusion

This chapter treated the syllabification of preconsonantal geminates. It was argued that preconsonantal geminates, in parallel to intervocalic geminates, can be analysed as the preservation of underlying moraic contrasts in the surface representation. By assuming that syllabification is applied to underlying representations and takes into account underlyingly specified moraic associations, surface-oriented contrastive syllabification is derived. In accordance with assertions that syllabification is not used contrastively in languages, this analysis avoids the necessity of specifying syllabification in the underlying representation.

In support of this analysis, the phonetic duration of preconsonantal geminate stops as compared to preconsonantal geminate /s/ was considered. Owing to the match in duration for preconsonantal geminate stops with intervocalic geminate stops, it was argued that preconsonantal geminate stops are true geminates, where the ambisyllabicity was motivated by the Syllable Contact Law. The ambisyllabic representation differed from the proposed representation of preconsonantal geminate /sː/ as a simple coda consonant. However, it was observed that preconsonantal geminate /sː/ is a shorter in duration than its intervocalic counterpart.

The neutralisation of nasal weight preconsonantally was attributed to the illicitness of the complex onset nasal-/s/, which violates the constraint *REVERSAL. This observation correlated with the above analysis, where it was proposed that moraic contrasts are preserved through the means of syllabification contrasts. Because nasals do not possess the flexibility of obstruents in consonant cluster formation in Blackfoot, underlying moraic contrasts were unable to be preserved.

Finally, theoretical and typological implications were considered. It was argued that the moraic analysis correctly predicted the various patterns found in Blackfoot, and that a syllabic account made broader predictions that were neither confirmed nor denied by the Blackfoot data. However, it was predicted that if the moraic account developed in this chapter is correct, the type of language predicted by the syllabic account does not exist.

The concept of moraic contrastiveness was discussed with respect to two other languages, Swedish and English, where it was shown that preconsonantal moraic faithfulness is not an isolated phenomenon, and that even contrastive syllabification patterns can be shown to arise in relatively well-understood languages. These languages were discussed only briefly, however, leaving more complete analyses of these and other languages to future research.

Chapter Six: Vowel Hiatus Resolution

This chapter discusses the strategies used in Blackfoot to syllabify underlying vowel sequences (vowel hiatus). While this chapter does not claim to be a complete analysis of the Blackfoot vowel system (see Frantz 1978, 1991 and Kinsella 1972 for further discussion), certain elements are discussed which are relevant to an understanding of the role of the mora and the syllable in Blackfoot phonotactics. This chapter focuses on the common strategies for vowel hiatus resolution in Blackfoot, and develops an OT analysis which aims to account for the various output forms of underlying vowel sequences. I show, as in analyses of other languages (e.g. Rosenthall 1994, Casali 1996), that the vowel hiatus resolution strategies employed by Blackfoot speakers can be predicted by taking into account sonority, moraic affiliations and syllable structure preferences—the same factors which I have argued to be responsible for consonant phonotactics in the language.

6.1 Vowel Hiatus and Moraic Theory

Under moraic theory, vowels differ fundamentally from consonants by virtue of their underlying moraic associations—arguably, vowels are minimally monomoraic underlyingly, excepting perhaps schwa and other reduced vowels (e.g. Hammond 1999). Their default moraicity is no doubt due to their high sonority relative to their surrounding segments: if syllables are minimally monomoraic, and moras are attracted to the most sonorous segment in a sequence, it is logical that the vowel will almost always fill this role. Long vowels are therefore assumed to be bimoraic; this assertion is supported by cross-linguistic evidence where open syllables with long vowels consistently pattern as heavy syllables. Gordon (1999), for example, asserts that in languages with a weight distinction, long vowels always pattern as heavy.

The problem of how to represent glides has been longstanding: are glides independent segments or non-syllabic vowels? Glides often alternate with vowels (Rosenthall 1994), giving rise to the assertion that the two segment types are related in some way. This analysis has its advantages in Blackfoot, where vowel hiatus often forces underlying vowels to surface as glides. As discussed in this chapter, this alternation appears not to be one of moraicity, but rather of relative sonority. When vowels occupy onset position, they are non-moraic; when vowels are the sonority peak of the syllable or the coda, they are moraic. However, when two underlyingly moraic vowels occur adjacently—in other words, when vowel hiatus occurs—it is the case that the less sonorous vowel is sometimes realised as a glide. As argued in this chapter, the glide retains its mora in some way in these environments, resulting in both rising and falling diphthongs.

The creation of diphthongs is only one of many ways that languages deal with underlying sequences of vowels. The markedness of vowel hiatus is a debateable question—some argue that its illicitness arises from the creation of an onsetless syllable (e.g. Rosenthall 1994, Casali 1996), while others argues that vowel sequences present articulatory difficulties to speakers (Iskarous 1999, Boroff 2005). This thesis does not concern itself with attempting to explain why vowel sequences are normally considered marked in Blackfoot, although section 6.2 argues against the onset analysis and invokes the constraint *HIATUS; instead, the discussion attempts to motivate the various realisations of these sequences. Blackfoot presents a particularly interesting case because it presents a typology in and of itself—underlying vowel sequences are treated in a variety of ways depending on which vowels are involved and in which order. This chapter develops an OT account that predicts the output of a given underlying vowel sequence. Vowel hiatus resolution—particularly in a language like Blackfoot—is particularly well-suited to an OT analysis. Hiatus resolution in Blackfoot receives a unified account when it is assumed that constraints are violable, where it might otherwise be riddled with exceptions.

An analysis of hiatus resolution is interesting to this thesis not only as a valuable step towards understanding Blackfoot phonotactics, but also because it provides another case where underlying moraic associations and syllabification play key roles in determining the language's phonotactics. Blackfoot's hiatus patterns can only be understood when it is assumed both that vowels are associated with moras underlyingly, and that faithfulness to moraic associations is highly ranked. Syllabification strives to remain faithful to these underlying specifications while avoiding marked structures in the output—yet another example of the classic faithfulness-markedness conflict.

6.2 Formalising Hiatus in OT

*6.2.1 *Hiatus*

Underlying vowel sequences can be syllabified in a number of ways. The most straightforward syllabification is perhaps one in which vowel hiatus is preserved; in other words, where both vowels form the sonority peak of their own syllable. Under this strategy, both vowels preserve their underlying representations—moras can be preserved as well as features. Therefore, the syllabic structure of the phenomenon referred to as ‘vowel hiatus’ is the structure represented below for the underlying vowel sequence /ia/:

(1) ‘Hiatus’ structure for underlying vowel sequence /ia/

```
σ      σ
|      |
μ      μ
|      |
i      a      [i.a]
```

The syllabification in (1) is pronounced phonetically as a sequence of two distinct vowels [ia]. Languages that avoid vowel hiatus avoid precisely this structure—a heterosyllabic sequence of vowels. This structure can be represented as a syllable structure markedness constraint:

(2) *HIATUS: sequences of heterosyllabic vowels are prohibited. (also Orie & Pulleyblank 2002)

```
*  σ      σ
   |      |
   μ      μ
   |      |
   V      V
```

By positing this constraint, we are assuming that sequences of heterosyllabic vowels are marked. This is supported by cross-linguistic evidence from languages that do not allow vowel hiatus (Casali 1996). However, the constraint does not explain why languages should avoid the above structure. The traditional explanation for the markedness of vowel hiatus has associated it with a violation of the constraint ONSET (e.g Rosenthall 1994, Casali 1996); others have suggested that it is phonetically or articulatorily difficult to pronounce vowels in hiatus (Iskarous 1999, Boroff 2005). However, I argue in this section that Blackfoot word medial onsetless syllables (i.e. vowel hiatus) are subject to alterations, while word-initial onsetless syllables are not only tolerated but actually preferred in some cases. The next section argues that a single constraint ONSET is insufficient to account for the patterns found in Blackfoot.

*6.2.2 *Hiatus vs. Onset*

Blackfoot generally avoids vowel hiatus.[37, 38] For example, the concatenation of the vowels /a/ and /i/ results in a merged segment /ɛː/:

(3) /imitaː + ikoan/ → [imitɛːkoan] 'puppy'

However, word-initially, Blackfoot not only tolerates onsetless syllables, but actually prefers onsetless syllables to glide onsets: glides are regularly deleted word-initially. On the other hand, glides are preserved word-medially; if a vowel-final prefix is added before a glide-initial word, the glide is preserved. This is illustrated in the examples below:

(4) Deletion of Word-initial Glides:

	/jiːníːwaːxkaː-wa/	→	[iːníːwaːxkaː-wa]	's/he picked berries'
	pick.berries-3S			
	/wáːsɛ́ːʔni-wa/	→	[aːsɛːʔni-wa]	's/he cried'
	cry-3S			
cf.	Preservation of Inter-vocalic Glides			
	/á-jiːníːwaːxkaː-wa/	→	[ájiːníːwaːxkaː-wa]	's/he is picking berries'
	DUR-pick.berries-3S			
	/á-waːsɛ́ːʔni-wa/	→	[áwaːsɛːʔni-wa]	's/he is crying'
	DUR-cry-3S			

[37] With the exception of /oa/, see section 6.7.2 below.
[38] Note that hiatus strategies in Blackfoot are only applied if hiatus occurs within a phonological word, and not between words.

