Glossa a journal of general linguistics

Windsor, Joseph W. 2017. Predicting prosodic structure by morphosyntactic category: A case study of Blackfoot. *Glossa: a journal of general linguistics* 2(1): 10. 1–17, DOI: https://doi.org/10.5334/gjgl.229

RESEARCH

Predicting prosodic structure by morphosyntactic category: A case study of Blackfoot

Joseph W. Windsor
University of Calgary, 2500 University Dr. NW, Calgary AB, T3G 1N4, CA
jwwindso@ucalgary.ca

This study examines phonetic correlates to three prosodic categories in Blackfoot: the syllable (σ), the prosodic word (ω), and the phonological phrase (φ). I provide evidence that the Blackfoot σ is recognizable by an obligatory process of vowel coalescence and the φ is recognizable by an obligatory process of right edge aspiration. The ω can be distinguished from these other two prosodic constituents by an optional phonetic process which mimics intersyllabic vowel coalescence, but does not apply obligatorily.

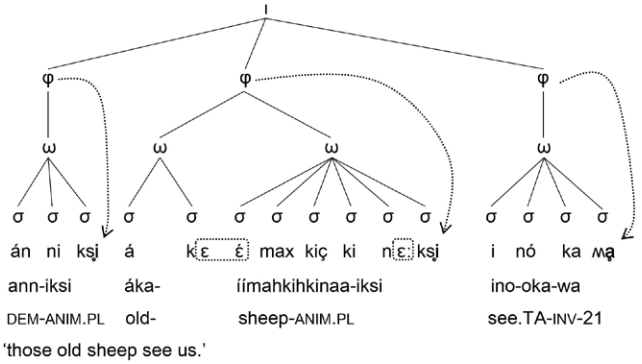
The prosodic categories investigated in this study are then correlated to three morphosyntactic categories: morphological agreement suffixes, lexical morphemes (adjectives and nouns), and demonstratives. This correlation is used to argue that morphological and syntactic processes function differently at the interface with phonology (cf. Russell 1999), ultimately raising questions with "word-internal syntax" analyses of Blackfoot suffixation which are derived through cyclic head movement (Bliss 2013; Wiltschko 2014) using the Mirror Principle (Baker 1985).

Keywords: Blackfoot; demonstratives; prosodic constituency; syntax-phonology interface; Sandhi phenomena; Phase Theory

1 Introduction

This study examines three phonetic correlates to prosodic structure which are correlated to morphosyntactic categories. I conclude that the Blackfoot prosodic phrase (φ) can be recognised by right-edge aspiration (indicated by arrows). The syllable (σ) in Blackfoot can be recognized by a process of obligatory vowel coalescence (resulting in instances of [ɛ] in (1), outlined). The σ is distinguished from the phonological word (ω) in that the process which causes vowel coalescence between ωs does not apply obligatorily.

(1) An example of Blackfoot prosodic constituency[1]



[1] Blackfoot orthographic convention (Frantz 1978) is to write pitch accented vowels with accents. Long vowels and consonants, which are contrastive (Frantz 1978; 2009; Frantz & Russell 1995; Elfner 2006), are written as double letters.

The example in (1) shows a representative sentence from the present study (reported in section 3). The diagram shows that aspiration (depicted as devoiced vowels) can be found at the right edges of φs which correspond to: the demonstrative, the nominal complex, and the verbal complex. Between the words /áka/ 'old' and /íːmaxkiçkinaː/ 'sheep' the vowel is represented in (1) as a coalesced [ɛː] (divided between the two words) but may also appear as [a.íː] in free variation. Between the noun /íːmaxkiçkinaː/ 'sheep' and *–iksi* 'ANIM.PL', vowel coalescence can once again be observed, as the intersyllabic vowel is obligatorily realized as [ɛː].

Following the discussion of the phonetic studies motivating the establishment of a prosodic hierarchy for Blackfoot, I use the cyclic syntactic spellout of Phase Theory (Chomsky 2000; 2001; 2008; Gallego 2010; detailed in section 2) to account for the formation of phonological phrases. I suggest that the prosodic hierarchy within the phonological phrase arises from matching prosodic words to syntactic heads (cf. Selkirk 2009; 2011; Elfner 2012; 2015). Next, I argue that non-isomorphism between the syntactic and phonological structures results from the fact that phonological phrases contain only the material from a single phase. Finally, I discuss the consequences that the prosodic/interface analyses of Blackfoot arguments have for theoretical approaches to inflection, which achieve suffixation through cyclic head movement (Bliss 2013; Wiltschko 2014) based on the Mirror Principle (Baker 1985):

(2) The Mirror Principle (Baker 1985: 375; Wiltschko 2014: 44)
Morphological derivations must directly reflect syntactic derivations (and vice versa)

Specifically, I demonstrate that the morphological affixation of suffixes displays distinct phonological patterning as compared to prefixation, which is argued to be syntactic in nature (cf. Russell 1999). Because the two processes have different phonological realizations, I argue that they should be treated separately – by separate morphological and syntactic components.

The remainder of this article is structured as follows: in section 2, I outline the theoretical assumptions which underlie this study. Section 3 outlines the present experiments and argues for the correlations between prosodic and syntactic structure based on morphosyntactic category. Section 4 discusses the consequences that the current phonological analysis has for morphosyntactic theory. Section 5 concludes.

2 The Interface

Some of the seminal work on the interface between syntax and phonology began in the 1980s (Beckman & Pierrehumbert 1986; Nespor & Vogel 1986 [2007]; Selkirk 1986; Halle & Vergnaud 1987; Gussenhoven 1988 – see Shattuck-Hufnagel & Turk 1996 for a summary of similarities and differences of the various proposals). Although the various levels of the prosodic hierarchy assumed by each of the aforementioned authors differ, it was generally assumed that prosodic constituents made reference to at least some syntactic structure. Later work sought to align the left and right edges of phonological constituents to syntactic constituents either by ensuring that i) a given syntactic constituent was contained within a phonological phrase (Wrap-XP: Truckenbrodt 1999) or ii) particular syntactic constituents were matched with corresponding prosodic constituents (Match Theory: Selkirk 2009; 2011; Elfner 2012; 2015). Other research has explored the need to adopt Phase Theory – the cyclic spellout of syntactic structure – into prosodic theory, which makes the possibility of a single phonological phrase spanning the material from two spellout domains unlikely (Kahnemuyipour 2004; Kratzer & Selkirk 2007; Ishihara 2007). Further, some recent research has suggested that Phase Theory and Match Theory

may be simultaneously necessary to account for prosodic structure, and that there is no reason the two are incompatible (Selkirk 2011; Clemens & Coon 2016). In the present paper, I argue that explaining prosodic constituency in Blackfoot will depend on both Match Theory and Phase Theory.

According to Match Theory, phonological constituents (e.g., the prosodic word (ω)) and the phonological phrase (φ)) are created by phonological constraints which seek to make phonological and syntactic constituent structure isomorphic with one another:

(3) MatchPhrase (Selkirk 2011: 439)
A phrase in syntactic constituent structure must be matched by a corresponding prosodic constituent, call it φ, in phonological representation.

(4) MatchWord (Selkirk 2011: 439)
A word in syntactic constituent structure must be matched by a corresponding prosodic constituent, call it ω, in phonological representation.

