Canadian Journal of Linguistics/Revue canadienne de linguistique 59(3): 303–338, 2014

Vowel devocalization in Northern East Cree

SARAH KNEE
Memorial University

1. INTRODUCTION

Cree, and Algonquian languages in general, are described as having two kinds of consonant clusters: primary and secondary (for Western Cree, see Pentland 1979, Wolfart 1996; for Eastern Cree, see MacKenzie 1982; for Maliseet-Passamaquoddy, see Teeter 1971, Sherwood 1983, LeSourd 1993; for Ojibwe, see Rhodes 1976a, Rhodes and Todd 1981, Valentine 1996, 2001). In general, primary clusters occur word-medially, with restrictions on the first consonant of the cluster (e.g., it must be a coda consonant) and secondary clusters are "derived" clusters that occur when an intervening vowel is deleted. As we will see in section 3, there are compelling reasons to justify an underlying vowel in secondary clusters, and hence, a distinction between these groups of clusters. What remains less substantiated is the claim of "deletion". In the Cree literature (and much of the Algonquian literature in general), a vowel is considered to be deleted when it is no longer perceived by the listener (although see Mühlbauer 2006, Gick et al. 2012, and Dyck et al. 2014 for notable exceptions). Without acoustic or articulatory study, it is impossible to determine if a vowel is truly deleted or if the vowel quality is somehow obscured (devoiced, shortened, etc.) to the point that it cannot be perceived, while still being produced.

This article examines secondary clusters in Northern East (NE) Cree to determine if the phenomenon of "vowel deletion" is indeed deletion of the vowel. I introduce the NE Cree segmental inventory and syllable structure in section 2. Section 3 then discusses secondary clusters and devocalization in NE Cree and Algonquian. In section 4, I discuss devocalization in the non-Algonquian literature, highlighting common characteristics of devocalization cross-linguistically. I further provide implications for secondary clusters in Algonquian and a model to account for the data (the Gestural Model). Section 5 presents and discusses the present acoustic study of NE Cree secondary clusters, the results of which suggest secondary clusters are actually CVC sequences with a vowel that is difficult to perceive. Section 6 concludes the article and presents avenues for further research.

I would like to thank my supervisor, Carrie Dyck, as well as Paul De Decker, Marguerite MacKenzie, Yvan Rose, and three anonymous reviewers. Special thanks to Marguerite MacKenzie for sharing the recordings and translating the North East Cree wordlist. All errors or omissions are mine. This research was funded in part by the Joseph-Armand Bombardier Canada Graduate Scholarship.

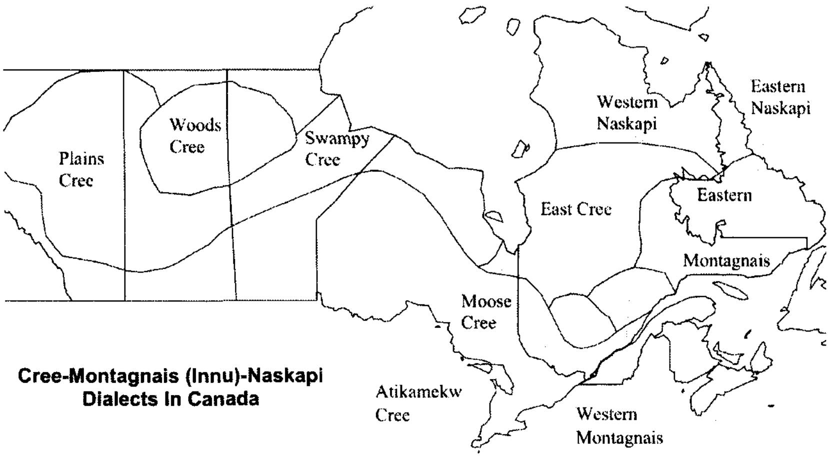

Figure 1: CMN dialect continuum
(courtesy of Marguerite MacKenzie)

2. NORTHERN EAST (NE) CREE

East Cree is part of the Cree–Innu dialect continuum (Michelson 1939, MacKenzie 1982) (see figure 1).[1] The Cree–Innu dialect continuum is divided into Western dialects (Moose Cree, Swampy Cree, Plains Cree, and Woodland Cree) and Eastern dialects (East Cree, Naskapi, Montagnais, and Atikamekw). There are two main dialects of East Cree: Northern (NE Cree) and Southern (SE Cree). The communities where each dialect is spoken are shown in figure 2.

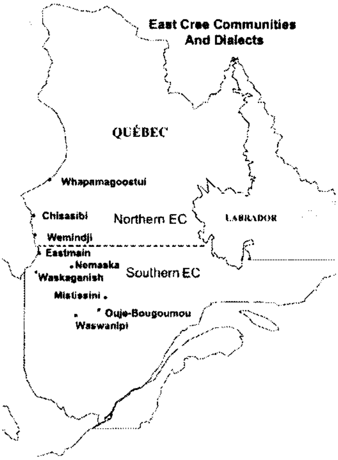

Figure 2: East Cree dialects
(map adapted from Salt et al.
2004:xxvi)

2.1 Consonants

The inventory of consonants in NE Cree is shown in table 1 (Dyck et al. 2006),[2] using the NE Cree orthography (where this differs from the International Phonetic Alphabet, phonetic variants are listed in square brackets). Note that while all oral stops and affricates are written

---

[1] This is also called the Cree–Montagnais–Naskapi (CMN) dialect continuum. Montagnais and Eastern Naskapi are both now referred to as Innu (see Salt et al. 2004).

[2] [w] and [y] are listed here simply for convenience. They are allophones of /u/ and /i/. Also, sequences such as <kw> can either be analyzed as complex segments (i.e., [kw]) or as simple onsets followed by a diphthong (i.e., [k-wâw]). Neither analysis, however, affects the claims about syllable structure in section 2.3.

Table 1: Consonants

	Labial	Alveolar	Palatal	Velar	Glottal
Stops	p	t	ch [ʧ, ts]	k, kw [k^{w}]	
Fricatives		s	sh [ʃ]		h
Nasals	m	n			
Glides	w		y [j]		

here as voiceless, they can also be phonetically voiced (i.e., have negative Voice Onset Time values). Anecdotally, there is a tendency for consonants to be voiced intervocalically and to be voiceless at word boundaries but there is substantial variation in these patterns.

2.2 Vowels and diphthongs

NE Cree distinguishes between "long" and "short" vowels. Today, this distinction is realized as a contrast in vowel quality: historically long vowels have become tense and historically short vowels are lax (MacKenzie 1982:93). The diacritic ^ is used in the NE Cree orthography for long vowels in this article.[3] The NE Cree vowel and diphthong inventories are provided in tables 2 and 3 (Dyck et al. 2006).

Table 2: Vowels

Long vowels		Short vowels	
î [i(:)]	û [u(:)]	i [ɪ, ɨ, ə]	u [ʊ]
â [æ, ɛ(:)]		a [ɪ, ɛ, ɨ, ə, ʌ]	

Table 3: Diphthongs

wî [wi]	wâ [wɑ]	uy [ʊy]
îw [iu]	âw [ɑw]	
iw [ɨw, uː, oː]	aw [aw]	
wîw [wiw]	wâw [(^{w})ɒ(^{w}), (^{w})ɔ(^{w})]	

Note that long vowels <ê> and <â> have merged to <â> in NE Cree (MacKenzie 1982:98). The <i> and <a> vowels have also merged (Valentine 1996, Dyck et al. 2006) in some Northern East Cree areas. However, I retain the use of <i> and <a> according to the convention of NE Cree orthography.