The data suggest that Blackfoot actually prefers onsetless syllables in word-initial position to highly sonorous glide onsets.

To account for the above data, there are two possibilities. The first is to assume simply that consecutive heterosyllabic vowels violate only ONSET; the second is to assume that word-medial onsetless syllables may be subject to a more stringent constraint that specifically militates against onsetless syllables in this environment. This would involve positing a constraint such as *HIATUS; such a constraint could be seen either as a subset of ONSET (in which case violations of *HIATUS are also violations of ONSET) or as a separate constraint.

6.2.2.1 Possibility 1: *HIATUS is unnecessary

First, consider the possibility that *HIATUS is unnecessary, and that ONSET is sufficient to account both for the avoidance of vowel hiatus and the deletion of word-initial glides. In order to account for the deletion of glides word-initially, it is necessary to posit a constraint denoting the markedness of glide onsets. I follow Smith (2006) in introducing the constraint *ONS/G:

(5) *ONS/G: onsets do not have the sonority level of glides.

In word-medial position, a vowel sequence /a + i/ is remedied by coalescence into the vowel /ɛː/, which shares features of both input vowels (for further discussion of these sequences, see section 6.4). Coalescence violates the constraints UNIF (uniformity) and MAX(F):

(6) UNIF: two segments that are distinct in the input must remain distinct in the output. (McCarthy & Prince 1995)

(7) MAX(F): features present in the input must be present in the output.

Because Blackfoot opts for coalescence, these two constraints are outranked by ONSET, the constraint responsible for hiatus avoidance:

(8)

ka + i	ONSET	UNIF/MAX(F)
ka.i	*!	
☞kɛː		*

In word-initial position, *ONS/G outranks ONSET:

(9)

$_{PrWd}$[wa…	*ONS/G	ONSET	UNIF/MAXF
$_{PrWd}$[wa…	*!		
☞ $_{PrWd}$[a…		*	

However, a problem arises when dealing with the preservation of (underlying) glides word medially, as in /ájiːníːwaːxkaːwa/ 's/he is picking berries'. In order to account for the preservation of the word-medial [j], it is necessary to rank MAX(SEG) highly to prevent the deletion of a segment and choose the correct winner:

(10)

aji	MAX(SEG)	*ONS/G	ONSET	UNIF/MAXF
ɛː	*!			*
a.i	*!		*	
☞aji		*		

However, ranking MAX(SEG) over *ONS/G chooses the wrong winner (marked by ☠) when the constraint is added to the tableau in (9):

(11)

$_{PrWd}$[wa…	MAX(SEG)	*ONS/G	ONSET	UNIF/MAXF
☠☞ $_{PrWd}$[wa		*		
$_{PrWd}$[a	*!		*	

Unless other constraints can be argued to account for this problem, ONSET cannot be used to account for the avoidance of vowel hiatus in Blackfoot.

6.2.2.2 Possibility 2: *HIATUS is necessary

The problems of the above analysis are avoided when *HIATUS is used in addition to ONSET. For vowel sequences, *HIATUS outranks UNIF and MAX(F). In addition, ONSET can be ranked lowly:

(12)

/ka + i/	*HIATUS	UNIF/MAX(F)	ONSET
ka.i	*!		*
☞kɛː		*	

Word-initially, *HIATUS is not violated. This enables the ranking of ONSET below *ONS/G, rather than above it, as was the case in (9) and (11):

(13)

$_{PrWd}$[wa…	*HIATUS	UNIF/MAXF	*ONS/G	ONSET
$_{PrWd}$[wa			*!	
☞ $_{PrWd}$[a				*

Finally, the retention of intervocalic glides is predicted by this constraint ranking, regardless of where MAX(SEG) is ranked:

(14)

kaji…	*HIATUS	UNIFORMITY/MAXF	*ONS/G	ONSET	*MAX(SEG)*
ka.i	*!			*	*
kɛː		*!			*
☞kaji			*		

The Blackfoot patterns are more accurately described if *HIATUS is assumed in addition to ONSET. While other constraints might be possible, the above discussion suggests at any rate that ONSET is insufficient in Blackfoot, and that word-medial and word-initial onsets are subject to different constraints. In this chapter, I will assume that this constraint is *HIATUS.

6.3 Hiatus Resolution in Blackfoot

6.3.1 Blackfoot Vowel Inventory

Blackfoot's vowel inventory is reproduced below:

(15) Blackfoot Vowel Inventory

i iː		
		o oː
	a aː	

As is the case for the consonant inventory, contrastive length plays a large role in expanding the size of the vowel inventory. A variety of additional vowels and diphthongs is derived via phonetic processes (e.g. laxing in closed syllables) and via combinations of vowels (see 2.3.2). This chapter discusses surface manifestations of underlying vowel sequences.

6.3.2 A Sonority Scale for Blackfoot Vowels

The strategies used to avoid vowel hiatus are predictable when described in terms of sonority. For vowels, sonority is directly correlated with height (e.g. Parker 2002). A sonority scale for Blackfoot vowels may be schematised as below, with low vowels as the most sonorous and high vowels as the least sonorous:

(16) Sonority Scale for Blackfoot Vowels

i o a

Least Sonorous Most Sonorous

It is a well-known generalisation that syllable nuclei are the more preferred the more sonorous the peak (see, e.g. Vennemann's 1988 'Head Law'). It can be predicted that languages that do not tolerate hiatus will tend to preserve the most sonorous vowel, as it is the most salient and its loss will therefore be greater. In the analysis presented in this chapter, I show that the relative sonority of the vowels plays a large role in determining the phonetic output.

6.3.3 Vowel Hiatus Resolution in Blackfoot

The surface realisations of underlying vowel sequences in Blackfoot are summarised in the following table:

(17) Realisation of Vowel Sequences in Blackfoot

		V2		
		a	**i**	**o**
V1	**a**	aː	ɛː	ɔː
	i	ja/a	iː	jo/o
	o	oa/a	oj	oː

Following the above discussion on sonority, these vowel sequences can be divided into three groups as follows:

(a) Vowel sequences with decreasing sonority: the sequences /ai, ao/ are subject to coalescence and are realised as a lax, mid vowel /ɛː, ɔː/, while /oi/ is realised as a diphthong /oj/.

(b) Vowel sequences with increasing sonority: these are realised as a rising diphthong (/ja, jo/), as two independent vowels (/oa/), or are (rarely) elided (/a, a, o/).

(c) Vowel sequences with equal sonority: sequences of identical vowels are realised as long vowels.

The remainder of this chapter is devoted to developing a moraic/syllabic account of these processes, both on an individual basis and with respect to directionality, i.e. why sequences with decreasing sonority are generally resolved by coalescence, while sequences of increasing sonority are not.

6.4 Hiatus Resolution in Vowel Sequences of Decreasing Sonority

Three vowel sequences of decreasing sonority arise through morphological concatenation in Blackfoot. Two of these sequences (/a + i/, /a + o/) are realised on the surface as a single long vowel ([ɛː] and [ɔː]). The third sequence (/o + i/) is realised as a diphthong ([oj]). This is illustrated in the following examples:

(18)	a.	imitɛːkoan	‘puppy’
		imitaː-ikoan	
		dog-young.being	
	b.	ipaxk͡sikɛːmo	‘stink like feet
		ipaxk-ika-imo	
		bad-foot-have.odour.of	
	c.	ɔ́ːxpomːɔ́ːpi	‘storekeeper’
		á-oxpomːaː-opi	
		DUR-buy.something-sit	
	d.	akɔ́ːkiːn	‘many graves’
		aká-okiːn	
		many-bury.in.elevated.cache	
	e.	nítskoxtojtapiːji	‘I am a spiteful person’
		nit-sːkoxto-itapiːji	
		1SG-spitefully-be.a.person	
	f.	naːmójkin	‘lily’
		naːmóː-ikin	
		bee-tooth	

In this section, I develop an analysis which predicts these patterns.