Phase Theory does not contradict either of the constraints in (3) or (4), but rather provides an additional condition which restricts phonological phrasing. Because the phonological component receives material from the syntactic component in stages, only a portion of the derivation is available to the phonological component at a given time. As such, certain syntactic information may become unavailable to the prosodic component of the grammar, once a phase has been spelled-out. Clemens & Coon (2016) use this idea to explain why their constraint, Argument-φ appears to impact prosodic constituency in some cases, but not others, while MatchPhrase (provided above) is always involved in the formation of phonological phrases.

Clemens & Coon (2016) adopt Chomksy's (2001; 2008) position that the nominal parallel of C^0 and v^0 are phase heads, based on the parallelism between the nominal and verbal domains. Chomsky assumes that the nominal phase head is (minimally) D^0. For Blackfoot, however, Bliss (2013) and Wiltschko (2014) both argue that D^0 is the nominal parallel of I^0, not C^0, and therefore I assume the nominal phase head is higher than D^0; the K^0/$Link^0$ in Bliss' or Wiltschko's analysis, or the Dem^0 in Windsor & Lewis (2016).[2]

If we accept Bliss (2013) and Wiltschko's (2014) (cf. Abney 1987) conclusion that D^0 is not the nominal parallel of C^0, but rather that it is a functional projection above D^0, we might also assume that the phase head is also higher than D^0. Furthermore, if we accept that phonological phrasing is constrained by syntactic phases then phonological phrases should not be able to span material contained in separate syntactic phases. Subsequently, a reasonable prediction based on these premises is that any material higher than D^0 will be spelled-out in a separate phase, and thus, a separate phonological phrase from the noun. This prediction will be used to explain the fact that demonstratives in Blackfoot are phrased separately from other nominal elements. In order to make this argument, though, I must first explain how to identify prosodic phrases in Blackfoot, which is the subject of the next section.

3 Prosodic categories and phonetic correlates

This section details two experiments which test the phonetic correlates of prosodic boundaries in Blackfoot. The first study shows a significant correlation between vowel aspiration[3] and what is analyzed as the right edge of φs. The second study provides evidence

[2] Chomsky (2001) also suggests that n^0 as the nominal parallel of v^0 is also likely a phase head. I assume, following Bliss (2013), that Blackfoot has N-to-*n* movement, allowing the noun to escape the lower phase.

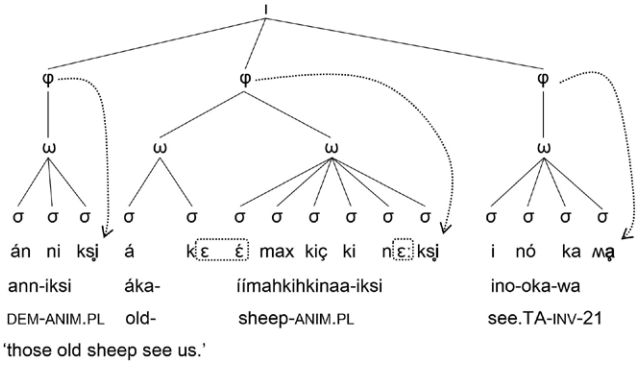
[3] This is typically referred to as vowel devoicing in the literature (Frantz 2009; Gick et al. 2011), but I analyse it as the epenthesis of a [SPREAD GLOTTIS] feature (Windsor 2016).

that an obligatory process of vowel coalescence is active between adjacent intersyllabic vowels. Finally, an optional phonetic process which mimics intersyllabic vowel coalescence is found at the boundaries between ωs.

3.1 Study 1: Right edge aspiration

Study 1 examines the role of sentential position as a predictor of what is typically described as vowel devoicing in the Blackfoot literature (Frantz & Russell 1995; Elfner 2006; Frantz 2009; Gick et al. 2011; Bliss 2013). Within this literature, vowel devoicing, what I will call aspiration, is typically described as occurring at the end of an orthographic word.[4] In the present article, I follow Russell & Reinholtz (1997) who conclude for the related Cree language, that "the units of Cree which are usually called "words" are in fact phrases at the phonological level" (Russell & Reinholtz 1997: 447).[5] There are several reasons to believe that the conclusions for Cree also hold true for Blackfoot, and they are detailed throughout the remainder of this section. As can be seen in the diagram in (1), repeated here as (5), the domain of aspiration (again indicated by arrows) is smaller than the utterance:

(5) An example of Blackfoot prosodic constituency



As can be seen in (5) above, there are three instances of aspiration (demarcated as voiceless vowels) within a single utterance, which happen to coincide with the orthographic words in that sentence. However, not all orthographic words display aspiration at their right edge (a conclusion from study 1). Finally, an orthographic word in Blackfoot may contain several ωs (a conclusion from study 2). These facts provide evidence that the domain of aspiration epenthesis in Blackfoot is higher than the ω, but lower than the ι – suggesting that that domain is the right edge of the φ. Before making that argument, however, it must first be shown that right edge aspiration is a positional alternation based on prosodic constituency.

3.1.1 Methodology

The first elicitation experiment examines the amount of aspiration observable on the right edge of a target noun when that noun appears in sentence final position versus sentence medial position. This was done by exporting the tokens into Praat (Boersma & Weenink 2016) and measuring the duration for which stable formant bands could be observed without

[4] The term "orthographic word" refers to a discernable unit in the spelling convention of the language, which has previously been used to argue for phonological and syntactic constituency (see Russell & Reinholtz 1997 or Bliss 2013).

[5] Donald Frantz (p.c. 2012) clarifies that in his grammar of Blackfoot, when describing the phonological process of vowel devoicing and the end of a "word", he did not intend that statement to be directly linked to a prosodic ω, but was rather discussing a process which takes place at the end of an orthographic word so that it could be understood by non-linguists. He agrees that these strings most often represent φs rather than ωs in the strict phonological sense.

voicing (as agreed upon by the two researchers).[6] A representative noun can be seen in Figure 1, where the spectrogram for the noun *ninaa* 'man' is shown with glottalic pulses indicated. The final portion of the vowel which displays stable formant bands is measured from the end of periodic voicing (0.109 seconds).

In Blackfoot, nouns typically end in a vowel due to final agreement morphology, shown in Table 1.

For the experiment used in the present study, a series of proximate animate singular nouns were elicited from three native speakers of the Kainai "Blood" dialect of Blackfoot[8] in one of two carrier sentences which translate as: 'this is an (*animate noun*)' and 'this (*animate noun*) is my pet/possession' (see example 6). The hypothesis underlying these elicitations is that the amount of aspiration observable on the animate singular suffix *–wa* can be measured and contrasted between the two positions; if the amount of aspiration differs between the two positions, then the orthographic word cannot represent the domain of aspiration, and it can be concluded that aspiration is a positionally-dependent epenthetic feature in the language. If no difference in the amount of aspiration exists between the two sentential positions, then the orthographic word can be said to represent the domain of aspiration, possibly with that feature being part of the underlying representation.