2.3 Syllable structure

Cree syllables have been described as (C)V(C), where (C) represents an optional onset or coda consonant (Wolfart 1996, Dyck et al. 2006); an additional consonant

---

[3] For clarity, I depart from standard Cree orthography, where [eː] (with no short counterpart) is written as <e>.

can also occur word-finally (Dyck et al. 2006). While all consonants are acceptable onsets, only certain ones appear in codas. In Plains Cree, this set of possible codas is [s, h] (Wolfart 1996) and in NE Cree, it is [s, ʃ, h] (MacKenzie 1982). This analysis predicts that there are no consonants clusters word-initially and that all word-medial consonant clusters consist of a coda + onset (so for Plains Cree, sC or hC and for NE Cree, sC, ʃC, or hC). Similarly, word-final clusters should consist of a coda + a possible word-final consonant. Many examples of these kinds of clusters are attested in NE Cree:[4]

(1) *Predicted (primary) consonant clusters in NE Cree*:

	Orthography	IPA	
a.	**iskw**âu	[ˈ**ısk**ɑw]	'woman'
b.	mi**sht**ikw	[ˈmı**ʃt**ɨkʷ]	'tree'
c.	ni**hp**in	[ˈnı**hp**ın]	'my lung'
d.	u**sk**in	[ˈʊ**sk**ın]	'his/her bone'

There are, however, many attested consonant clusters that do not conform to the predictions made by the suggested syllable template. As shown in (2), unpredicted clusters of three (2a–c) or four (2d) consonants can occur. Consider (2b), which has two unpredicted clusters, [kʃt] and [mt], both beginning with a consonant other than [s, ʃ, h].

(2) *Unpredicted (secondary) consonant clusters in NE Cree*:

	Orthography	IPA	
a.	ti**hchik**âchâu	[tı**htʃ**ˈ**k**atʃaw]	's/he kicks'
b.	pâyi**kushtâmit**iniu	[payı**kʃtam**ˈ**t**ınıw]	'ninety'
c.	ushî**mishish**	[ʊˈʃ**imʃʃ**]	'his/her younger sibling'
d.	achi**hkush**	[ıtʃı**hkʃ**]	'star'

The Algonquian literature distinguishes between these predicted and unpredicted clusters by claiming that the former are true underlying (primary) clusters and the latter are derived (secondary) clusters that form when a short unstressed vowel in an underlying CVC sequence is deleted (for Western Cree, see Pentland 1979, Wolfart 1996; for Eastern Cree, see MacKenzie 1982; for Maliseet-Passamaquoddy, see Teeter 1971, Sherwood 1983, LeSourd 1993; for Ojibwe, see Rhodes 1976a, Rhodes and Todd 1981, Valentine 1996, 2001). This analysis is supported by the NE Cree writing system, which includes the "deleted" vowel in the spelling of secondary clusters and does not have a vowel in primary clusters.

In the following section, I discuss the literature in support of secondary clusters in Algonquian. In section 3.1, I discuss the motivation for positing an underlying vowel and in section 3.2, I suggest the possibility that this vowel is not deleted but reduced to the point of being imperceptible.

---

[4] All IPA transcriptions for NE Cree examples come from consensus transcriptions of word lists spoken by NE Cree speaker Luci Bobbish-Salt.

3. SECONDARY CLUSTERS IN ALGONQUIAN

As mentioned above, the Algonquian literature distinguishes between primary (underlying) and secondary (derived) consonant clusters. For example, Plains Cree has both primary and secondary clusters. Primary clusters, bolded in (3), all occur non word-initially and are of the shape hC(w) or sC(w) (note that, unlike NE Cree, Plains Cree does not permit ʃC(w) clusters).[5] Secondary clusters occur when a short unstressed vowel is "deleted" between consonants (4).

(3) *Primary clusters in Plains Cree*:

	Orthography	
a.	a**st**otin	'cap'
b.	ê**sk**an	'horn'
c.	si**hk**os	'weasel'
d.	âpi**ht**aw	'half'

(Wolfart and Carroll 1981:6–7)

(4) *Secondary clusters in Plains Cree*:

	Orthography	IPA	
a.	ko**nit**a	[ko**nt**a]	'in vain, without reason'
b.	ni**nit**awêyihtên	[ni**nt**awe:yihte:n]	'I want (it)'
c.	**iskwêsis**ak	[**skwe:ss**ak]	'girls'
d.	tâ**nis**i	[ta**ns**i]	'how; how are you'

(Wolfart 1996, Wolfart and Carroll 1981:13)

Such a claim posits the existence of an abstract representation that differs from a speaker's output.[6] For example, if we reconsider the data in (4), we have the situation in (5).

(5) *Secondary clusters in Plains Cree*:

	Orthography	Representation	Surface form
a.	ko**nit**a	/ko**nɪt**a/	[ko**nt**a]
b.	ni**nit**awêyihtên	/ni**nɪt**awe:yihte:n/	[ni**nt**awe:yihte:n]
c.	**iskwêsis**ak	/**ɪskwe:sɪs**ak/	[**skwe:ss**ak]
d.	tâ**nis**i	/ta**nɪs**i/	[ta**ns**i]

This analysis makes two claims: (i) secondary clusters have an abstract representation of CVC and (ii) secondary clusters undergo vowel deletion to surface as CC. In the rest of this section, I review these claims in turn. I suggest that the evidence for the first claim is compelling but that there is insufficient evidence for the second claim. I then propose an alternate view, namely that secondary clusters are illusory.

---

[5] IPA transcriptions not provided in original source.

[6] Note that this approach is compatible only with certain theories of phonology. Claims about secondary clusters in later sections do not require a specific degree of abstraction and are amenable to a variety of theories. In this article, I remain agnostic regarding a particular theory of phonology or phonetics.

3.1 Evidence for underlying vowels in secondary clusters

Evidence for an underlying vowel in Algonquian secondary clusters comes from sociolinguistic variation, paradigmatic alternations, and pitch-accent related alternations, discussed below. In this subsection, I refer to the underlying vowel as "deleted", as it is described in the literature. In section 3.2, I propose that such vowels are not truly deleted.

3.1.1 Sociolinguistic variation

Sociolinguistic variation in word pronunciation is a source of evidence for underlying vowels in secondary clusters. In Plains Cree, for example, secondary clusters can alternately be produced as CVC sequences (e.g., underlying *konita* can be pronounced [konta] or [konita] and *tânisi* can be pronounced [tansi] or [tanisi]) (Wolfart and Carroll 1981). Wolfart and Carroll (1981:12–13) explain that this variation is sociolinguistically constrained, being favoured in fast, casual speech. MacKenzie (1982:125–126) notes the same variation in Eastern Cree and this also happens in other varieties of Algonquian. For example, Rhodes (1976b:130) claims that for older Manitoulin Island speakers, deletion in Odawa is a "kind of casual speech phenomena". This variability in pronunciation suggests that secondary clusters are underlying CVC sequences realized with the intervening vowel deleted.