Coalescence refers to the merging of two segments into a new segment containing elements of both segments but which is not identical to either segment. It is a common strategy for hiatus resolution; in Blackfoot, the creation of mid vowels [ɛː] and [ɔː] from sequences of underlying vowels presents an example of this process. Within vowel systems, a number of possibilities are open; however, Casali (1996) identifies a particularly common type of coalescence which he terms ‘Height Coalescence’. This type of coalescence occurs only when V1 is non-high and V2 is high (or higher than

V1). Casali found that this type of coalescence always results in a non-high vowel agreeing in frontness and roundness with V2.

Casali's account of height coalescence works very well for Blackfoot. Recall the two instances of height coalescence in the language:

(19) a. a + i → ɛː
b. a + o → ɔː

Casali identifies two types of height coalescence found in languages. The first, 'e-coalescence', refers to coalescence where the [-ATR] feature of /a/ is not preserved (of the type /a + i/ → /e/). The second, 'ɛ-coalescence', traditionally refers to coalescence where [-ATR] is preserved from a sequence of non-high vowels (of the type /a + e/ → /ɛ/). Some languages additionally show ɛ-coalescence when the second vowel is high (/a + i/ → /ɛ/). According to Casali, the type of coalescence chosen depends on the vowel system of the language. He makes the prediction that ɛ-coalescence will be limited to languages without a [-ATR] distinction for high vowels, so that all underlying [-ATR] vowels are redundantly [-high]. While possessing a somewhat unusual vowel system, Blackfoot coalescence is therefore typologically not unusual: coalescence between a mid vowel and a low vowel (/a + o/) is expected to give a vowel preserving the [ATR] value of the low vowel (/ɔː/), while the realisation of /a + i/ as /ɛː/ is expected based on the presence of mid vowel coalescence and the lack of phonemically contrastive [ATR] features.

Recall from the discussion above that coalescence violates two constraints: UNIF and MAX(F). Because coalescence is chosen over a heterosyllabic representation of the two vowels, *Hiatus is ranked above both Unif and Max(F), as shown in the tableau below, repeated from (12) above:

(20)

/ka + i/	*Hiatus	Unif/Max(F)
ka.i	*!	
☞kɛː		*

In order to develop an analysis which predicts the correct output vowel given a sequence of input vowels, I adopt Casali's (1996) proposal to combine the sonority scale and defining vowel features to produce a ranked family of Max(F) constraints, predicting that certain features are more likely to be preserved than others.

In terms of features, I follow Casali (1996) in assuming the height features [low], [±ATR], and [±high] and the non-height features [front] and [round]. Height features for the Blackfoot vowel system (including the coalesced vowels /ɛː/ and /ɔː/, in this thesis assumed to be present on the phonetic level) are represented in the following table:

(21) Height Features for Blackfoot vowels

<table>
<tr><td rowspan="3"></td><td>[+hi]</td><td rowspan="2">[+ATR]</td><td>i iː</td></tr>
<tr><td rowspan="3">[-hi]</td><td>o oː</td></tr>
<tr><td rowspan="2">[-ATR]</td><td>ɛː ɔː</td></tr>
<tr><td>[low]</td><td>a aː</td></tr>
</table>

For the purposes of this thesis, it is sufficient to assume that front vowels [i, iː, ɛː] are specified [front] and that other vowels are unspecified for frontness, as proposed by

Casali (1996). Similarly, [o, oː, ɔː] are specified [round] while all other vowels are unspecified for roundness.

Recall the sonority scale for Blackfoot vowels, which is repeated below:

(22) Sonority Scale for Blackfoot Vowels

i o a

Least Sonorous Most Sonorous

Because sonority correlates with height for vowels, I adopt here Casali's (1996:88) proposal of ranking height features according to the sonority scale. This can be represented as below, with distinguishing vowel features associated with their respective vowel:

(23) Featural Sonority Scale

i,	o	ɛ, ɔ	a
[+high]	[-high]	[-ATR]	[low]

Least Sonorous Most Sonorous

This scale can be applied to create a ranked family of MAX(F) constraints after Casali (1996:88):[39]

(24) MAX(F): features present in the input must be preserved in the output.

(25) MAX(low) » MAX(-ATR) » MAX(-high) » MAX(+high), MAX(+ATR)

This ranking is considered to be both fixed and universal. As argued by Casali (1996) and in this thesis, the above ranking is responsible for determining the output vowel in

[39] Casali (1996:88) uses PARSE constraints, while I choose to formulate these instead as MAX.

vowel coalescence, where highly ranked features will be preserved in preference to lowly ranked features. However, coalescence requires a distinctive element of both vowels to be preserved in the output (otherwise the process would be identical to elision). Highly ranked features can therefore be lost because some height features are incompatible with others (for example, [low] and [-high] are incompatible with [+high]).

The features [front] and [round] are also subject to faithfulness constraints:

(26) MAX(front): the feature [front] must be preserved in the output.
(27) MAX(round): the feature [round] must be preserved in the output.

Because these features do not correlate with vowel sonority (e.g. Howe & Pulleyblank 2004), they are not subject to any fixed ranking: the two features can be ranked freely with respect to the other feature constraints. Crucially, however, these two constraints can be used as a distinctive feature in determining the output vowel. In height coalescence as occurs in Blackfoot, an output vowel is realised with the height features of the more sonorous vowel and the frontness or roundness feature of the less sonorous vowel—thus retaining distinguishing features from both vowels, but height features from the more sonorous vowel. This results in an optimally sonorous vowel.

For example, an underlying sequence of the vowels /a/ and /o/ in Blackfoot results in the output vowel /ɔː/. The input vowels contribute the following features:

(28) /a/: [low], [-ATR], [-high]
/o/: [-high], [+ATR], [round]

The feature [low] is the most highly ranked feature in terms of faithfulness constraints. The least marked vowel that can possess this feature is the low vowel /a/. This is an unacceptable coalesced vowel because it is identical to one of the input vowels, and therefore a violation of MAX(SEG).

A second possibility in this case would involve the preservation of the low vowel with the [+round] feature of /o/ preserved. This would result in the back low rounded vowel [ɒ]. However, this vowel is rare cross-linguistically and relatively highly marked. This typological preference can be formalised as the constraint *[low, round], which is highly ranked in Blackfoot.

Having exhausted the possibility of preserving the most highly ranked feature, [low], the next highly ranked candidate, [-ATR], is examined for preservation. As justified by the output vowel, [ɔː], this feature is indeed realised. Back vowels are rounded in their unmarked form, and the feature [round] from V2 is preserved without creating a marked segment, as was the case for the low, back, rounded vowel. Thus, even though the vowel [ɔ] is not a part of the vowel inventory (assuming that all instances of [ɔ] originate from /ao/), it is considered unmarked enough that its introduction is justified.[40] The following tableau illustrates some of the possible output vowels for the sequence /ao/:[41]

---

[40] Frantz (1978) assumes that [ɔː] patterns as a low vowel.

[41] Note that the output of coalescence is always bimoraic in Blackfoot. Less than two moras would result in a violation of FAITHμ, which is highly ranked in Blackfoot, as argued in the previous chapter. More than two moras would violate the bimoraic maximum for syllable size in Blackfoot (see discussion below). While the continued presence of moraic faithfulness remains relevant to this thesis, this topic is not discussed explicitly in this chapter.

(29)

/ao/	MAX(SEG)	*[low, round]	MAX(low)	MAX(-ATR)	MAX(-high)
aː	*!				
ɒː		*!			
☞ɔː			*		

The other case of height coalescence, [a+i] → [ɛː], plays out similarly. These two input vowels are specified for the following features:

(30) /a/: [low], [-ATR], [-high]
/i/: [+high], [+ATR], [front]

The same problem as described above occurs if [low] is preserved as [a]: all features of /i/ will be lost: [low] [-high] and [+high] are incompatible, as are [-ATR] and [+ATR]. In Blackfoot, if [low] is preserved, so must [-high] and [-ATR]. This possibility is ruled out by MAXSEG. As was the case previously, preservation of the non-height features of the second vowel would result in a marked segment, a front low vowel [æ], which is rare cross-linguistically. This vowel is ruled out by the constraint *[low, front].[42]

Once again, the next candidate for preservation, [-ATR], proves to be the correct winner. The preservation of [-high] over [+high] is also attributed to the ranking in (25). The preservation of [-high] over [+high] is allowed because there is an additional non-height feature specified on /i/ that is not specified on /a/, namely, [front]. The conjunction of these features results in the correct output vowel, [ɛː]. As was the case for [ɔː], the vowel [ɛː] is also not part of the Blackfoot vowel inventory, but is assumed to be unmarked enough that its introduction is not problematic. A tableau illustrating the ranking of constraints for the underlying vowel sequence /ai/ is given below:

(31)

/ai/	MAX(SEG)	*[front, low]	MAX(low)	MAX(-ATR)	MAX(-high)	MAX(+high)
aː	*!					*
æː		*!				*
☞ɛː			*			*

One possible problem in the above analysis stems from the rejection of several output vowels based on markedness and intolerance for their introduction into the Blackfoot inventory, while the successful vowels /ɛː/ and /ɔː/ are similarly not present in the regular vowel inventory. I propose that these vowels are acceptable because they are not marked either cross-linguistically or within Blackfoot, where both an unrounded front vowel and a rounded back vowel are attested. Further, the Blackfoot three-vowel system is itself somewhat asymmetrical: a fully symmetrical three vowel system would contain two high vowels and a low vowel, while the Blackfoot vowel inventory contains a high vowel, a mid vowel, and a low vowel. It is also attested that five vowel systems are more common cross-linguistically. The introduction of these vowels therefore helps to create a more symmetric and stable vowel system, whether on a phonetic or a phonemic level.