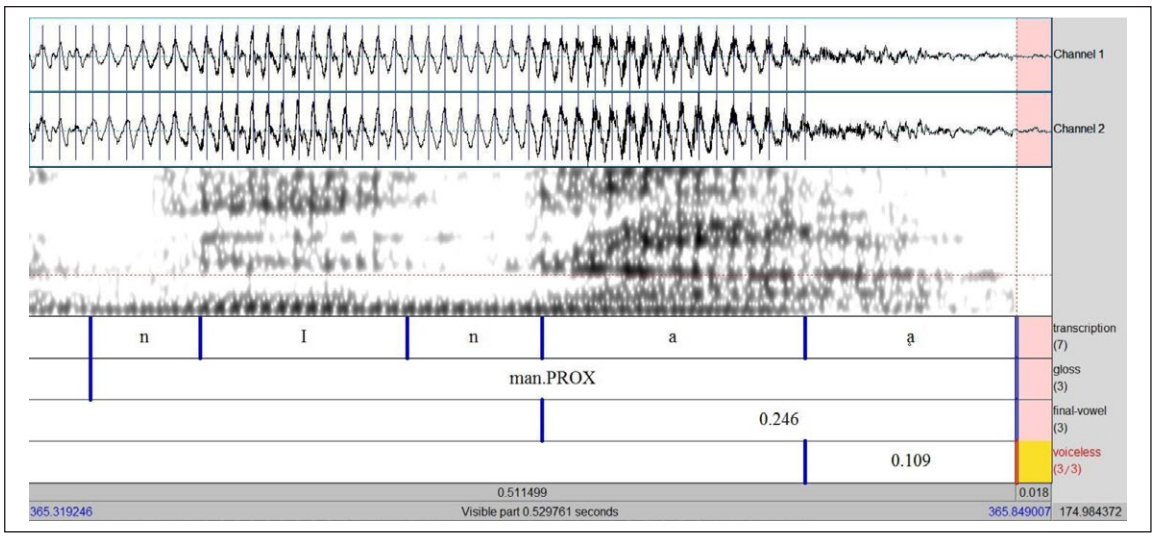


Figure 1: Final aspirated vowel.

		Animate	Inanimate[8]
Singular	Proximate	*–wa*	–
	Obviative	*–yi*	
Plural		*–iksi*	*–istsi*

Table 1: Blackfoot agreement morphology (Bliss 2013: 30).

[6] From the original study presented in Windsor & Cobler (2013).

[7] Inanimate nouns cannot serve as the subjects of sentences in Blackfoot, and therefore cannot take proximate case.

[8] A fourth speaker was excluded from this study for dialectal differences which made the carrier sentence ungrammatical for him due to animacy mismatches which did not exist for the three (younger) speakers. The alternate carrier sentence proposed by the Elder speaker was deemed ungrammatical for the three younger speakers due to the limited distribution of which nouns could be used in conjunction with it.

(6) Sample elicitation sentences for study 1

a. Ámo anistápssiwa **pííta**. (sentence-final target)
amo anistápssi-wa pííta-wa
DEM be.called.AI-3.SG eagle-PROX
'This is an **eagle**.'

b. Ámo **pííta** nitsináána. (sentence-medial target)
amo pííta-wa n(it)-itsináán-wa
DEM eagle-PROX 1.SG-possession-PROX
'This **eagle** is my pet.'

Elicitations were based on a translation task with the researchers asking the subject how to say the equivalent English sentence in Blackfoot over multiple recording sessions. Recordings were made on a Zoom H4n digital stereo recorder with internal microphones set to 90° and the recording level also set to 90. A wind sock was used over the microphones to eliminate a small amount of background noise from the air vents in the room. The recordings were subsequently imported into Praat for analysis. The duration of aspiration for each of the targets (n = 137) were measured and categorized based on the sentence-medial or sentence-final position of the target.

3.1.2 Results

Vowels, both phonemically long and short, were found to devoice the final third of the overall duration in final position (ranging between 27%–44%) averaging 0.1202 seconds. Separating aspiration lengths by position, a two-sample t-test with a Welch correction was run on the data with the following result: [$t(91.207) = 6.0408; p < 0.001$]. This shows a significant increase in the amount of aspiration observed when a target is in sentence-final position, as can be seen in Figure 2.

The diagram in Figure 2 is a visual representation of the data used in the t-test. This shows that when the target appears in sentence final position (on the right), there is a statistically significant increase in aspiration. With the exception of a few outliers, almost no aspiration is observed on the target when it is removed from the right edge of the sentence (or put in medial position, as depicted on the left of figure 2).[9] If the orthographic word corresponded to the phonological unit which caused aspiration at its right edge, the position that that unit took within the sentence would not alter the amount of observable aspiration. As this prediction is not borne out and aspiration is dependent on sentence position, it can be concluded that the orthographic word is not the domain of aspiration.

In conclusion, this first elicitation experiment shows that aspiration at the right edge of some domain is a statistically significant indicator of a particular prosodic boundary, one which can encompass a morphosyntactically complex grammatical unit; this suggests that the unit in question is likely to be larger than the ω. However, at present, the available evidence does not allow the conclusion that the unit in question is necessarily a φ as opposed to some higher prosodic constituent. Discerning the particular prosodic constituents and their grammatical correlates is the subject of the second study, reported in the next section.

3.2 Study 2: Intersyllable vowel coalescence and sandhi phenomena

Study 1 concluded that the domain of aspiration (what has previously been called vowel devoicing) in Blackfoot was not the orthographic word, because orthographic words removed from the right edge of the sentence displayed significantly less aspiration com-

[9] Note that aspiration inside the sentence is still possible as seen in examples (1) and (5), however, the target word in the elicitation sentences for study 1 displays little-to-no aspiration when removed from the right edge of the sentence by the word *nitsináána* 'my possession'.

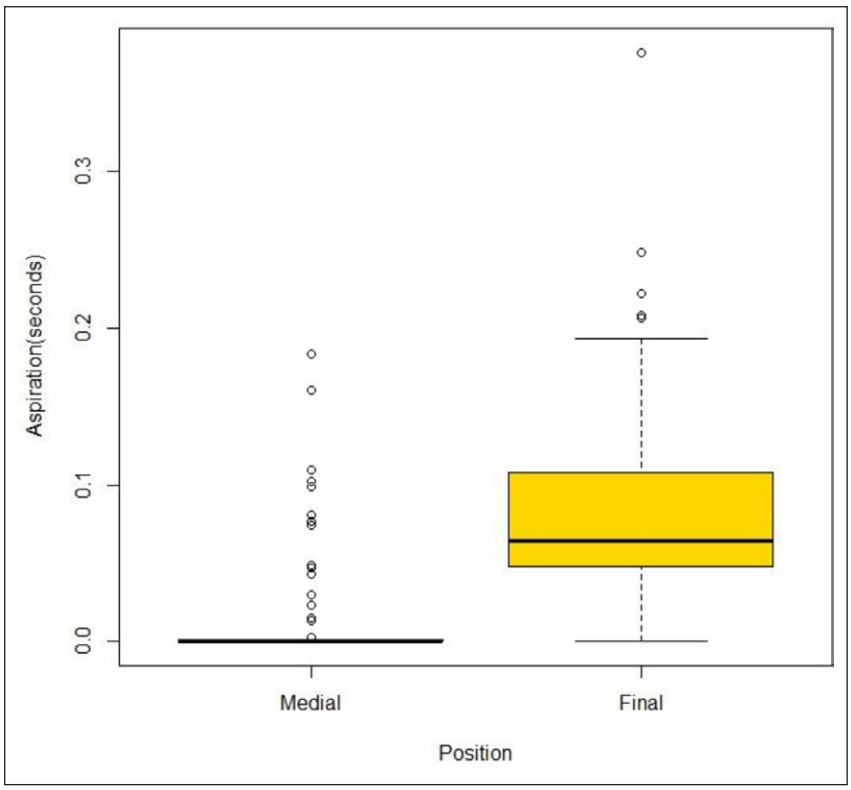


Figure 2: Aspiration by position.

pared to those found in sentence-final position. Although a conclusion was not reached as to the precise identity of the prosodic constituent responsible for aspiration, the hypothesis that the prosodic constituent in question must be lower than the intonational phrase (ι) is supported by the right-edge aspiration that could be observed in multiple locations within the utterance. The second study investigates the phonetic correlates of prosodic constituents between the syllable (σ) and the domain of aspiration, which I ultimately argue is the prosodic phrase (φ).