3.1.2 Paradigm alternations

Paradigmatic alternations provide evidence for underlying vowels in derived clusters in SE Cree, Nishnaabemwin, and Passamaquoddy. Paradigmatic alternations occur when vowels in metrically weak (unstressed) positions are deleted. In SE Cree (specifically, Mistassini), short unrounded vowels are often deleted word-initially. However, when a prefix, such as *n(t)-* 'my',[7] appears in front of the word, the underlying vowel is pronounced (6).

(6) *Southern East Cree (Mistassini)*:

a.	iskwêw				s	k	w	e:		'woman'
	ntiskwêm	n	t-	i	s	k	w	e:	m	'my wife'
b.	awâs				w	a:	s			'child'
	ntawâsm	n	t-	ə	w	a:	s	i:	m	'my child'

(MacKenzie 1982:116–118)

Similarly, paradigmatic alternations provide evidence for underlying vowels in Nishnaabemwin, a variety of the Ojibwe Ottawa dialect (Valentine 2001:57–59). As shown in (7), various forms of 'shoe' provide evidence for an underlying form, /makizin/. When the first syllable of /makizin/ is in a weak position, as in *mkizin* 'shoe' and *mkiznan* 'shoes', the [a] is deleted. When the second syllable is in a weak position, as in *nmakzin* 'my shoe', the first [i] is deleted. When the third syllable is in a weak position, as in *mkiznan* 'shoes', the final [i] is deleted. However, these vowels surface when they receive stress. We see this for the first syllable in *nmakzin* 'my

---

[7] The [t] in *n(t)-* is epenthetic and appears before short vowels (MacKenzie 1982:117).

shoe', the second in *mkizin* 'shoe' and *mkiznan* 'shoes', and the third in *mkizin* 'shoe' and *mnakzin* 'my shoe'.

(7) *Nishnaabemwin*:

a.	mkizin		m		k	i	z	i	n			'shoe'
b.	mkiznan		m		k	i	z		n	-a	n	'shoes'
c.	nmakzin	n-	m	a	k		z	i	n			'my shoe'

Paradigmatic alternations in Passamaquoddy, an Eastern Algonquian language spoken in Maine, also provide evidence for underlying vowels in secondary clusters (LeSourd 1993:158, 161, 168, among others). As shown in (8),[8] alternations within paradigms provide evidence for underlying forms such as /pəsihkəm/ and /məsahk/.

(8) *Passamaquoddy*:

a.	ps-íhkə̀-k wear(?)-by.body-3AN-(SUBJ)		p		s-	i	h	k	ə		-k	'if he wears it'
	h-pə̀s-kə̀m-ən 3-wear(?)-by.body-3IN	h-	p	ə	s-			k	ə	m	-ən	'he wears it'

b.	psáhk-éyo sorry-AI-(3)	m(p)		s	a	h	k	-e	y	o		'he is sorry about sth'
	mə́sk-éyi-n (3)-sorry-AI-PEG	m	ə	s			k	-e	y	i	-n	'he is sorry about it'

These paradigmatic alternations reveal that "deleted" vowels are recoverable under particular circumstances (e.g., addition of a prefix and stress shift), suggesting that they are part of the morphemes in question at some abstract level.

3.1.3 Alternations related to pitch accent

Pitch accent patterns provide further evidence for an underlying intervening vowel in secondary clusters. This can be seen in Western Cree, where speakers can perceive trisyllabic words as disyllables. Such words bear the same pitch accent pattern as other trisyllabic words; that is, even though only two syllables are heard, the pitch accent patterns as if there were three syllables (Pentland 1979:119, Mühlbauer 2006). Mühlbauer (2006) illustrates this in Plains Cree (see 9). The bare noun *nâpêw* [nàpew] 'man', like typical disyllabic nouns, is marked by a pitch fall in the penultimate syllable. When the diminutive suffix *-sis* or the obviative suffix *-a* is added to the noun, creating a trisyllabic word, the pitch pattern changes to include a pitch rise directly preceding the pitch fall (see alternation 1 in (9)). When the vowel in these suffixes is deleted, resulting in perceived disyllables, the pitch accent still patterns as if there were three syllables (see alternation 2 in (9)).

---

[8] Abbreviations used in this article:

AI	animate intransitive	PEG	peg (empty) morpheme
AN	animate	PL	plural
DIM	diminutive	SG	singular
IN	inanimate	SUBJ	subject
OBV	obviative		

(9) *Pitch patterns in Plains Cree*:

	Orthography	Alternation 1	Alternation 2	
a.	nâpêw	[nàpew]	—	'man'
b.	nâpê(w)-sis	[nápèsɪs]	[nápèss]	'a boy, lit: a man-DIM'
c.	nâpêw-a	[nápèwʌ]	[nápèw]	'man-OBV'

This kind of alternation is also found in other varieties of Cree (for East Cree, see MacKenzie 1982:122–123) as well as other Algonquian languages (for Maliseet-Passamaquoddy, see Teeter 1971:194).

In this section, I have provided evidence from sociolinguistic, paradigmatic, and pitch-accent related alternations that secondary clusters in Algonquian are generally derived from underlying CVC sequences. In the next section, I challenge the assumption that these clusters are derived via deletion.

3.2 Re-examining vowel deletion in Algonquian

As mentioned earlier, the assumption that secondary clusters in Algonquian result from vowel deletion can be broken down into two parts: (i) there are underlying vowels in secondary clusters and (ii) these vowels are deleted. In section 3.1, I reviewed evidence in favour of the first part of this assumption. In this section, I suggest the second part of the assumption is problematic, both from a theoretical and an empirical standpoint. I discuss each in turn.

If the NE Cree secondary consonant cluster data in (2) does result from vowel deletion, it becomes impossible to characterize the syllable structure without permitting obstruents in syllable nuclei. For illustration, consider *chisihîkin* [t^{h}shigɪn][9] 'broom' and *âpihtuwin* [æphtuːn] 'half'. In the case of *chisihîkin*, we can posit a syllable break after the first vowel (e.g., [t^{h}shi.gɪn]), but this leaves us with the obstruent cluster [t^{h}sh] that cannot be syllabified without assuming that one or more of the obstruents are in a nucleus. Similarly, even if we assume, counter to the literature, that the [p] in *âpihtuwin* is in a coda (e.g., [æp.htuːn]), we are left with the cluster [ht] that, again, is difficult to syllabify without assuming an obstruent in a nucleus. This, on its own, is not convincing enough to abandon the assumption of vowel deletion. While this would be a radical departure from the proposed Cree syllable structure, there is a precedent for syllables with obstruent nuclei (e.g., see Derrick's 2007 description of syllable structure in Blackfoot and Dell and Elmedlaoui's 1988 description of Imdlawn Tashlhiyt Berber). The biggest challenge to the assumption of vowel deletion in secondary clusters comes from empirical evidence.

The assumption of vowel deletion in Algonquian is primarily based on impressionistic transcriptions, which can be problematic for describing gradient phenomena. Because adult perception is categorical, certain gradient phenomena can be missed without the aid of an acoustic or articulatory study. For example, if a "trace" of a vowel exists in vowel deletion environments but is difficult to perceive, no vowel is transcribed and any evidence for the existence of a vowel is not recorded. This is particularly problematic for secondary clusters, where the Algonquian literature

---

[9] <ch> is pronounced as [t^{h}] in this case.

suggests that there are gradient vowel realizations. For example, in NE Cree, <u> is sometimes perceived as deleted (Dyck et al. 2014) and other times as devoiced (MacKenzie 1982). Similarly, in Western Cree (Pentland 1979:120) and certain varieties of Ojibwe (Rhodes and Todd 1981:58), a trace of a "deleted" vowel can still be present. If these vowels are not actually deleted, it is possible that in some Algonquian languages, "secondary clusters" are better re-analyzed as phonetically being CVC sequences with a difficult-to-perceive intervening vowel.