---

[42] According to Frantz (1978, 1991), some Blackfoot speakers do produce [æ] from sequences of /ai/. MAX(low) outranks *[front, low] for these speakers.

The third underlying vowel sequence where sonority decreases, /oi/, is particularly interesting because, unlike /ao/ and /ai/, the sequence is realised as a diphthong [oj] and not as a coalesced segment. I propose that coalescence is indeed the preferred realisation of underlying vowel sequences of decreasing sonority in Blackfoot, and in the case of /oi/, coalescence is not opted for because no suitable coalesced vowel can be found. The attested result—diphthongisation—is still dispreferred with respect to coalescence, but is preferred to the introduction of a marked vowel.

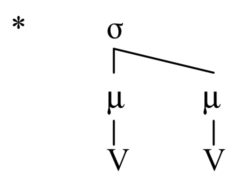
The two input vowels contain the following features:

(32) /o/: [-high], [+ATR], [round]
/i/: [+high], [+ATR], [front]

Proceeding in the same fashion as above, the first candidate for preservation is [-high]. This feature is incompatible with [+high], so the winning vowel will have to be a mid vowel. Both vowels are [+ATR]; the output vowel will therefore be [+ATR] as well. It is at this point that this analysis may encounter a problem: why is not [front] preserved as the input feature of /i/? Ruling out the front rounded vowel [ø] as a marked segment (by a constraint *[front, round]), its unrounded counterpart, [e], seems like a reasonable candidate—it preserves the height features of the more sonorous vowel, and [front] from the less sonorous vowel. The solution to this problem must result from a high ranking of MAX(round). This proposal parallels that of de Lacy (2003), who argues that the feature [round] is always preserved in vowel coalescence if it is present in the input. For languages such as Attic Greek, de Lacy proposes that [+round] is preserved because it is cross-linguistically more highly marked than [-round]. With no evidence to the contrary, it is reasonable to assume that Blackfoot has a similar constraint preserving the feature [round]. If MAX(round) is highly ranked, then the output vowel in /oi/ coalescence must be /o/, a result that is unacceptable because it is identical to one of the input vowels, and incurs a violation of MAX(SEG). Because there is no acceptable output for coalescence, the sequence /oi/ is resolved by the second best strategy for hiatus resolution in Blackfoot, diphthong formation.

Rosenthall (1994:17) proposes the existence of a constraint *DIPH, structurally represented as the prohibition of a syllable with two vowels linked to two moras, as illustrated below:

(33) *DIPH (Rosenthall 1994:17)



For the present discussion, this markedness constraint is used to denote the dispreference for diphthongs. Because /ai/ and /ao/ are not realised as diphthongs ([aj, aw]), *DIPH must outrank MAX(low):

(34)

/ai/	*DIPH	MAX(low)
aj	*!	
☞ɛː		*

The following tableau illustrates the output of the underlying vowel sequence /oi/:

(35)

/oi/	MAX(SEG)	*[front, round]	MAX (round)	*DIPH	MAX (low)	MAX (-ATR)	MAX (-high)	MAX (+high)
oː	*!							*
øː		*!						*
eː			*!					*
☞oj				*				

The alternative patterning of /oi/ sequences can therefore be accounted for using the same constraints as were assumed in the production of [ɛː] and [ɔː] through coalescence.

An interesting validation of this analysis of /oi/ comes from the realisation of the sequence when it occurs before a coda consonant, such as a geminate. Blackfoot is subject to a constraint specifying that syllables can have a maximum of two moras, *3µ:

(36) *3µ: a syllable cannot have more than two moras.[43]

Long vowels are regularly shortened in closed syllables in Blackfoot in response to this constraint, which outranks FAITHµ in Blackfoot:

(37)

ɛːkːV…	*3µ	FAITHµ
ɛːkːV…	*!	
☞ɛkːV…		*

Monomoraic falling diphthongs are crosslinguistically rare. Rosenthall (1994) argues that falling diphthongs adopting the shared representation used by rising diphthongs

[43] Regardless of its formulation, this constraint is also violated by syllables with more than three moras.

(Rosenthall 1994, section 6.7.1) are ruled out by the constraint SonRise, which prohibits two vowels sharing a mora to decrease in sonority:

(38) SonRise (Rosenthall 1994:24)

$$
\begin{array}{llll}
* & \sigma & & \\
 & | & & \\
 & \mu & & \\
 & V_i & V_j & \qquad son_i > son_j
\end{array}
$$

Interestingly, some Blackfoot speakers produce a high, front rounded vowel [ʏ][44] (Frantz 1991), the same vowel that was rejected where both moras could be preserved. These speakers rank SonRise and *3μ over *[front,round], which is in turn ranked above Faithμ:

(39)

oik:V	*3μ	SonRise	*[front, round]	Faithμ
$_\sigma[o_\mu\ j_\mu\ k_\mu]\ _\sigma[k\ a_\mu]$	*!			
$_\sigma[[oj]_\mu\ k_\mu]\ _\sigma[k\ a_\mu]$		*!		*
☞ $_\sigma[ʏ_\mu\ k_\mu]\ _\sigma[k\ a_\mu]$			*	*

This pattern serves to illustrate that constraints that serve to eliminate marked outputs can be violated in the presence of higher ranked constraints.

In conclusion, the output vowels of coalescence in sequences of decreasing sonority can be predicted from a combination of sonority-based feature faithfulness constraints and markedness constraints pertaining to certain combinations of features. The remainder of this chapter is devoted to a discussion of hiatus resolution for vowel

[44] The quality of the vowel is not considered in terms of its features, except that it is both front and round.

sequences of increasing sonority, which are not realised as a coalesced vowel but rather as rising diphthongs. I assume here that this difference is once again the result of constraint ranking, where the above analysis is retained. This is possible because rising diphthongs have different structural representations from falling diphthongs.

6.5 Representation of Vowel Sequences of Increasing Sonority

In Blackfoot, underlying vowel sequences of rising sonority are not resolved via coalescence. Instead, with the exception of /oa/, they are realised phonetically as a glide followed by a vowel, as shown in the following examples:

(40)	a.	isːapjáʔt͡sis	'telescope/binoculars'
		sːapi-aʔtsis	
		look.at-INST	
	b.	naːpjaːkiː	'Caucasian woman'
		naːpi-aːkiː	
		Creator-woman	
	c.	saːpikaːkjaʔtsis	'stirrup'
		sap-ikaːki-aʔtsis	
		in-position.one's.foot-INST	
	d.	kixt͡sipimjotaʔs	'pinto horse'
		kiːxt͡sipimi-otaʔs	
		spotted/striped.animal-horse.of	
	e.	akáːapjojis	'Fort McLeod'
		wakaː-naːpi-mojis[45]	
		many-creator/trickster-dwelling	
	f.	isˑpiːpjoxsiwa	'he got into a critical situation'
		sspi-ipi-ohsi-wa	
		be.high-riotous-REFL-3SG	

[45] Stem-initial nasals are regularly deleted in word compounding.

The sequence /oa/ is not resolved, but remains in hiatus:

(41) a. imitɛːkoan ‘puppy’
b. aːwoáaːtsiːwa ‘she passed by him’
waːwo-áaːt-iː-wa
reverse-move.in.relation.to-PAST-3SG
c. istːoan ‘knife’

This sequence will be discussed in section 6.7.2.