It is well established that when a σ with no coda comes into contact with a σ lacking an onset in Blackfoot, a process of vowel coalescence occurs (Elfner 2006; Frantz 2009; Bliss 2013). For example, when an animate noun ending in /a/ is pluralized (taking the *–iksi* suffix), /a/ + /i/ is pronounced [ɛ].[10]

(7) /imit**aː**/ + /**i**ksi/ → [imit**ɛː**ksi̥]
dog ANIM.PL dog-ANIM.PL
'dogs'

In the example above, the /aː/-final noun 'dog' is realized with the animate plural suffix beginning with an /i/ vowel. The resulting form surfaces with [ɛː].

A similar process of vowel coalescence is also observed between vowel-final adjective prefixes and vowel-initial nouns which they can cliticize onto:

(8) /ák**a**/ + /**íː**maxkiçkinaːʍą̊/ → [ak**éː**maxkiçkinaːʍą̊]
old sheep-PROX old-sheep-PROX
'old sheep'

[10] Some other dialects of Blackfoot show a process of diphthongization in this environment rather than coalescence (Frantz 2009; Bliss 2013). There is no reason to expect that the results I present here would be any different for a diphthongization dialect.

Similar to the noun + plural example given in (7), the example in (8) shows that vowel coalescence occurs between nouns and their adjoining adjectives. However, this process is not obligatory, and this form can also be pronounced without vowel coalescence between the adjective and noun:

(9)

/ák**a**/	+	/**íː**maxkiçkinaːʍḁ/	→	[ák**aíː**maxkiçkinaːʍḁ]
old		sheep-PROX		old-sheep-PROX

'old sheep'

According to my consultant[11] (from whom all the data for this second study are drawn) both of the pronunciations listed in (8) and (9) are acceptable. One possible explanation for the optional application of vowel coalescence in this environment would be to attribute the coalescence to a phonetic sandhi process applying between ωs à la enhancement and overlap (Quantal Theory; Keyser & Stevens 2006; Stevens & Keyser 2010; cf. Zsiga 1994; 1997; 2000). Russell (1999; 2008), examining the related Cree language, shows that the optional phonetic processes, of the type predicted by enhancement & overlap, that occur at the boundaries of ωs may mimic ω-internal obligatory processes but do not occur with the same regularity in application. Russell (2008) additionally cites a variety of phonetic studies which show that such sandhi phenomena are most frequently found at the boundaries between ωs (Zsiga 1994; 1997; 2000; Nolan et al. 1996; Ellis & Hardcastle 2002; Ladd & Scobbie 2003; Tserdanelis 2005). Although it is not the case that all sandhi phenomena are optional, Russell and many of the references therein argue that the location where optional phonetic phenomena are most expected is between ωs (cf. Sadock 1980). Coupling these previous studies with the Match Theoretic notion that syntactic heads such as those which contain adjectives are matched as ωs provides a rational for the hypothesis that adjectival prefixes are likely separate ωs from the nouns that they cliticize onto. If this hypothesis is borne out, it stands to reason that aspiration, belonging to a constituent above that matched from an adjective, but below the ι, must be a φ.

3.2.1 Methodology

In order to test the hypothesis that adjectival prefixes and nouns represent separate ωs, and to posit a prosodic representation of nominal expressions in Blackfoot, a series of sentences were elicited similar to those in (10), using the same methodology reported for study 1.

(10) Sample elicitation sentences for study 2

a.

Anniks**i**	**a**k**áí**mahkihkin**ai**ksi	inóókawa.
[anːiksi̥	ak**ɛː**maxkiçkinɛksi̥	inoːkaʍḁ]
~[anːiksi̥	ak**ai**maxkiçkinɛksi̥	inoːkaʍḁ][13]
ann-iksi	ák**a-íí**mahkihkin**aa-i**ksi	ino-oka-wa
DEM-ANIM.PL	old-sheep-ANIM.PL	see.TA-INV-21

'Those old sheep see us.'

b.

Ann**a**	**i**mitááwa	inóókawa.
[anːḁ	imitaːʍḁ	inoːkaʍḁ]
ann-wa	imitaa-wa	ino-oka-wa
DEM-PROX	dog-PROX	see.TA-INV-21

'That dog sees us.'

[11] The consultant for this study is the eldest from the three speakers used in study 1, the other two speakers were not available to participate in study 2 at the time it was conducted.

[12] See description of variable pronunciation above surrounding examples (8) and (9).

The boundaries between the demonstrative and (adjective)noun were analyzed for presence or absence of aspiration and/or vowel coalescence, as were the boundaries between adjectives and nouns, and nouns and the plural morpheme. A generalized linear model (GLM) was then run on the binary (yes/no) results of this analysis to determine if any of the phonetic observances were correlates of particular syntactic boundaries. Any pauses that were observable between syntactic categories were measured using Praat.

3.2.2 Results

The results of the findings from the second elicitation experiment are reported in the bar graph in Figure 3.

As can be seen in Figure 3, 94.4% of demonstratives showed aspiration at their right edge (34 of 36 tokens) and 0% of demonstratives showed vowel coalescence with an adjacent adjective or noun (0 of 36 tokens). In contrast, no aspiration was observed at all between adjectives and nouns or between nouns and the plural suffix (0 of 74 tokens). At the boundary between nouns and the plural suffix, 97.2% of the tokens showed vowel coalescence (35 of 36 tokens) and only one token could not be reliably analysed as displaying this sound change. Coalescence at the boundary between adjectives and nouns was optional; only 75% of the tokens in this category displayed coalescence (27 of 36 tokens), including specific tokens which were produced both with and without coalescence between the adjective and noun.

The tokens were coded for syntactic boundary, the length of the pause (if any) that existed between the elements, the existence of aspiration on the right edge, and whether or not vowel coalescence occurred. An analysis of variance (ANOVA) was run on a generalized linear model (GLM) using a binomial distribution. Aspiration, coalescence, and length of pause were considered as factors in predicting an adjective-noun boundary or a demonstrative-(adjective)noun boundary. No significant interactions between these factors was observed. The length of pause between elements at these boundaries was likewise not found to be significant ($p = 0.107$). However, the main effects of aspiration and coalescence were both significant predictors. In the GLM, aspiration was found to be a significant predictor of demonstrative-(adjective)noun boundaries [$G^2(70) = 84.143, p < 0.001$], and vowel coalescence was found to be a significant predictor of adjective-noun boundaries [$G^2(69) = 5.24, p = 0.022$].