The idea of hidden or soundless vowels is not new to the Algonquian literature. In Blackfoot, short vowels are devoiced utterance-finally (Frantz 1991). Gick and colleagues (2012) present ultrasound and video (lip movement) evidence that these vowels are actually articulated, despite not being perceived by native speakers and lacking acoustic correlates. Dyck and colleagues (2014) present evidence of "hidden" vowels in SE Cree: in a pilot study, they find that the duration of the first consonant of a secondary cluster is significantly longer than the consonant in CV sequences. They interpret this as evidence for a trace of a vowel in secondary clusters. Using the Gestural Model (see section 4.3), the authors suggest that what has been transcribed as the first consonant of a secondary cluster might actually be a full CV syllable with a "hidden" vowel articulation.

In the remainder of this article, I argue that "deleted" vowels may still be present in NE Cree. First, I compare existing Algonquian data to data from languages in which vowel deletion has been reanalyzed as vowel "weakening" or "extreme shortening", emphasizing the similarity between the data sets (section 4). I then (in section 5) present an acoustic study, similar to that of Dyck and colleagues (2014), on data gathered from NE Cree. I demonstrate that secondary clusters exhibit a phonetic correlate of CVC sequences whose consonant gestures overlap with the vowel gesture, essentially hiding the vowel. This suggests that secondary clusters are actually CVC sequences with a difficult-to-perceive (or inaudible) vowel.

4. VOWEL DEVOCALIZATION

While languages such as Berber, English, German, Greek, Japanese, Korean, Montreal French, and Spanish have traditionally been described as having phonological vowel deletion, they have recently been reanalyzed. In these languages, "deletion" is now described as a shortening or weakening process, which I will refer to as "devocalization". I will first describe common properties of devocalization in these languages (section 4.1) and its implications (section 4.2), then detail a model used to account for these similarities (section 4.3).

4.1 Common characteristics

Descriptions of (reanalyzed) devocalization share certain characteristics. Across languages, devocalization is favoured in specific contexts, occurs gradiently, and is affected by word frequency. In this section, I describe the common characteristics of vowel devocalization, primarily referring to Gordon's (1998) survey of devocalization in 50 languages. Throughout, I show that "vowel deletion" in Algonquian typically shares characteristics with vowel devocalization.

4.1.1 Prosodic context and vowel type

Vowels in metrically weak (e.g., unstressed, unaccented) positions are particularly prone to devocalization. In contrast, vowels in metrically prominent positions — for example, pitch-accented vowels in Japanese and Inuktitut — are not devocalized (Gordon 1998).

Devocalization primarily affects schwa and vowels that are short or lax (32/50 languages reported in Gordon 1998; for English, see Zwicky 1972, Hooper 1978; for German, see Beckman 1996). While devocalization can happen to mid and low vowels, high vowels are particularly prone (15/50 languages have only high vowel devocalization Gordon 1998; for Greek, see Dauer 1980; for Montreal French, see Cedergren and Simoneau 1985; for Japanese, see Kondo 1993, Beckman 1996). For example, in Modern Greek, the high vowels [i] and [u] are devocalized in metrically weak positions (e.g., *pukamisa*[10] 'shirts' can be perceived as [pˈkamsa], where the underlined syllable is stressed (Dauer 1980)).

Similarly, "vowel deletion" in Algonquian affects short/lax vowels in metrically weak positions (for Nishnaabemwin, see Valentine 2001; for Passamaquoddy, see LeSourd 1993; for Cree, see MacKenzie 1982, Wolfart 1996, Dyck et al. 2006). Short [u] is reported as devoiced (which, along with deletion, could be devocalization) in Cree (MacKenzie 1982:126) and deleted in Innu. Short [i] is reported as deleted in Plains Cree (Wolfart 1996:432)[11] and short [i] and [a] can be "deleted" in Moose and Swampy dialects (Ellis 1983:44) and Eastern Cree dialects (MacKenzie 1982:126).

4.1.2 Segmental environment

Certain segmental environments can facilitate devocalization. In English and German, syncope is preferred between an obstruent and a sonorant or an obstruent and a sibilant fricative (Zwicky 1972, Hooper 1978, Beckman 1996). Consider *awfully*, in English. This is often perceived as [ɑfli], with the vowel between the obstruent [f] and sonorant [l] devocalized. In many other languages, devocalization is favoured between two voiceless consonants (for Greek, see Dauer 1980; for Japanese, see Kondo 1993, Nagano-Madsen 1995; for Lushootseed, see Urbancyzk 2001; for Montreal French, see Cedergren and Simoneau 1985; for Andean Spanish, see Delforge 2008). For example, Delforge (2008) reported that 83% of cases of devoicing occurred between voiceless consonants in Cusco Spanish.

The segmental environment for "deletion" in Cree becomes more restrictive as one moves from Eastern varieties to Western varieties. In SE Cree (specifically, Mistassini), for example, "deletion" can occur between most if not all consonants (MacKenzie 1982:126–127), while in Plains Cree, "deletion" occurs predominantly between homorganic consonants (Wolfart 1996:432).

---

[10] This is transliterated from the Greek *πουκα΄μισα*.

[11] An anonymous reviewer suggests short [a] is also deleted in Plains Cree (e.g., *sênapân* 'ribbon' can be produced as *sênapân*).

4.1.3 Position

Vowel devocalization is favoured in word-, phrase-, or utterance-final position (45/50 languages in Gordon 1998), with the notable exceptions of languages bearing stress or high tone in these positions (e.g., Turkish, Montreal French, Inuktitut).

Similarly, word-final "deletion" of short vowel suffixes exists in dialects of Cree and Innu. For example, in East Cree, *-a* suffixes are perceived as deleted or whispered (MacKenzie 1982:123).

4.1.4 Variation and gradience

Cross-linguistically, devocalization displays variable behaviour; what is sometimes perceived as a (derived) consonant cluster is at other times perceived as a CVC sequence (for Berber, see Coleman 2001; for English, see Zwicky 1972, Manuel et al. 1992, Davidson 2006; for European French, see Delattre 1951, Verluyten 1988; for German, see Strauss 1982, Kohler 1990, Hall 1992, Jannedy 1994; for Greek, see Dauer 1980; for Korean, see Jun and Beckman 1994; for Lushootseed, see Urbancyzk 2001; for Montreal French, see Cedergren and Simoneau 1985; for Japanese, see Beckman and Shoji 1984, Kondo 1993). This type of variation often correlates with speech rate and style. When comparing the speech of an individual, the faster and more casual the speech, the fewer "optional" vowels are perceived; conversely, the slower and more formal the speech, the more vowels are perceived (for English, see Dalby 1986, Davidson 2006; for German, see Jannedy 1994; for Greek, see Dauer 1980).