There are two possibilities for the representation of these clusters that will be considered in this thesis: (a) the less sonorous vowel is transformed into a glide, resulting in a complex onset with the preceding consonant, or (b) the sequence is a rising diphthong. I argue that (b) is the correct interpretation.

Contrary to the data in (40), underlying glides are regularly deleted following consonants, as shown in the following examples:

(42) a. isˑt͡simamskaːpoː ‘pineapple’
sˑt͡sim-wamskaːp-oː
throw-south-travel
b. áːpataːmst͡sinːima ‘Chinese person’
aːpát-jaːmst͡sinːi
behind-braid
cf. c. iːxtɛ́ːpijoːxt͡simjoʔp ‘radio’
iːxt-á-ipi-joːxt͡simi-oʔp
INST-DUR-loudly-hear-INST
d. itapíwaʔsit ‘become alive’
itapí-waʔsi-t
live-become-IMP

Because Blackfoot morphophonological processes are generally quite attuned to which sequences are allowed phonotactically (Elfner 2005), and because glides are preserved after vowels (making the possibility that glide-deletion is morphological unlikely), we are forced to attribute the deletion of the glides in (42a) and (42b) and the well-formedness of the glides in (40) to some difference in representation, originating from some difference in underlying structure. In particular, I propose to analyse the glides in (42) as underlying glides (i.e. non-moraic vowels) and the glides in (40) as underlying vowels (minimally monomoraic). The difference in the phonological processes above is thus attributed to moraic faithfulness. The underlying glides do not have a mora, and have no reason to acquire one. Their syllabic representation is as follows, with the glide associated directly with the syllable node:

(43) Representation of glide-vowel sequence

a. Underlying representation b. Surface Representation

The glide is deleted following a consonant in order to avoid forming a complex onset. In terms of OT, this deletion is an interaction between MAX(SEG) and *CG (a constraint prohibiting consonant-glide onsets)[46]:

(44)

k + wa	*CG	MAX(SEG)
kwa	*!	
ka		*

[46] This constraint is narrowly formulated because the author wishes to avoid overgeneralisations in terms of which types of complex onsets are allowed in Blackfoot. As discussed in chapter 5, this matter presents a rather complicated problem that must be left to future research.

On the other hand, the underlying moras associated with the glides in (40) are crucial to account for the different phonological patterns. I assume here that rising diphthongs are formally represented as two vowels sharing a single mora (Rosenthall 1994, Smith 2006), as illustrated below:

(45) Representation of monomoraic rising diphthong

a. Underlying Representation

$$\begin{array}{cc} \mu & \mu \\ | & | \\ \text{i} & \text{a} \end{array}$$

b. Surface Representation

$$\begin{array}{l} \sigma \\ | \\ \mu \\ |\diagdown \\ \text{i}\ \ \text{a} \end{array}$$

The representation in (45b) is preferable over the structure in (43b). The number of moras from the input to the output is still reduced, incurring a violation of FAITHμ. However, crucially, underlying /i/ is still associated with a mora in the output. According to Morén (1999) and others, two sets of moraic faithfulness constraints exist, one requiring faithfulness to the moras themselves (FAITHμ) and one requiring faithfulness to moraic associations (FAITHLINKμ). FAITHLINKμ is not violated in the shared diphthong representation, even though FAITHμ is violated:

(46)

$i_\mu\ a_\mu$	FAITHLINKμ	FAITHμ
j a_μ	*!	*
☞$[\text{i a}]_\mu$		*

The shared mora representation does not incur a violation of *CG because the glide, by virtue of its shared mora, is not part of the onset but is instead part of the nucleus. Thus, consonant-rising diphthong sequences are allowed to surface in Blackfoot, even though consonant-glide sequences are not.

The shared mora representation of rising diphthongs contrasts with the representation of falling diphthongs as bimoraic, as formulated in the *DIPH constraint given in (33). In Blackfoot, this difference in moraicity is well-motivated on several counts. First of all, falling diphthongs in Blackfoot ([oj]) do behave as though they are bimoraic—they do not contrast for length, regardless of the input number of moras. This can be represented as below:

(47)	/o + i/ → [oj]	/oː + i/ → [oj]
	/o + iː/ → [oj]	/oː + iː/ → [oj]

Further, some Blackfoot speakers reduce the diphthong to a coalesced vowel [ʏ] in closed syllables, suggesting that a falling diphthong plus a moraic coda consonant violates the bimoraic maximum constraint for syllables in the language (see discussion in section 6.4 above).

Rising diphthongs, on the other hand, behave somewhat differently. While the input moraicity of the less sonorous vowel does not affect the moraicity of the diphthong, rising diphthongs in Blackfoot contrast for length depending on the moraicity of the more sonorous vowel. This is illustrated below:

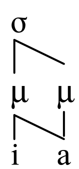
(48)	/i + a/ → [ja]	/iː + a/ → [ja]
	/i + aː/ → [jaː]	/iː + aː/ → [jaː]

Further, rising diphthongs can occur in closed syllables, as in the following examples:

(49) a. isːapjaʔ.t͡sis ‘telescope/binoculars’
b. isːpiːpjox.siwa ‘he got into a critical situation’
c. isːikopjat͡ːsiwa ‘he laid her off (from employment)’

This suggests that rising diphthongs can have two representations, one which is monomoraic (as given in (45)) and one which is bimoraic. I suggest that the bimoraic rising diphthong also shares a mora, as the length is contained within the more sonorous vowel, and is not equally shared between the two input vowels (as was the case with falling diphthongs):

(50) Representation of bimoraic rising diphthong



I suggest that this representation is realised phonetically as the long rising diphthong [jaː], where [j] remains associated with a mora, but does not add additional weight to the syllable. This representation is supported by the absence of compensatory lengthening in these sequences, which might be expected given the high priority given to moraic faithfulness in general throughout the language.

Overall, despite their abstractness, the representations in (45) and (50) are well-motivated and provide a more accurate description of the Blackfoot patterns as compared to other possibilities. The next section compares the proposed representations with alternate representations under OT, in an attempt to determine why the proposed representation is optimal in terms of constraint ranking. Also discussed is the problem of directionality, as discussed in the next section.

6.6 Asymmetrical Coalescence

Sequences of underlying vowels which increase in sonority are treated differently from sequences of decreasing sonority in Blackfoot—they are never subject to coalescence. Such a system is not unusual; for an analysis of some other 'asymmetric' systems, see Casali (1996).

Casali (1996) uses the term 'asymmetric coalescence' to refer to languages where coalescence is used to resolve vowel sequences of decreasing sonority but some other method (such as elision or diphthongisation) to resolve vowel sequences of increasing sonority. Interestingly, languages with the opposite asymmetrical pattern (coalescence with vowel sequences increasing in sonority only) do not seem to exist. Languages with symmetrical coalescence, where coalescence occurs with vowel sequences of both increasing and decreasing sonority, are attested (e.g. Afar, Casali 1996), though rare; however, it appears to be the case that an implicational universal may exist with respect to coalescence systems, such that the use of coalescence for vowel sequences increasing in sonority implies the use of coalescence for sequences with decreasing sonority. In terms of optimality theory, the formalisation of this implicational relationship poses an interesting problem. Casali's (1996) use of positional constraints, where root segments are subject to higher ranked faithfulness constraints than affix segments, comes close to providing an account of this problem. However, the types of lexical salience that Casali assumes do not generally apply to Blackfoot—hiatus resolution seems to apply the same strategies, regardless of whether segments are lexical or affixal. I propose here that the typological patterns concerning asymmetrical coalescence can be accounted for if the second vowel in the sequence is assumed to be more privileged in the input than the first vowel.[47] I use position-sensitive MAX(F) constraints to achieve the correct patterns.

In the above discussion, I proposed that coalescence is the preferred strategy for hiatus resolution of falling sonority vowel sequences in Blackfoot; in the case of the sequence /oi/, I suggested that it was realised as a diphthong because no suitable coalesced vowel could be formed given the features present in the input vowels. However, sequences such as /ia/ and /oa/ have the same input features as their reverse sequences. As discussed above, I propose introducing a ranked family of MAXF constraints, which pertain particularly to the second vowel in the sequence:

(51) MAX(F)V2: features present in V2 in the input must be preserved in the output.

As was the case with the MAX(F) constraints, a fixed ranking can be assumed which parallels the sonority scale:

(52) MAX(low)V2 » MAX(-ATR)V2 » MAX(-high)V2 » MAX(+high)V2, MAX(+ATR)V2

Following Casali (1996), I assume that a MAX(F)V2 constraint will always outrank its corresponding MAX(F) constraint; for example it is universally true that MAX(low)V2 outranks MAX(low). However, it is not necessarily the case that all MAX(F)V2 constraints outrank all MAX(F) constraints; for example, MAX(low) could outrank MAX(+high)V2 in a given language.