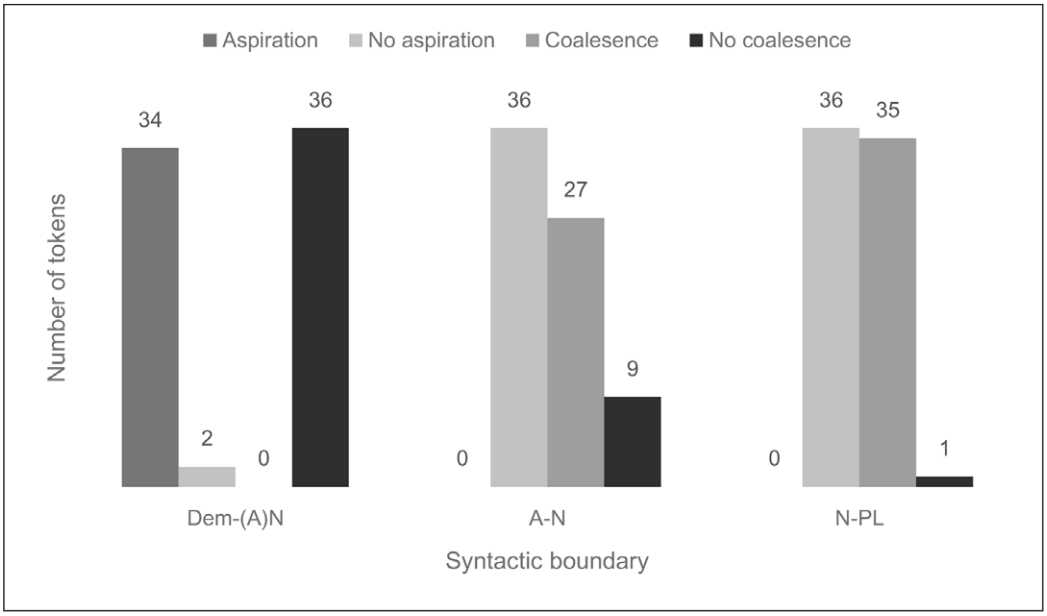


Figure 3: Phonological effect by boundary.

The same test was completed comparing noun-plural boundaries, finding vowel coalescence to be a significant predictor of these boundaries as well: [G^2 (69) 11.852, $p < 0.001$]. A two-sample test of proportions was completed on the patterns of vowel coalescence found between the adjective-noun boundaries and the noun-plural boundaries with the following result: [$z = 2.7226$; $p = 0.007$]. The test of proportions shows that the ability for each of the syntactic boundaries to predict the application of vowel coalescence is significantly different between the two grammatical correlates. In other words, vowel coalescence obligatorily applies between the noun and the plural morpheme, but is optional between adjectival prefixes and the nouns they cliticize to.

These results provide evidence for three distinct levels of phonological constituency within the nominal domain in Blackfoot. I suggest that the demonstrative (as well as the entire nominal complex in these examples) instantiates a φ; adjectives and nouns are each matched as ωs, and the plural suffix represents only a σ. These conclusions are summarized in Table 2.

In this section, I have shown the phonetic correlates to three prosodic categories in Blackfoot. From this, I conclude that the demonstrative must be encompassed within a prosodic constituent separate from the adjectival prefix and noun as right-edge aspiration is a significant predictor of this syntactic boundary. Further, because a significant difference in the realization of vowel coalescence is observed between the adjectival prefix and noun compared to the noun and plural morpheme, I argue that the prosodic representations for each of these boundaries must also be separate. I suggest that the boundary which separates the demonstrative from other nominal elements under discussion is a φ; the boundary separating the adjectival prefix and the noun is a ω; and, the plural morpheme instantiates a σ. The rationale behind these hypothesized prosodic units is provided in the following section.

4 Discussion and consequences

The preceding sections have shown how three sound alternation processes characterize three distinct levels of the prosodic hierarchy in Blackfoot: one level (suggested to be φs) can be recognized by obligatory aspiration at the right edge; an intermediate level (suggested to be ωs) can be recognized by an optional phonetic process of vowel coalescence sandhi; and, the third level (suggested to be σs) can be recognized by an obligatory process of vowel coalescence. Study 2 positively correlated these phonetic effects to various morphosyntactic categories such that: demonstratives display aspiration at their right edge 94.4% of the time; vowel coalescence was observed at the boundary between an adjective and noun 75% of the time; and, plural morphology showed obligatory vowel coalescence 97.2% of the time.

To anchor the discussion of why these phonetic correlates should be considered as instantiating the prosodic units suggested, I return to the Match Theory constraint which matches lexical syntactic heads to prosodic words, MATCHWORD. Using this constraint as a starting point, it is a reasonable hypothesis that the noun and possibly the adjective should both be matched as ωs in phonological representation. It has been proposed that optional phonetic processes (e.g. optional vowel coalescence) frequently occur between ωs, possibly due to phonetic overlap (Sadock 1980; Zsiga 1994; 1997; 2000; Russell

Syntactic position	Hypothesized prosodic boundary	Right-edge aspiration	Coalescence acceptable, but not obligatory	Obligatory coalescence
DEM – (A)N	φ	✓	×	×
N – N	ω	×	✓	×
N – PL	σ	×	×	✓

Table 2: Results of prosodic boundary cues by syntactic representation.

1999; 2008; Keyser & Stevens 2006; Stevens & Keyser 2010).[13] It is therefore reasonable to suggest that if an optional process of vowel coalescence is observed between two lexical syntactic heads, this process marks the boundaries between two ωs. Because phonetic overlap frequently mimics phonological processes found ω-internally (cf. Russell 1999; 2008), we can conclude that the boundary between nouns and the plural suffix is likely to be smaller than the ω (since vowel coalescence at this boundary was obligatory).

From this conclusion, it is possible to analyze the plural morpheme *–iksi* as being a sequence of syllables, possibly a metrical foot. However, because this suffix does not appear to contribute stress to any of the tokens analyzed, there is no reason to assume a metrical foot is the correct analysis of this structure. Finally, if right-edge aspiration is not evidenced at ω, or ω-internal, boundaries, it is reasonable to conclude that right-edge aspiration must demarcate a prosodic boundary higher than the ω. Given that there are several instances of right-edge aspiration within a clause, it is unlikely that the domain of aspiration is an intonational phrase, or higher.[14] Together, these facts suggest that the domain of aspiration in Blackfoot is at the right edge of a φ. The conclusion to be drawn from this discussion is that the demonstrative in Blackfoot is parsed into a φ separate from other nominal elements such as an adjectival prefix or noun. However, why this should be the case is not immediately clear, unless we assume that the demonstrative is spelled out in a separate phase from the other nominal elements. However, suggesting there is a phase boundary between the nominal complex and the demonstrative has consequences for current syntactic analyses of Blackfoot.