In many of the cases traditionally analyzed as total vowel deletion, acoustic cues suggest the presence of a vowel (Manuel et al. 1992, Fokes and Bond 1993, Fougeron and Steriade 1997, Davidson 2006). For example, Manuel and colleagues (1992) found that productions of *support* in casual speech vary from the presence of a full vowel between [s] and [p] to the presence of a voice bar, the presence of aspiration, and no apparent evidence for a vowel. Some researchers identify these variations as various intermediate realizations between a full vowel and complete deletion (for German, see Jannedy 1994; for Greek, see Dauer 1980; for French, see Cedergren and Simoneau 1985; for Korean, see Jun and Beckman 1994; for Andean Spanish, see Delforge 2008; the reader is referred to Beckman 1996 for further discussion). For example, for both high vowel elision in Modern Greek (Dauer 1980) and unstressed vowel reduction in Andean Spanish (Delforge 2008), vowels are reported as having three intermediate realizations: (a) reduced duration, (b) weakened voicing, and (c) no voicing.

Even in cases where no vowel is perceived, acoustic cues may still suggest the presence of a vowel. For example, Davidson (2006) found the duration of voiceless fricatives and plosive aspiration to be greater when followed by apparent vowel deletion in English (e.g., the [f] in *fatigue*, for example, is greater in duration when the following vowel is not perceived than when the vowel is fully realized).

As discussed in section 3.11, speech rate and style also appear to influence vowel devocalization in Algonquian languages. In Western Cree (Wolfart and Carroll 1981:13) and in Eastern Cree (MacKenzie 1982:103), devocalization occurs more in fast, casual speech. There is also evidence for intermediate forms (i.e., forms between fully deleted and fully realized vowels) in Algonquian. For example, in NE Cree, <u> is often perceived as being devoiced or as labialization instead of being deleted (MacKenzie 1982). Pentland (1979:120) explains that in Western Cree, a trace of a "deleted" vowel can still be present, possibly as a whispered vowel. Similarly, for certain varieties of Ojibwe, Rhodes and Todd (1981:58) report some traces of a "deleted" vowel, often in the form of labialization.[12]

4.1.5 *Word frequency*

Devocalization tends to affect high-frequency words more than low-frequency words (Hooper 1978, Patterson et al. 2003). For example, Patterson and colleagues (2003) found higher rates of pretonic schwa deletion in English for high-frequency words than for low-frequency words in conversational speech from the Switchboard corpus.

Since there are no corpus statistics for Algonquian languages, it is not possible to assess whether word frequency is a factor in vowel "deletion" in Algonquian.

4.2 Implications

The similarities between Algonquian and the languages discussed above suggest that what has traditionally been called vowel "deletion" in Algonquian is actually vowel devocalization — a shortening or weakening of the vowel — instead of true deletion. If this is the case, then secondary clusters in Algonquian can be reanalyzed as CVC sequences with difficult-to-perceive vowel nuclei. In the next section (section 4.3), I present a model capable of accounting for the devocalization data. I then present an acoustic study to test whether this model could account for the NE Cree data (section 5).

4.3 The Gestural Model

The Gestural Model (Browman and Goldstein 1989, 1990, 1992) provides a compelling account for the characteristics of devocalization discussed in section 4.1. In this model, the basic units of speech are articulatory gestures. Utterances are considered as acts composed of a set (constellation) of gestures defined by the "formation and release of various constrictions such as bilabial closure (for [b])" (Browman and Goldstein 1990:95). For example, the utterance *pan* [ˈpæn] is comprised of five gestures:

i. velum — lowering (wide)
ii. tongue tip — touching (clo) alveolar ridge (alv)
iii. tongue body — open (wide) at pharynx (phar)
vi. lips — bottom lip touches (clo) top lip (lab)
v. glottis — opening (wide)

---

[12] An anonymous reviewer notes that traces of inaudible "deleted" vowels in Plains Cree can often be seen in spectrograms as a voicing burst of > 3ms where the "deleted" vowel should be.

Each of these gestures has a certain duration and they are organized together in a specific order to create the utterance *pan*. This organization, called the gestural score, is illustrated in figure 3.[13]

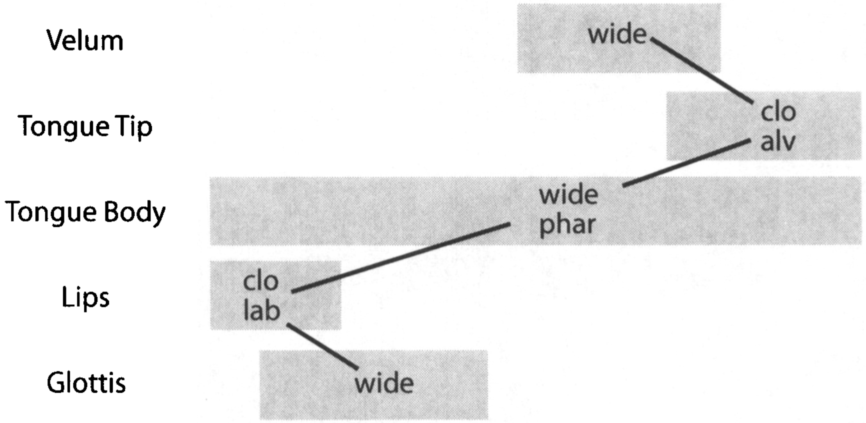

Figure 3: Gestural score for *pan* [pæn]

Note that the same gestures could have a different gestural score and produce a different word (e.g., *nap*). Grey boxes indicate the activation interval — the duration for which the gesture will be formed, held, and released. Notice that these intervals can be overlapping. In figure 3, both the glottal and velar gestures overlap with the vowel (tongue body) gesture, in the first case, producing aspiration (or vowel devoicing) and in the second case, producing nasalization near the end of the vowel.

Overlapping gestures have been proposed to account for vowel devocalization (see Beckman 1996 for an overview). The gestures of the flanking consonants overlap the vowel in question to the point that the vowel is perceived as partially to fully devoiced or, at an extreme endpoint, is imperceptible. Browman and Goldstein (1989) refer to the latter as gestural hiding. Essentially, the gestures of the vowel are "hidden" by the surrounding segments.

To illustrate gestural hiding, consider figures 4 and 5 for the first syllable of *potato*. The line over the segment block represents the duration of the segment gesture. In both figures, the gestures for the consonants overlap the vowel gestures. In the second case, however, the degree of overlap is so great that the vowel gesture is completely eclipsed, or hidden, resulting in a vowel that is produced but not perceived.

The Gestural Model provides an account for the characteristics of vowel devocalization described in section 4.1. For example, it predicts that short high vowels might be hidden (or subject to apparent deletion) more frequently than their longer counterparts due to their relatively short gestures. Gradience can be accounted for by assuming variation in the timing of the gestural score of the syllable. Finally, the

---

[13] For information on how the gestural score is calculated, see Browman and Goldstein 1992.

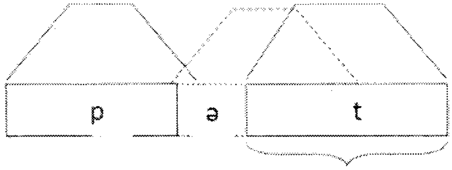

Figure 4: Small degree of gestural overlap, vowel is perceived

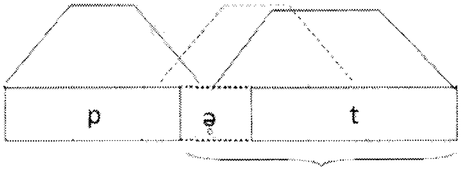

Figure 5: Greater degree of gestural overlap, vowel is not perceived

commonly-reported effect of speech rate on devocalization can be explained by the positive correlation between speech rate and gestural overlap (Hardcastle 1985; see Browman and Goldstein 1992 for further discussion).