---

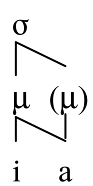
[47] The merits of assuming a linear stance in this chapter are left to future research. The position-sensitive constraints proposed here are merely a preliminary formulation of what is perhaps a more complicated phenomenon.

6.7 An OT Analysis of Hiatus Resolution in Vowel Sequences Increasing in Sonority

6.7.1 Rising Diphthongs

I agued above that underlying vowel sequences increasing in sonority are realised in the output as long or short rising diphthongs, represented structurally as two vowels sharing a mora with an optional additional mora associated with the more sonorous vowel, depending on the moraicity of the input vowel. The proposed representation is given below:

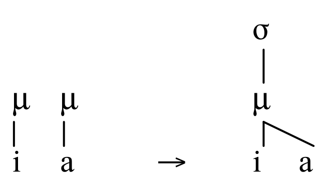
(53) Representation of rising diphthong



As discussed in this chapter, the output of underlying vowel sequences varies from language to language and within languages. The discussion in this section aims to determine which constraint ranking is responsible for the output representation in (53) as opposed to other possibilities, especially coalescence as was used in sequences of decreasing sonority.

First of all, examine the monomoraic rising diphthongs. Assuming an input of two monomoraic vowels, the following derivation occurs from input to output:

(54) Representation of rising diphthong



Two constraints are obviously violated: FAITHμ (because the total number of moras in the input is reduced from two to one in the output) and *SHAREμ (e.g. Broselow et al. 1997), a constraint that forbids the association of more than one segment with a single mora. Because the two vowels are not syllabified into two distinct syllables, *HIATUS outranks FAITHμ and *SHAREμ:

(55)

i_μ a_μ	*HIATUS	FAITHμ	*SHAREμ
$_\sigma[i_\mu]$ $_\sigma[a_\mu]$	*!		
☞ $_\sigma[ia]_\mu$		*	*

The more interesting question is why these sequences are not resolved via coalescence as were the same sequences in the opposite order. Based on the typology of coalescence systems described earlier in this chapter, I assume that coalescence in sequences of increasing sonority is more marked than coalescence in sequences of decreasing sonority. As discussed above, this is achieved through the assumption of position-sensitive MAX(F)V2 constraints.

(56)

i_μ a_μ	MAX(low)V2	FAITHμ	*SHAREμ
$\varepsilon_{\mu\mu}$	*!		
☞$[ia]_\mu$		*	*

This contrasts with the tableau for the opposite sequence, which is indeed resolved via coalescence. This is repeated from section 6.4, and the position-sensitive MAX(low)V2 can be ranked highly without altering the output, as V2 in the sequence /ai/ does not possess the feature [low]:

(57)

/ai/	MAX(low)V2	MAX(SEG)	*[front, low]	MAX(low)	MAX (-ATR)	MAX (-high)	MAX (+high)
aː		*!					*
æː			*!				*
☞ɛː				*			*

The proposed coalesced vowel for the sequence /io/ preserves the features of V2, but is not chosen as the winning candidate because it violates the constraint *[front, round], as was the case in the opposite sequence:[48]

(58)

i_μ o_μ	MAX(-high)V2	*[front,round]	FAITHμ	*SHAREμ
$ø_{\mu\mu}$		*!		
☞$[io]_\mu$			*	*

How does this effect the ranking of the constraints permitting coalescence, UNIF and MAX(F)? As proposed above, MAX(F) constraints are ranked below their respective MAX(F)V2 constraints. UNIF is ranked below *HIATUS, as discussed in the previous section. In addition, it is necessary to rank UNIF above FAITHμ and *SHAREμ in order to avoid coalescence when the coalesced vowel does preserve the features of the second

[48] This candidate also incurs a fatal violation of UNIF, which, as argued below, outranks MAXμ and *SHAREμ.

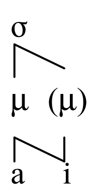
vowel, as for speakers where /ai/ is realised as [æː]. This ranking of Unif rules out the output [æː] for /ia/:[49]

(59)

i_μ a_μ	Max(low)V2	Unif	Faithμ	*Shareμ
$æ_{\mu\mu}$		*!		
☞$[ia]_\mu$			*	*

An additional question that may be posed is why falling diphthongs are not realised as monomoraic diphthongs, if this structure is preferred to coalescence in Blackfoot. The answer is not an obvious one; given the constraints thus far, the structure given below for an input /ai/ seems perfectly well formed:

(60) Representation of falling diphthong



Because the only difference between the two inputs is the order of the segments, it seems reasonable to propose that some sort of sonority sequencing constraint is responsible for the difference in output representations. Rosenthall (1994:24) proposes the constraint 'sonority rise' (SonRise) which forbids two vowels sharing a mora to decrease in sonority:

[49] For some speakers of Blackfoot, [æː] is also ruled out via the constraint *[front,low].

(61) SonRise (Rosenthall 1994:24)

$$
* \begin{array}{c} \sigma \\ | \\ \mu \\ \wedge \\ V_i \quad V_j \end{array} \qquad son_i > son_j
$$

Ranking the constraint above Unif and MaxF produces the correct patterns: coalescence for /ai/ and monomoraic diphthong formation for /ia/. This is illustrated in the following two tableaux:

(62)

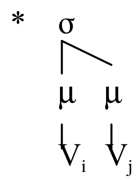
/ai/	*Diph	SonRise	Max(low)V2	Unif	Max(low)	Faithμ	*Shareμ
$[a_\mu\ j_\mu]$	*!						
$[aj]_\mu$		*!				*	*
☞$\varepsilon_{\mu\mu}$				*	*		

(63)

/ia/	*Diph	SonRise	Max(low)V2	Unif	Max(low)	Faithμ	*Shareμ
$[j_\mu\ a_\mu]$	*!						
$\varepsilon_{\mu\mu}$			*!	*	*		
☞$[ja]_\mu$						*	*

The above constraints and rankings work for Blackfoot, because Blackfoot in general disprefers bimoraic diphthongs. However, typologically, languages prefer bimoraic falling diphthongs of the type $[a_\mu\, j_\mu]$ but monomoraic rising diphthongs of the type $[ja]_\mu$. Rosenthall (1994) claims that monomoraic falling diphthongs and bimoraic rising diphthongs (of the type $[j_\mu\ a_\mu]$) are rare crosslinguistically. Accordingly, Rosenthall introduces a constraint SONFALL which prohibits bimoraic structures of the type below increasing in sonority:

(64) SONFALL



$son_i < son_j$

Because bimoraic rising diphthongs are rare, it might be safer in this analysis to assume that they are absent because of a constraint like SONFALL, as illustrated below:

(65)

/ia/	*DIPH	SONFALL	SONRISE	MAX(low)V2	UNIF	MAX(low)	FAITHμ	*SHAREμ
[j_μ a_μ]	*!	*!						
$\varepsilon_{\mu\mu}$				*!	*	*		
☞[ja]$_\mu$							*	*

This analysis works quite well within the vowel system, and can account for the hiatus resolution patterns found in Blackfoot. The next section discusses /oa/, which is not realised as a rising diphthong but rather as hiatus.

6.7.2 /oa/

Contrary to /io/ and /ia/, /oa/ is not realised as a diphthong but rather is realised as two heterosyllabic vowels, i.e. as two vowels in hiatus. Because the constraint *HIATUS is violated in this case, it must be outranked by a constraint forbidding the formation of the diphthong [wa].

Rosenthall (1994) suggests that the constraint SONFALL can be used to eliminate the possibility of creating rising diphthongs out of mid-low vowel sequences. However, his analysis crucially assumes that low and mid vowels do not differ in sonority. While a simple formulation of this constraint in terms of sonority is not possible, low and mid vowels do share the feature [-high], which was shown to be associated with sonority in the analysis of coalescence. I propose here that a constraint can be posited that prohibits the association of two [-high] vowels with a single mora:

(66) *SHAREμ[-hi,-hi]

$$
\begin{array}{ll}
* & \sigma \\
 & | \\
 & \mu \\
 & V_i \quad V_j \\
 & [\text{-hi}]\ [\text{-hi}]
\end{array}
$$

This constraint rules out the creation of a rising diphthong of the form [oa], where both segments share a mora. The bimoraic rising diphthong is ruled out via the constraint SONFALL, coalescence is ruled out by MAX(low)V2, and elision by MAX(SEG). Because this sequence is resolved by allowing hiatus, this suggests that *HIATUS is outranked by *SHAREμ[-hi,-hi], SONFALL, MAX(low)V2, and MAX(SEG). This is illustrated in the following tableau:

(67)

o_μ a_μ	MAX(SEG)	SONFALL	MAX(low)V2	*SHAREμ[-hi,-hi]	*HIATUS
$o_{\mu\mu}$	*!				
$_\sigma[o_\mu\ a_\mu]$		*!			
$ɔ_{\mu\mu}$			*!		
$[o\ a]_\mu$				*!	
☞ $_\sigma[o_\mu]\ _\sigma[a_\mu]$					*

Ultimately, an OT analysis is quite successful in providing an account of a language like Blackfoot where a wide variety of strategies are used to deal with underlying vowel sequences.