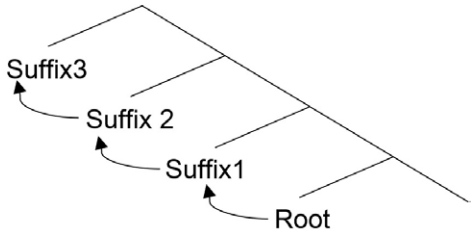
There are currently two proposals as to where Blackfoot demonstratives associate with the syntactic spine. Bliss (2013) and Wiltschko (2014) analyze the demonstrative as originating in Spec,DP and raising to Spec,KP to achieve the correct linearization: demonstratives obligatorily precede nouns. This raising analysis is a consequence of a diagnostic assumption built into the Universal Spine Hypothesis (Wiltschko 2014); that morpheme linearization in Blackfoot is created through cyclic head movement à la Baker's Mirror Principle:

(11) The Mirror Principle (repeated from (2); Baker 1985; Wiltschko 2014)
Morphological derivations must directly reflect syntactic derivations (and vice versa).

Assuming the mirror principle, Bliss and Wiltschko each argue that Blackfoot suffixation occurs through cyclic head movement according to the following algorithm:

(12) Blackfoot suffix linearization algorithm (Bliss 2013: 12)

a.



b. [Root – Suffix1 – Suffix2 – Suffix3]

[13] Another possible analysis could attribute the optionality of vowel coalescence to multiple possible prosodic representations (cf. Selkirk 1995). When coalescence is observed, it is because the adjective and noun have been parsed into a single ω. When no coalescence is observed, it is because the adjective and the noun have been parsed into separate ωs.

[14] Selkirk (2011) suggests that intonational phrases typically match syntactic clauses.

According to the algorithm in (12), Bliss derives the sequence √noun > plural by movement of the N^0 to Φ^0 (where she argues that the plural *–iksi* is associated with the syntactic spine). This type of cyclic head movement, using the positions Bliss (2013) uses to merge each of the grammatical components, correctly predicts the order N > *n* > Φ in an example such as 'your dogs':

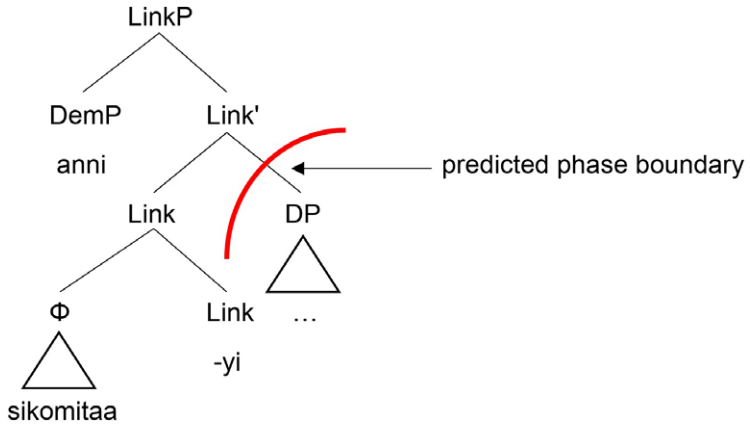
(13) a. kitomitaamiksi[16]
kit-omitaa-m-iksi
2.SG-dog-POSS-ANIM.PL
'your dogs'
b. [[$_D$ kit- [[$_\varphi$ [$_n$ [$_N$ omitaa]$_i$ -m] -iksi] [t_i [t_i]$_{NP}$]$_{nP}$]$_{\varphi P}$]$_{DP}$

In the example in (13), the N^0 *omitaa* undergoes head movement to the n^0 containing the possessive suffix *–m*. The complex n^0 then undergoes cyclic head movement to the Φ^0 which is argued to contain the animate plural suffix *–iksi*. In examples with singular animate nouns, Bliss (2013) and Wiltschko (2014) argue that the noun raises higher still, to incorporate into the K^0/$Link^0$ (depending on whether the structure assigns proximate or obviative case). To achieve the correct word order, the demonstrative must then move from Spec,DP to Spec,KP/Spec,LinkP. Bliss (2013) and Wiltschko (2014) argue that this position is the nominal parallel of Spec,CP:

(14) a. [CP [IP [AspP [*v*P [VP]]]]]
b. [KP [DP [ΦP [*n*P [NP]]]]]

Following the hypothesis outlined in section 2 that the nominal parallel of the C^0 phase head is also a phase (Chomsky 2008), if the nominal parallel is the K^0/$Link^0$, then that head must be a phase head. This makes the prediction that the demonstrative and the nominal complex would be spelled out in the same phase:

(15) anni sikomitaayi
ann-yi sik-omitaa-yi
DEM-OBV black-dog-OBV
'that dog'



Under this analysis, we are unable to account for why an AP in Spec,NP (Bliss 2013) is realized as a ω, and a DemP in Spec,LinkP is realized as a φ – evidenced by the distinction between optional coalescence between ωs and obligatory right-edge aspiration on φs concluded in the present study.

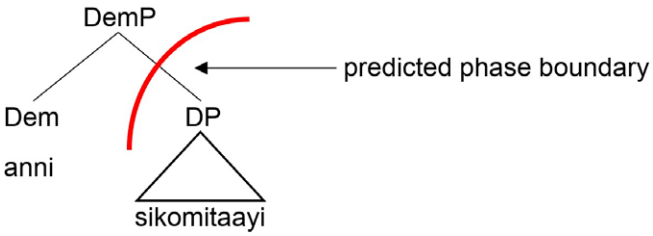
[15] Bliss (2013: 117) analyzes the person prefix *kit-* as a DP in Spec,*n*P, I merge it in the D^0 for the purposes of linear order only. The analysis does not hinge on the location of this morpheme since the algorithm for prefixes is different from that of suffixes according to Bliss (2013: 14) and is instead based on relative structural height. (See Bliss & Gruber 2015 for a full syntactic and semantic analysis of these forms.)

In this paper, I argue for an alternative analysis of Blackfoot demonstratives (see also Lewis 2015). I do not assume the Mirror Principle in this analysis. If the morphemes such as *–m* 'possessive' and *–iksi* 'animate plural' were syntactic heads, linearized by cyclic head movement, we would predict that the MATCHWORD constraint would create separate prosodic words for these syntactic heads. However, there is no evidence to suggest that *–iksi*, or any other suffix does instantiate a separate ω in Blackfoot. This is consistent with the conclusions of Russell (1999) who argued, for two other polysynthetic languages, that prefixes and suffixes (in the related Cree language, for example) show different prosodic constituencies. Specifically, Russell argues that these distinctions result from the fact that Cree prefixes (which create separate ωs) are the result of syntactic structure, but that suffixes (which are not realized as separate ωs) are the result of non-syntactic morphological processes. Unsurprisingly, based on the present study, Blackfoot seems to align with the analysis for Cree: prefixes are matched as separate ωs, and are therefore separate syntactic heads, and suffixes are incorporated into the ω containing the lexical head. Because I do not assume the Mirror Principle, I am not forced to analyze suffixation as cyclic head movement. Therefore, I argue that rather than raising to Spec,LinkP, through a word order movement, the DemP associates with the syntactic spine in a position above DP. This analysis creates the parallel provided in (16) and predicts that Dem^0 is the phase head, spelling out the DP in a separate phase from the demonstrative.