Phonetic lengthening is a common corollary of vocalic gestural hiding. For example, Davidson (2006) found that initial fricatives and plosive aspiration were both greater in duration in cases of vowel devocalization than before a fully voiced vowel. Similarly, Price (1980) found the *r* to be greater in duration after vowel devocalization in the case of *p'rade* (variant of *parade*) than in *prayed*. It is possible, then, that if secondary clusters in Algonquian are actually CVC sequences with a difficult-to-perceive vowel, the consonants in secondary clusters will be phonetically lengthened. This possibility is investigated in the next section.

5. THE STUDY

I propose that secondary clusters in NE Cree, and Algonquian in general, can be reanalyzed as CVC sequences in which a lengthened consonant overlaps with the difficult-to-perceive vowel. I have demonstrated that remarkable similarity exists between the behaviour of vowel "deletion" in Algonquian and vowel devocalization in other languages. While compelling, this argument on its own is not enough to determine whether vowels in secondary clusters are devocalized or deleted. A phonetic study is required for this task. Ideally, one would consider articulatory data (e.g., Gick et al. 2012). However, to the best of my knowledge, such data is not currently available. Fortunately, it is possible to examine this articulatory issue indirectly by looking at an acoustic correlate of gestural hiding: phonetic lengthening. If secondary clusters are in fact CVC sequences with a difficult-to-perceive vowel, then we expect the consonants to be phonetically lengthened. In other words, if we compare the consonants in CVC sequences whose vowel is difficult to perceive (i.e., secondary clusters) to consonants in CVC sequences whose vowel is easy to perceive, then we expect that the former will be greater in duration than the latter.

The present pilot study was designed to test this hypothesis for NE Cree. For the study, I investigated whether consonant duration correlated with vowel "deletion" in NE Cree. If it does, then this suggests that underlying vowels are still present in secondary clusters but are hidden by adjacent consonant gestures. To test this, I measured the duration of consonants on either side of a deleted vowel (i.e., consonants in secondary clusters) and compared it with the duration of consonants on either side of a perceived vowel. If consonants next to "deleted" vowels are significantly longer in duration than their CVC counterparts, then this provides evidence for phonetic lengthening and support for gestural hiding. On the other hand, if consonants in secondary clusters are not significantly longer than their CVC counterparts, then we do not find evidence to support gestural hiding or the presence of devocalized vowels.

5.1 Data collection

I used word lists spoken by NE Cree speaker Luci Bobbish-Salt to find cases of stops, fricatives, and nasals in secondary clusters and CVC sequences. These word lists were digitally recorded by Marguerite MacKenzie in Chisasibi in 2006, using a Sony ICD-UX70 recorder. Ms. Bobbish Salt is a native NE Cree speaker from Chisasibi and speaks English as a second language. Each word in the word list was read in isolation. The speech rate was slow for all of the items on the word list. The consonants I was able to measure are summarized in tables 4 and 5.

Table 4: Number and type of C1s measured

STOPS				FRICATIVES				NASALS			
C_1	CC	CVC	Total	C_1	CC	CVC	Total	C_1	CC	CVC	Total
p	25	20	45	s	—	—	—	m	26	24	50
t	19	31	40	sh	—	24	24	n	18	26	44
k	21	24	45	h	—	—	—				
Total	65	75	130	Total	—	24	24	Total	44	50	94

Table 5: Number and type of C2s measured

STOPS				FRICATIVES				NASALS			
C_2	CC	CVC	Total	C_2	CC	CVC	Total	C_2	CC	CVC	Total
p	1	13	14	s	20	8	28	m	7	26	32
t	14	13	27	sh	27	10	37	n	14	33	47
k	4	14	18	h	27	3	30				
Total	19	40	59	Total	74	21	95	Total	21	59	79

Note that "CC" indicates that the consonant occurred in a secondary cluster and "CVC" indicates that the consonant occurred in a CVC sequence. Where the consonant is labelled C_1, it is either the first consonant in a secondary cluster or the first consonant in a CVC sequence. Where the consonant is labelled C_2, it is either the second consonant in a secondary cluster or the second consonant in a CVC sequence. For example, consider the word *tihchikâchâu* [tɪhʧ'kaʧaw] 's/he kicks'. In the CVC sequence [tɪh], [t] = C_1, [h] = C_2. In the secondary cluster [ʧk], [ʧ] = C_1, [k] = C_2. Due to the nature of the database, I did not find many tokens of [s] or [h] as C_1.

Many of the words in the word list share the same root. In such cases, I measured a particular consonant in only two of these words. This way, if there was something unique about the production of a particular root, there would not be enough examples to bias the results. For example, consider the list of words in (10).

(10) *NE Cree data sharing the same root*:

kiniwâpiht-h	'(you.SG) look at it!'
kiniwâpiht-im	'(you.SG) look at her/his X!'
kiniwâpiht-im-wâhkin	'(you.SG) look at his/her X later!'
kiniwâpiht-im-ikw	'(you.PL) look at it!'
kiniwâpiht-im-uhchâkw	'(you.PL) look at it later!'
kiniwâpiht-im-wâhkw	'(you.PL) look at it her/his X!'
kiniwâpiht-im-uwâhchâkw	'(you.PL) look at his/her X later!'
kiniwâpiht-ihtâu	'let's look at it!'
kiniwâpiht-im-uhkâhkw	'let's look at it later!'
kiniwâpiht-im-wâtâu	'let's look at her/his X!'
kiniwâpiht-im-wâhkâhkw	'let's look at his/her X later!'

All of these words are found in the corpora and share the stem /kiniwâpiht/. In all of these words, orthographic <pih> is always produced as the secondary cluster [ph]. Only the <pih> in *kiniwâpihtihtâu* and *kiniwâpihtim* — the first two, alphabetically, in the paradigm — were measured.

5.2 Measuring the data

For secondary clusters, I measured both the duration of C_1 and the duration of the entire cluster using Praat (Boersma and Weenink 2009). I then calculated the duration of C_2 by subtracting the value of C_1 from the duration of the cluster. For CVC sequences, I measured the duration of C_1, C_1 and the following vowel, and the entire sequence. I then calculated the duration of C_2 by subtracting the value of C_1 and the following vowel from the value obtained for the entire CVC sequence.

To create the measurements, I delineated segments using Praat Textgrids. I then created a script to extract the measurements within the Textgrid boundaries. My measurements were based on the spectrogram and waveform of the audio files and I used the audio cues described below. Sample screenshots of measurements are provided in the appendix.

5.2.1 Measuring C1

I measured stops beginning at the offset of the previous segment, placing a boundary just before the loss of spectral energy, at the point where the waveform lost complexity and was flat or near-flat. I ended the measurement after the noise burst, before the onset of the following segment. In cases where the segment was a vowel or nasal, this was before formants began. When the next segment was a fricative, this was just before high spectral energy and large aperiodic waves. Where a stop was followed by [h], any aspiration was considered to be part of [h].

I measured fricatives beginning at the onset of high frequency spectral energy and aperiodicity in the waveform. In the case of fricatives following stops, this was after the noise burst. I ended the measurement after the high spectral energy ended and the waveform became periodic (nasal or a vowel) or flat (stop). A common secondary cluster was [ʃʃ]. In this case, as it was impossible to tell where C_1 ended and C_2 began, the full secondary cluster was measured and both C_1 and C_2 were considered to be half the length of the secondary cluster.