6.8 Conclusion

This chapter developed an OT analysis to account for the main vowel hiatus resolution patterns in Blackfoot. This included motivating the inclusion of a *HIATUS constraint in addition to ONSET, predicting the outcome of coalescence between two vowels of decreasing sonority and accounting for why a diphthong is produced in the /oi/ sequence and examining why sequences of rising sonority are not realised as coalesced segments.

The constraint ONSET was argued to be insufficient to account for Blackfoot's avoidance of heterosyllabic vowel sequences based on the favouring of onsetless syllables to glide onsets word-initially. This phonotactic pattern suggested that onsets are actually disfavoured if they are of sufficiently high sonority—a pattern that required a relatively low ranking of the general constraint ONSET. Using the constraint *HIATUS allowed for the separation of word-medial onsetless syllables from word-initial ones, and allowed the desired patterns to emerge.

The outcome of vowel sequences of decreasing sonority in Blackfoot (/ai, ao, oi/) was predicted to be coalescence based on the ranking of the constraints UNIF and the constraint family MAXF below the constraint *DIPH. The constraint MAXF was expanded into a ranked family of constraints which patterned alongside the sonority scale for vowels. Using this constraint ranking, it was shown that the constraint ranking predicted the correct output vowels for /ai/ and /ao/, [ɛː] and [ɔː]. In the case of /oi/, I argued that it is realised as a diphthong in Blackfoot because the possible coalesced vowels were all marked vowels, combining the features [front] and [round]. The output is therefore [oj] in Blackfoot, forcing a violation of *DIPH to avoid the creation of marked vowels.

To account for the realisation of sequences of increasing sonority (/ia, io/) as rising diphthongs rather than coalesced vowels, I introduced a family of position-sensitive constraints, MAX(F)V2, which called for the preservation of features in the second vowel of the sequence. This avoided coalescence outputs which resulted in the loss of highly ranked features in the second input vowel, such as [low]. In order to avoid predicting coalescence outputs where these features are indeed realised, it was necessary to assume that UNIF ranked above FAITHμ and *SHAREμ.

The sequence /oa/ proved exceptional by being syllabified as a sequence of two heterosyllabic vowels, and thus incurring a violation of *HIATUS. However, the desired output was achieved by ranking the constraints MAX(SEG), SONFALL, MAX(low)V2, and

*SHAREμ[-hi,-hi] above *HIATUS. By so doing, it was predicted that the sequence /oa/ be realised in hiatus even though hiatus is generally avoided elsewhere in the language.

In order to avoid the creation of similar monomoraic diphthongs in the decreasing sonority sequences, I introduced Rosenthall's constraint SONRISE, which prohibits mora sharing among two vowels of decreasing sonority. This constraint was ranked above the coalescence constraints, correctly continuing to produce coalesced segments in the falling sonority sequences. Similarly, to avoid the creation of bimoraic rising diphthongs, I introduced Rosenthall's SONFALL, which disallows moraic segments contained within a syllable to increase in sonority.

Another potential achievement of the analysis presented in this chapter is its ability to account for asymmetric coalescence. The apparent non-existence of asymmetric coalescence systems of the opposite type (i.e. with coalescence for sequences of increasing sonority but not decreasing sonority) is also predicted by the above analysis, by virtue of the position-sensitive constraints relating to V2. However, the success of this analysis when applied to the vowel systems of other languages remains a topic for future research.

Chapter Seven: Conclusion

Blackfoot phonotactics and syllable structure have proved especially problematic in previous discussions of Blackfoot phonology. This thesis presents the first systematic attempt to define the phonotactic patterns and attempt to understand syllabification. While incomplete, this thesis takes a valuable step toward a more complete understanding not only of the motivations behind phonotactic patterns and syllabification in Blackfoot, but also toward an understanding of the phonological system in general. It is hoped that the groundwork presented in this thesis in terms of segment weight and syllable structure will help pave the way for future research in other poorly understood aspects of Blackfoot phonology, such as the pitch accent system.

This thesis investigated in detail two aspects of Blackfoot phonotactics: the syllabification of moraic consonants and the resolution of vowel hiatus. After providing background information relating to the language and the theories assumed in this thesis, chapter 4 began by discussing intervocalic geminates in Blackfoot, including their representation under classical moraic theory, their historical development in Blackfoot, and the motivation for their proposed representation using Optimality Theory. Next, the restricted distribution of /x/ and glottal stop, the only consonants not contrastive for length in the phoneme inventory, was discussed, and in both cases this restricted distribution was motivated with reference to the segment's moraic specification. This chapter aimed to provide a preliminary overview of segment weight in Blackfoot by analysing the weight of clearly moraic segments.

Chapter 5 built on the analyses developed in the preceding chapter and analysed one of the more unusual properties of the Blackfoot phonological system, preconsonantal length contrasts. By assuming that preconsonantal length contrasts can be analysed in the same way as intervocalic contrasts, an analysis was developed in this chapter whereby it was proposed that preconsonantal length contrasts arise from underlying moraic contrasts. It was argued that these moraic contrasts were directly responsible for the contrastive syllabification patterns observed for Blackfoot. Contrastive syllabification in Blackfoot did not therefore require the specification of syllable structure in the underlying representation or the evocation of faithfulness constraints for syllable structure. However, it was shown that the syllabification contrasts in Blackfoot, even when motivated by underlying moraic contrasts, still served to fill a typological gap in terms of moraic theory, fulfilling assumptions implicit in the moraic model. Patterns of moraic faithfulness were discussed for two languages (Swedish and English), in order to illustrate how the analysis derived for Blackfoot preconsonantal geminates, whereby moraic contrasts are preserved preconsonantally, can be applied to account for unexpected data in other languages.

The second major section of the thesis consisted of chapter 6. This chapter provided a comprehensive treatment of the vowel hiatus resolution strategies used in the language. The primary goal of this chapter was to develop an analysis which could account not only for the general patterns of asymmetric coalescence, but also for the many exceptions within this basic system. The Optimality theoretic analysis developed in this chapter allowed the non-uniform patterns to be derived from a single analysis, and a single ranked set of constraints. Also of interest to this thesis was the dependence of the analysis on the underlying moraic specifications of the vowels, and the role of moraic faithfulness in deriving the correct output. Another achievement of this chapter was the development of a better understanding of the Blackfoot vowel system, particularly in the introduction of rising diphthongs as structures distinct from glide-vowel sequences.

This thesis does not provide a comprehensive overview of Blackfoot phonotactics, nor is it comprehensive enough to make a statement regarding a Blackfoot syllable template at this time. This work is intended to set the groundwork on which further investigation can build. Even within the analyses presented within this thesis, more knowledge regarding phonetic duration, vowel quality and variation, and speaker-to-speaker or dialectal variation is necessary before definitive statements regarding the conclusions made in this thesis can be proposed. In terms of Blackfoot phonotactics and syllable structure, a major topic was left untouched in this thesis—the syllabic and moraic representation of complex consonant clusters as in /ikːsːtskjomitaː/ 'greyhound bus/dog'. A comprehensive analysis of these clusters is necessary to understand the complicated nature of Blackfoot phonotactics. This topic is, however, left for future research.

References

Alcántara, Jonathan B. 1998. The architecture of the English lexicon. Doctoral dissertation, Cornell.

Blevins, Juliette. 1995. The syllable in phonological theory. In J. A. Goldsmith (ed.) *The Handbook of Phonological Theory*. Cambridge, MA: Blackwell, 206-244.

Borroff, Marianne L. 2005. Articulatory phasing of glottal stop. In John Alderete et al. (eds.) *Proceedings of the 24th West Coast Conference in Formal Linguistics.* Somerville, MA: Cascadilla Proceedings Project, 70-78.

Broselow, Ellen et al. 1997. Syllable weight: Convergence of phonology and phonetics. *Phonology* 14:47-82.