(16) a. [CP [IP [AspP [*v*P [VP]]]]]
b. [DemP [DP [ΦP [*n*P [NP]]]]]

Based on this analysis, we can capture the fact that demonstratives show a significant correlation with right-edge aspiration, argued to epenthesize at the right edges of φs. Whereas adjectives and nouns are matched as ωs parsed into a φ, demonstratives are in a separate spellout phase, and therefore phonologically phrased separately. This can be seen using the same datum presented in (15) above:

(17)



Under the hypothesis that phonological phrasing is constrained by syntactic phases (Kahnemuyipour 2004; Kratzer & Selkirk 2007; Ishihara 2007; Clemens & Coon 2016), this analysis correctly predicts the fact that the demonstrative is phrased separately from the rest of the nominal complex. Further, it explains why demonstratives are significantly correlated with right-edge aspiration. The phonological representation, as predicted by syntactic structure, is captured in the following example (where | represents a phase boundary):

(18) *anna* *akáómitaawa* *(inóókawa)*
ann-wa aka-omitaa-wa ino-oka-wa
DEM-PROX old-dog-PROX see.TA-INV-21
'that old dog (sees us)'

a. [[$_{Dem}$ anna] | [[$_{D}$ Ø] [[[$_{A}$ aka-]]$_{AP}$ [[$_{n}$ Ø [$_{N}$ omitaawa] [[$_{N}$ *t*]]$_{NP}$]$_{nP}$]$_{DP}$]$_{Dem}$P

b. [(an:a̰)$_{ω}$]$_{φ}$ [(ak)$_{ω}$ (ɔmita:ʁa̰)$_{ω}$]$_{φ}$

As can be seen in the representations provided in (18), syntactic heads containing pronounceable material are matched as ωs. Syntactic phrases (i.e., DemP and DP) are matched as φs providing they do not span separate phases.[16] Aspiration, represented as devoiced vowels, occur at the right edges of φs and vowel coalescence may occur between adjacent ωs (represented as [ɔ] in the above example created by the adjacent final /a/ of *aka-* 'old' and the initial /o/ of *omitaawa* 'dog.PROX'). This representation, assuming the Dem^0 as a phase head, correctly predicts the phonetic correlates observed in studies 1 and 2.

5 Conclusion

This article has provided evidence from translation tasks with native Blackfoot speakers to show that the right edges of phonological phrases (φ) are demarcated with aspiration, which frequently presents as final vowel devoicing. The boundaries between prosodic words (ω) are often realized with a vowel coalescence sandhi phenomenon, but not obligatorily so. The boundaries between syllables (σ) display an obligatory vowel coalescence sound alternation.

This evidence from experimental elicitation was used to explore the relationship between syntactic heads and morphological suffixes in Blackfoot and their phonological realization. I conclude, based on the difference in phonological representation observed between prefixes and suffixes, that Blackfoot patterns with the related Cree language in that prefixes instantiate separate prosodic words created by syntactic structure, and suffixes are incorporated into the prosodic word containing the lexical root and are derived by non-syntactic morphological processes (à la Russell 1999). These observations were used to motivate an analysis not reliant on cyclic head movement to achieve the correct linearization facts which allowed me to correctly predict that the sister of the demonstrative is spelled out in a separate phase; thus accounting for the fact that Blackfoot demonstratives appear to be parsed into a phonological phrase by themselves, something that could not be predicted by an analysis that was reliant on cyclic head movement (Bliss 2013; Wiltschko 2014). Finally, the results of this study suggest that phases may be required to account for phonological phrasing (Kahnemuyipour 2004; Ishihara 2007; Kratzer & Selkirk 2007), and that Phase Theory is not incompatible with a Match Theoretic analysis of the syntax-phonology interface (cf. Selkirk 2011; Clemens & Coon 2016).

Abbreviations

σ = syllable, ω = phonological word, φ = prosodic phrase, ι = intonational phrase, DEM = demonstrative, ANIM = animate gender, INAN = inanimate gender, SG = singular, PL = plural, TA = transitive-animate, INV = inverse, 21 = 1.PL.inclusive ('we' inclusive), DUR = durative (imperfective), IMP = imperative, PROX = proximate case, OBV = obviative case. NB: proximate animate singular nouns are glossed simply as PROX keeping with convention (cf. Bliss 2013).

Acknowledgements

This research was supported by the Social Sciences and Humanities Research Council. The author would like to thank his Blackfoot teachers and language consultants for their invaluable and ongoing contributions to this research. *Piitaikiihtsipiimi, Aistanskiaki, Issapoikoan, kii Ainootaa, nitsíniiyi'takihpinnaan*. This research has also benefited greatly from the feedback of three anonymous reviewers and the participants of the ETI3 workshop.

A special thanks also goes to Stephanie Coward for her review of and help with the statistics presented in this article.

[16] I suggest that the *n*P and AP in (18) do not get realized as φs due to binarity restrictions (see Ghini 1993; Elfner 2012; 2015).

Competing Interests

The author has no competing interests to declare.

References

Abney, Stephen. 1987. *The English noun phrase in its sentential aspect*. Cambridge, MA: Massachusetts Institute of Technology dissertation.

Baker, Mark. 1985. The mirror principle and morphosyntactic explanation. *Linguistic Inquiry* 16. 373–415.

Beckman, Mary E. & Jannet Pierrehumbert. 1986. Intonational structure in Japanese and English. In Colin Ewen & John Anderson (eds.), *Phonology Yearbook* 3, 255–309. Cambridge: Cambridge University Press.

Bliss, Heather Anne. 2013. *The Blackfoot configurationality conspiracy: Parallels and differences in clausal and nominal structure*. Vancouver: University of British Columbia dissertation.

Bliss, Heather & Bettina Gruber. 2015. Temporal restrictions on personal pronouns: The composition of Blackfoot proclitics. *Lingua* 156. 175–199. DOI: https://doi.org/10.1016/j.lingua.2014.12.008

Boersma, Paul & David Weenink. 2016. Praat: Doing phonetics by computer [computer program]. http://www.praat.org.

Chomsky, Noam. 2001. Derivation by phase. In Michael Kenstowicz (ed.), Ken Hale: A life in language, 1–52. Cambridge, MA: MIT Press.

Chomsky, Noam. 2008. On phases. In *Current Studies in Linguistics Series* 45, 133–166. DOI: https://doi.org/10.7551/mitpress/9780262062787.003.0007

Clemens, Lauren & Jessica Coon. 2016. Deriving verb-initial word order in Mayan. Unpublished Ms. University at Albany, State University of New York and McGill University.

Elfner, Emily. 2006. *The mora in Blackfoot*. Calgary, AB: University of Calgary MA Thesis.

Elfner, Emily. 2012. *Syntax-prosody interaction in Irish*. Amherst, MA: University of Massachusetts dissertation.

Elfner, Emily. 2015. Recursion in prosodic phrasing: Evidence from Connemara Irish. *Natural Language and Linguistic Theory* 33. 1169–1208. DOI: https://doi.org/10.1007/s11049-014-9281-5

Ellis, Lucy & William J. Hardcastle. 2002. Categorical and gradient properties of assimilation in alveolar to velar sequences: Evidence from EPG and EMA data. *Journal of Phonetics* 30. 373–396. DOI: https://doi.org/10.1006/jpho.2001.0162

Frantz, Donald G. 1978. Abstractness of phonology and Blackfoot orthographic design. In William C. McCormack & Stephen A Wurm (eds.), *Approaches to language: Anthropological issues*, 307–325. Paris: Mouton Publishers.