For nasals, I began measurements at the offset of the previous segment, marked by the change in or appearance of formant structure, and ended them based on similar cues. All measurements were aided by the presence of the hallmark "nasal band" (Borden et al. 2007:140).

In the few cases in which the offset of the previous segment or onset of the next segment was difficult to determine, I omitted the consonant in question from my measurements.

5.2.2 Other measurements

C_1 and the following vowel were measured from the onset of C_1 to the onset of C_2. Similarly, a secondary cluster and a CVC sequence were measured from the onset of C_1 to the end of C_2. Onset and offset of these sequences were determined in the manner described in the previous section.

5.3 Data coding: Factors considered

The primary factor of interest that I coded for was sequential environment (i.e., whether a consonant occurred in a secondary cluster or a CVC sequence). I considered C_1 and C_2 in each sequential environment separately. In order to be sure changes in consonant duration could be attributed to sequential environment and not to other factors, I considered other factors commonly suggested to influence consonant duration in the literature, namely, syllable position (Clark et al. 2007:333), the location of consonants with respect to accent, the presence of a phrase or word boundary (White 2002), the presence of a preceding or following pause (Umeda 1977), and place of articulation (Laver 1994:434–435, van Son and van Santen 1997).

For the NE Cree data, the syllable count, the position of the syllable, and the location of consonants with respect to accent are all in question. If secondary clusters contain intervening vowels that are not perceived, then the syllable count of the word is different than if this vowel is deleted. This means that the position of a syllable and of a consonant with respect to accent will change depending on whether the vowels in question are deleted or not. Since we do not know whether they are deleted or not, we cannot code for these factors.

I initially coded for the place of articulation of each consonant. However, because NE Cree has only one or two consonants at most places of articulation, it is difficult to make a meaningful distinction between place of articulation and the particular segments themselves. For example, "velar" would essentially mean [k]; "glottal", [h]; "postalveolar", [ʃ]; and "labial", [p] or [m]. For this reason, I decided not to include place of articulation in this study.[14]

I coded for the remaining factors (presence of a phrase or word boundary and presence of a preceding or following pause), collapsing them into a single category: word-position. Because all of the data in this study consist of words in isolation, any word-initial segment is also phrase-initial and postpausal; similarly any word-final segment is also phrase-final and prepausal. I also coded for manner of articulation. While I did not find substantial evidence for an effect of manner on consonant duration in the literature, a preliminary look at the data suggested that this factor did influence duration. Note that the effect of manner of articulation and word or phrase position is tangential to this study. The main concern is whether sequential environment (e.g., secondary cluster or CVC sequence) can explain some of the variation in consonant duration, after considering other possible factors.

To summarize, after measuring the consonants, I divided C_1 and C_2 data and considered them separately. I then coded the data according to sequential environment (whether the consonant occurred in a CVC sequence or in a secondary cluster), manner of articulation (stop, nasal, or fricative), and the position of the consonant within a word (word-initial, word-medial, or word-final). To illustrate, consider the word *apishâshiu* [ɪpʃæːʃiw] 'it is small', containing the secondary cluster [pʃ]. The cluster position (C_1 or C_2), manner, and word-position was coded for both [p] (C_1, stop, word-medial) and [ʃ] (C_2, fricative, word-medial). More examples are provided in examples 11 and 12.

(11) *Secondary clusters*:

		C_1 cluster			C_2 cluster		
Orthography	CC	C_1	Manner	Position	C_2	Manner	Position
aPISHâshiu	psh	p	stop	word-medial	sh	fricative	word-medial
ishkwâSHISH	shsh	sh	fricative	word-medial	sh	fricative	word-final
KUStim	ks	k	stop	word-initial	s	fricative	word-medial

---

[14] I did, however, do an initial test to see if dividing the data into Labial, Coronal, and Post-Coronal would prove beneficial. Dividing the data this way, place of articulation did not prove to significantly affect consonant duration. This is not included in the statistical analysis that follows. Because of the low number of tokens, adding more factor groups decreases the reliability of the test.

(12) *CVC sequences*:

Orthography	CVC	C_1 cluster C_1	Manner	Position	C_2 cluster C_2	Manner	Position
KIPitâkin	kip	k	stop	word-initial	p	stop	word-medial
nishtuSHÂP	shâp	sh	fricative	word-medial	p	stop	word-final
mâMÂPisun	mâp	m	nasal	word-medial	p	stop	word-medial

5.4 Analysis and results

To determine which factors were significant contributors to consonant duration, I performed two ANOVAs. For C_1, I performed a 2 × 3 × 2 ANOVA with two levels of position of consonant within word (word-medial, word-initial), three levels of manner of articulation (plosive, nasal, fricative), and two levels of sequential environment (secondary cluster, CVC sequence). For C_2, I performed the same ANOVA, with the exception that the levels for position of consonant were word-medial and word-final. All outliers were removed from the data before performing these tests. Outliers were consonants whose duration was outside two standard deviations of the mean of C_1 duration for C_1 and the mean of C_2 duration for C_2. This removed 4 tokens for C_1 and 9 tokens for C_2. The descriptive statistics are shown in tables 6 and 7 (all measurements are in ms) and the ANOVA results are shown in tables 8 and 9.

Table 6: Descriptive statistics, C_1 duration

Factors	Mean	SE	SD	95% confidence interval Lower bound	Upper bound
Plosive	92	4.48	47.3	83.1	101
Nasal	79.1	4.65	48	69.9	88.3
Fricative	187	6.09	46	175	199
Word-initial	54.1	5.53	35.9	43.2	65
Word-final	140	3.01	44.5	134	146
Secondary cluster	121	4.47	53.3	112	129
CVC sequence	90.9	3.56	54.2	83.9	97.9

The rest of this section will discuss each of the factors in turn, detailing their influence, if any, on C_1 and C_2 duration.

5.4.1 *Manner of articulation*

Manner of articulation had a significant effect on both C_1 duration (F(2, 219) = 50.50, $p < .001$) and C_2 duration (F(2, 212) = 11.80, $p < .001$). This is shown in figure 6.

To determine the effect of each manner of articulation on consonant duration, I performed Sheffé post-hoc tests, which revealed a significant difference for all manners of articulation for C_1 ($p \leq .001$). Fricatives were the longest (M = 187, SD 46), followed by plosives (M = 92, SD 47.3), and nasals were the shortest (M = 79.1, SD 48). For C_2, fricatives (M = 234, SD 77.7) were significantly longer ($p < .001$) than

Table 7: Descriptive statistics, C_2 duration

Factors	Mean	SE	SD	95% confidence interval	
				Lower bound	Upper bound
Plosive	134	8.13	47.9	118	151
Nasal	118	7.04	34.3	105	132
Fricative	234	15.5	77.7	203	264
Word-medial	132	4.48	66.4	123	141
Word-final	226	16.1	71.2	194	258
Secondary cluster	164	7.34	78	149	178
CVC sequence	130	10.6	52.8	152	194

Table 8: ANOVA, C_1 duration

Effect	F statistics	p-value
Word position	F(1, 219) = 94.70	< **.001**
MOA	F(2, 219) = 50.50	< **.001**
Environment	F(1, 219) = 24.10	< **.001**
Position*MOA	F(2, 219) = 1.22	.270
Position*environment	F(1, 219) = 0.13	.719
MOA*environment	F(2, 219) = 0.69	.503
Position*MOA*environment	F(2, 219) = 8.59	**.004**

Notes: MOA = manner of articulation
Environment = sequential environment

Table 9: ANOVA, C_2 duration

Effect	F statistics	p-value
Word position	F(1, 212) = 29.00	**<.001**
MOA	F(2, 212) = 11.80	**<.001**
Environment	F(1, 212) = 1.30	.257
Position*MOA	F(2, 212) = 1.70	.108
Position*environment	F(1, 212) = 1.60	.202
MOA*environment	F(2, 212) = 1.70	.184

Note: Environment*position*MOA could not be assessed.

stops (M = 134, SD 47.9) and nasals (M = 118, SD 34.3). Stops and nasals were not significantly different from each other ($p = .676$).