Casali, Roderic F. 1996. Resolving hiatus. Doctoral dissertation, UCLA.

Chomsky, Noam and Morris Halle. 1968. *The Sound Pattern of English*. New York: Harper and Row.

Clements, George N., and Samuel Jay Keyser. (1983). *CV Phonology: A Generative Theory of the Syllable*. Cambridge, MA: MIT Press.

Cohn, Abigail C. 2003. Phonological structure and phonetic duration: the role of the mora. *Working Papers of the Cornell Phonetics Laboratory* 15: 69-100.

Costa, David J. 1996. Reconstructing initial change in Algonquian. *Anthropological Linguistics* 38:39-72.

Davis, Stuart and Seoung-Hoon Shin. 1999. The syllable contact constraint in Korean: An optimality theoretic analysis. *Journal of East Asian Linguistics* 8:285-312.

De Lacy, Paul. 2002. The formal expression of markedness. Doctoral dissertation, University of Massachusetts, Amherst.

Elfner, Emily. 2005. The role of sonority in Blackfoot phonotactics. *Calgary Papers in Linguistics* 26:27-91.

Ermineskin, Rachel and Darin Howe. 2005. On Blackfoot syllabics and the Law of Finals. Paper presented at the 37th Algonquian Conference, October 22, 2005, Carleton University, Ottawa, Canada.

Frantz, Donald G. 1978. Abstractness of phonology and Blackfoot orthography design. *World Anthropology: Approaches to Language*, 307-325. Mouton.

Frantz, Donald G. 1991. *Blackfoot Grammar*. Toronto: University of Toronto Press.

Frantz, Donald G. n.d. The Blackfoot Language, website last accessed July 1, 2006: www.people.uleth/~frantz/blkft.html

Frantz, Donald G. & Norma Jean Russell. 1989. *Blackfoot Dictionary of Stems, Roots, and Affixes.* Toronto: University of Toronto Press.

Goddard, Ives. 1974. Review of *Toward a Generative Grammar of Blackfoot: with particular attention to selected stem formation processes*. *Language* 50:601-604.

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

Goddard, Ives. 1996. *The Handbook of American Indians, vol. 17: Languages*. Washington: Smithsonian Institution.

Gordon, Matthew. 1999. Syllable weight: Phonetics, phonology, and typology. Doctoral dissertation, UCLA.

Ham, William H. 2001. *Phonetic and Phonological Aspects of Geminate Timing*. New York: Routledge.

Hammond, Michael. 1999. *The Phonology of English: A Prosodic Optimality-Theoretic Approach*. Oxford: Oxford University Press.

Hayes, Bruce. 1989. Compensatory lengthening in moraic phonology. *Linguistic Inquiry* 20: 253-306.

Howe, Darin. 2000. Oowekyala segmental phonology. Doctoral dissertation, University of British Columbia.

Howe, Darin and Douglas Pulleyblank. (2004). Harmonic scales of faithfulness. *Canadian Journal of Linguistics* 49:1-49.

Hubbard, Kathleen. 1995. 'Prenasalised consonants' and syllable timing: Evidence from Runyambo and Luganda. *Phonology* 12:235-256.

Hyman, Larry. 1985. *A Theory of Phonological Weight*. Dordrecht: Foris.

Iskarous, Khalil. 1999. Vowel dynamics and vowel phonology. In Kimary Shahin et al. (eds.) *The Proceedings of the Seventeenth West Coast Conference on Formal Linguistics*. Stanford, CA: Center Study Language & Information, 308-316.

Kaneko, Ikuyo. 1999. A metrical analysis of Blackfoot nominal accent in Optimality Theory. MA thesis, University of British Columbia.

Kaneko, Ikuyo. 2000. Velar spirantization and velar phonemes in Blackfoot. In John D. Nichols (ed.) *Papers of the 31st Algonquian Conference*, 200-210.

Kinsella, Norman G. 1972. The vowel system of Blackfoot. M.A. Thesis, University of Calgary.

Levin, Juliette. (1985). A metrical theory of syllabicity. Doctoral dissertation. MIT. Cambridge, MA.

Lowery, Brenda Marion. 1979. The phonological system of Blackfoot. In E. P. Hamp et al. (eds.) *Contributions to Canadian Linguistics*. Ottawa: National Museums of Canada.

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

McCarthy, John J. 2003. Sympathy, cumulativity, and the Duke-of-York gambit. In Caroline Féry & Ruben van de Vijver *The Syllable in Optimality Theory*. Cambridge: Cambridge University Press, 23-76.

McCarthy, John J. (ed.). 2004. *Optimality Theory in Phonology*. Malden: Blackwell.

McCarthy, John & Alan Prince. 1995. Faithfulness and reduplicative identity. *University of Massachusetts Occasional Papers* 18: 249-384.

Moravcik, Edith. 1978. Reduplicative constructions. In J. Greenberg (ed.) *Universals of human language, vol. 3: Word Structure*. Stanford: Stanford University Press, 297-334.

Morelli, Frida. 2000. The phonotactics and phonology of obstruent clusters in optimality theory. Doctoral dissertation, University of Maryland at College Park.

Morén, Bruce Timothy. 1999. Distinctiveness, coercion and sonority: A unified theory of weight. Doctoral dissertation, University of Maryland at College Park.

Murray, Robert W. and Theo Vennemann. 1983. Sound change and syllable structure in Germanic phonology. *Language* 59: 514-528.

Orie, Olanike Ola and Douglas Pulleyblank. 2002. Yoruba vowel elision: Minimality effects. *Natural Language and Linguistic Theory* 20:101-156.

Parker, Stephen G. 2002. Quantifying the sonority hierarchy. Doctoral dissertation, University of Massachusetts, Amherst.

Prince, Alan and Paul Smolensky. 2004. *Optimality Theory: Constraint Interactions in Generative Grammar.* Malden: Blackwell.

Proulx, Paul. 1989. A sketch of Blackfoot historical phonology. *International Journal of American Linguistics* 55:43-82.

Proulx, Paul. 2005. Initial change in Blackfoot. *Calgary Papers in Linguistics* 26:1-26.

Rose, Sharon. 2000. Epenthesis positioning and syllable contact in Chaha. *Phonology* 17: 397-425.

Rosenthall, Samuel. 1994. Vowel/glide alternation in a theory of constraint interaction. Doctoral dissertation, University of Massachusetts, Amherst.

Rubach, Jerzy. 1984. *Cyclic and Lexical Phonology: The Structure of Polish.* Dordrecht: Foris.

Sievers, Eduard. 1881. *Grundzüge der Phonetik*. Leipzig: Breitkopf and Hartel.

Selkirk, Elisabeth. 1984. On the major class features and syllable theory. In M. Aronoff & R. Oehrle (eds.), *Language Sound Structure*. Cambridge, MA: MIT Press, 107-136.

Smith, Jennifer L. 2006. Representational complexity in syllable structure and its consequences for Gen and Con. In M. Krämer et al. (eds.) *Freedom of Analysis?*, papers collected for a workshop conducted at the University of Tromsø, September 2005. Available: roa.rutgers.edu (#800).

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

Steriade, Donca. 1997. Phonetics in phonology: the case of laryngeal neutralization. Ms., UCLA.

Stocken, Harry W. Gibbon. *ca.* 1890. *First Ten Chapters of Matthew's Gospel (syllabics)*: CIHM 30168.

Taylor, Allan R. 1969. A grammar of Blackfoot. Doctoral dissertation, University of California, Berkeley.

Thomson, Gregory. 1978. The origin of Blackfoot geminate stops and nasals. In E.-D. Cook & J. Kaye (eds.), *Linguistic Studies of Native Canada.* Vancouver: University of British Columbia Press, 249-254.

Tims, John William, Rev. 1890. *The Gospel according to St. Matthew, translated into the language of the Blackfoot Indians.* London: British and Foreign Bible Society.

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

Vennemann, Theo. 1988. *Preference Laws for Syllable Structure and the Explanation of Sound Change.* Berlin: Mouton de Gruyter.

Wells, John. 1990. Syllabification and allophony. In Susan Ramsaran (ed.) *Studies in the Pronunciation of English, a Commemorative Volume in Honour of A.C. Gimson.* London: Routledge, 76-86.

Wright, Richard. 2004. A review of perceptual cues and cue robustness. In Bruce Hayes et al. (eds.) *Phonetically Based Phonology.* Cambridge: Cambridge University Press, 34-57.

Zec, Draga. 1988. Sonority Constraints on Prosodic Structure. Doctoral Dissertation, Stanford University.

Zec, Draga. 1995. Sonority constraints on syllable structure. *Phonology* 12:85-129.