Frantz, Donald G. 2009. *Blackfoot grammar*. 2nd Edition; Toronto: University of Toronto Press.

Frantz, Donald G. & Norma Jean Russell. 1995. *Blackfoot dictionary of stems, roots, and affixes*. 2nd Edition; Toronto: University of Toronto Press.

Gallego, Ángel J. 2010. *Phase Theory*. Philadelphia: John Benjamins. DOI: https://doi.org/10.1075/la.152

Ghini, Marco. 1993. Phi-formation in Italian: A new proposal. *Toronto Working Papers in Linguistics* 12. 41–78.

Gick, Bryan, Heather Bliss, Karin Michelson & Bosko Radanov. 2011. Articulation without acoustics: "Soundless" vowels in Oneida and Blackfoot. *Journal of Phonetics* 40. 46–53. DOI: https://doi.org/10.1016/j.wocn.2011.09.002

Gussenhoven, Carlos. 1988. Intonational phrasing and the prosodic hierarchy. *Phonologica*. 89–99.

Halle, Morris & Jean-Roger Vergnaud. 1987. *An essay on stress*. Cambridge, MA: MIT Press.
Ishihara, Shinichiro. 2007. Major phrase, focus intonation, multiple spell-out. *The Linguistic Review* 24. 137–167. DOI: https://doi.org/10.1515/TLR.2007.006
Kahnemuyipour, Arsalan. 2004. *The syntax of sentential stress*. Toronto, ON: University of Toronto dissertation.
Keyser, Samuel J. & Kenneth N. Stevens. 2006. Enhancement and overlap in the speech chain. *Language* 82. 81–109. DOI: https://doi.org/10.1353/lan.2006.0051
Kratzer, Angela & Elisabeth Selkirk. 2007. Phase Theory and prosodic spellout: The case of verbs. *The Linguistic Review* 24. 93–135. DOI: https://doi.org/10.1515/TLR.2007.005
Ladd, Robert D. & James M. Scobbie. 2003. External sandhi as gestural overlap? Counterevidence from Sardinian. In John Local, Richard Ogden & Rosalind Temple (eds.), *Phonetic interpretation: Papers in laboratory phonology* VI, 164–182. Cambridge: Cambridge University Press.
Lewis, Blake. 2015. The syntax and semantics of demonstratives: A DP-external approach. *In Proceedings of the 2014 annual conference of the Canadian Linguistic Association*, 1–15.
Nespor, Marina & Irene Vogel. 1986 [2007]. *Prosodic phonology*. Dordecht: Foris.
Nolan, Francis, Tara Holst & Barbara Kühnert. 1996. Modelling [s] to [ʃ] accommodation in English. *Journal of Phonetics* 24. 113–137. DOI: https://doi.org/10.1006/jpho.1996.0008
Russell, Kevin. 1999. The "word" in two polysynthetic languages. In T. Alan Hall & Ursula Klenhenz (eds.), *Studies on the phonological word*, 203–222. Amsterdam: John Benjamins. DOI: https://doi.org/10.1075/cilt.174.08rus
Russell, Kevin. 2008. Sandhi in Plains Cree. *Journal of Phonetics* 36. 450–464. DOI: https://doi.org/10.1016/j.wocn.2007.10.003
Russell, Kevin & Charlotte Reinholtz. 1997. Nonconfigurationality and the syntax-phonology interface. In Brian Agabayani & Sze-Wing Tang (eds.), *Proceedings of the Fifteenth West Coast Conference on Formal Linguistics*, 441–456. Stanford: CSLI Publications.
Sadock, Jerrold M. 1980. Noun incorporation in Greenlandic: A case of syntactic word formation. *Language* 46. 300–319. DOI: https://doi.org/10.1353/lan.1980.0036
Selkirk, Elisabeth O. 1986. On derived domains in sentence phonology. In Colin Ewen & John Anderson (eds.), *Phonology Yearbook* 3, 371–405. Cambridge: Cambridge University Press.
Selkirk, Elisabeth O. 1995. The prosodic structure of function words. In Jill N. Beckman, Laura Walsh Dickey & Suzanne Urbanczyk (eds.), *Papers in Optimality Theory,* 439–470. Amherst, MA: GLSA Publications.
Selkirk, Elisabeth O. 2009. On clause and intonation phrase in Japanese: The syntactic grounding of prosodic constituent structure. *Gengo Kenkyu* 136. 35–73.
Selkirk, Elisabeth O. 2011. The syntax-phonology interface. In John Goldsmith, Jason Riggle & Alan C. L. Yu (eds.), *The handbook of phonological theory,* 435–484. 2nd Edition; Malden: Wiley-Blackwell. DOI: https://doi.org/10.1002/9781444343069.ch14
Shattuck-Hufnagel, Stefanie & Alice E. Turk. 1996. A prosody tutorial for investigators of auditory sentence processing. *Journal of Psycholinguistic Research* 25. 193–247. DOI: https://doi.org/10.1007/BF01708572
Stevens, Kenneth N. & Samuel J. Keyser. 2010. Quantal theory, enhancement, and overlap. *Journal of Phonetics* 38. 10–19. DOI: https://doi.org/10.1016/j.wocn.2008.10.004
Truckenbrodt, Hubert. 1999. On the relations between syntactic phrases and phonological phrases. *Linguistic Inquiry* 30. 219–255. DOI: https://doi.org/10.1162/002438999554048
Tserdanelis, Georgios. 2005. *The role of segmental sandhi in the parsing of speech: Evidence from Greek*. Columbus, OH: Ohio State University dissertation.

Wiltschko, Martina. 2014. *The universal structure of categories: Towards a formal typology*. Cambridge: Cambridge University Press. DOI: https://doi.org/10.1017/CBO9781139833899

Windsor, Joseph W. 2016. *Contrast, phonological features, and phonetic implementation: Aspiration in Blackfoot*. Calgary Working Papers in Linguistics 29. 61–80.

Windsor, Joseph W. & Blake Lewis. 2016. Constituency of demonstratives in Blackfoot. Unpublished Ms. University of Calgary.

Windsor, Joseph W. & J. L. Cobler. 2013. A unified explanation of three phrase-final phenomena in Blackfoot. Presented at the annual conference of the Canadian Linguistic Association in Victoria, BC, 3 July 2013.

Zsiga, Elizabeth C. 1994. Gestural overlap in consonant sequences. *Journal of Phonetics* 22. 121–140.

Zsiga, Elizabeth C. 1997. Features, gestures and Igbo vowels: An approach to the phonetics-phonology interface. *Language* 73. 227–274. DOI: https://doi.org/10.2307/416019

Zsiga, Elizabeth C. 2000. Phonetic alignment constraints: Consonant overlap and palatalization in English and Russian. *Journal of Phonetics* 28. 69–102. DOI: https://doi.org/10.1006/jpho.2000.0109

How to cite this article: Windsor, Joseph W. 2017. Predicting prosodic structure by morphosyntactic category: A case study of Blackfoot. *Glossa: a journal of general linguistics* 2(1): 10.1–17, DOI: https://doi.org/10.5334/gjgl.229

Published: 23 February 2017

]u[*Glossa: a journal of general linguistics* is a peer-reviewed open access journal published by Ubiquity Press.

OPEN ACCESS