5.4.2 *Word position*

There was a significant effect of consonant position for C_1 and C_2, as shown in figure 7.

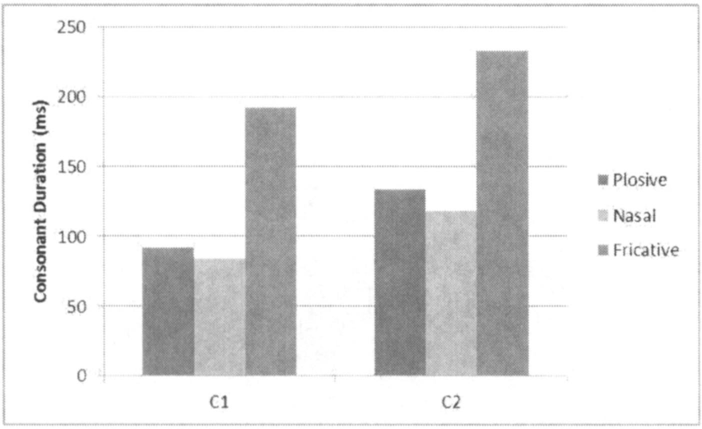

Figure 6: Manner of articulation

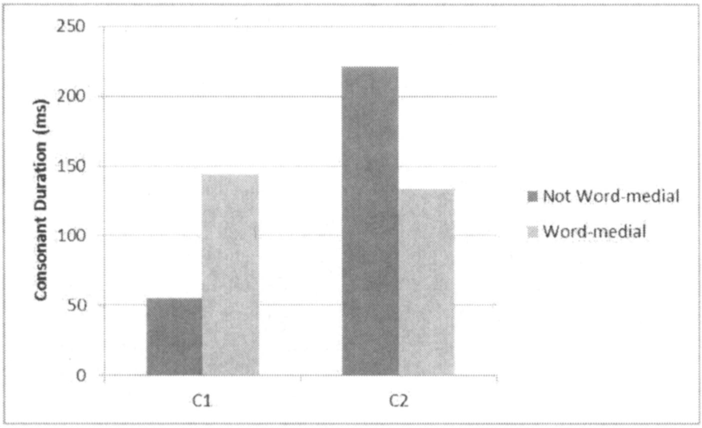

Figure 7: Word position

The ANOVA for C_1 (table 8) revealed a significant effect of consonant position within a word (F(1, 219) = 94.70, $p < .001$). Word-medial consonants (M = 140, SD 44.5) were significantly longer than word-initial consonants (M = 54.1, SD 35.9). Similarly, the ANOVA for C_2 (table 9) showed that word-final consonants (M = 226, SD 71.2) were significantly longer than word-medial consonants (M = 132, SD 66.4) (F(1, 212) = 29.00, $p < .001$).

5.4.3 *Sequential environment*

Figure 8 shows the results for sequential environment.

The ANOVA in table 8 revealed that the sequential environment had a significant effect on the duration of C_1 (F(1, 219) = 24.10, $p < .001$). C_1 was significantly longer in secondary clusters (M = 164, SD 78) than in CVC sequences (M = 130, SD 52.8).

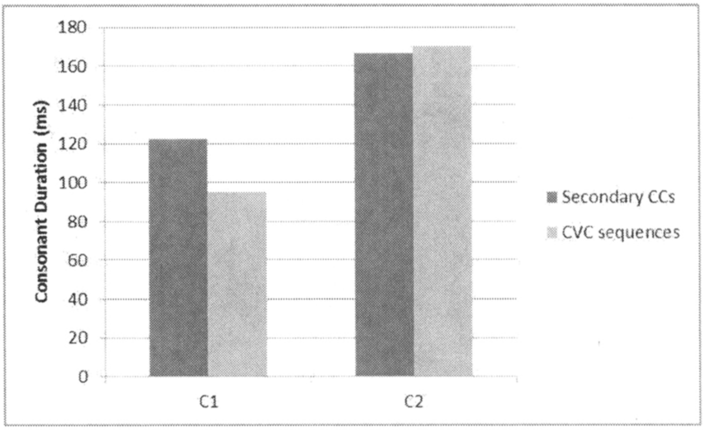

Figure 8: Sequential environment

In contrast, the ANOVA in table 9 did not reveal a significant effect of sequential environment on C_2 duration (F(1, 212) = 1.30, $p = .257$). C_2 duration in secondary clusters (M = 164, SD 78) was not significantly different than C_2 duration in CVC sequences (M = 130, SD 52.8).

5.4.4 Three-way interaction between factors

For C_1, a significant interaction was found between word-position, manner, and sequential environment (F(2,219) = 8.59, $p = .004$). In other words, I found that the effect of sequential environment on C_1 duration depends on C_1's MOA and word position. To examine this interaction further, I split the data by word-position and manner and ran one-way ANOVAs to determine the effect of sequential environment on the duration of C_1 in each of the groups. Descriptive statistics are found in table 10 and the results of the ANOVAs are in table 11 (CC stands for secondary cluster and CVC for CVC sequences). Results were considered significant if the F statistic was greater or equal to the F_{CRIT} (1, 219) = 3.84.[15]

Word-initial plosives, word-medial nasals, and word-medial fricatives were significantly longer in secondary clusters (M = 79.5, SD 55.5; M = 131, SD 32.5; M = 206, SD 56.4) than in CVC sequences (M = 34.4, SD 27; M = 83.1, SD 22.9; M = 167, SD 25.6). In contrast, word-initial nasals and word-medial plosives were not significantly different in secondary clusters (M = 58.5, SD 53.5; M = 128, SD 36.2) than in CVC sequences (M = 44, SD 17.7; M = 126, SD 32.4). There were not enough word-initial fricatives to make a comparison between sequential environments.

In contrast to C_1, no interactions were found to be significant for C_2.

---

[15] I used SPSS to perform these ANOVAs. As SPSS does not calculate the correct F-statistic (or, consequently, p-value) in this procedure, I recalculated the F-statistics. To do this, I divided the new Mean Square for the factor in question by the Mean Standard Error (MSE) of the original factorial ANOVA (i.e., F-stat = NewMeanSq/MSE). I then determined the F_{CRIT} by consulting an F Distribution table with $\alpha = 0.05$, using the degrees of freedom from the original factorial ANOVA.

Table 10: Interaction descriptive statistics, C_1 duration

Position/Factors		N	Mean	SE	SD	95% confidence interval	
						Lower bound	Upper bound
Word-initial:							
Plosive	CC	6	79.5	22.7	55.5	21.2	138
Plosive	CVC	17	34.4	6.54	27	20.6	48.3
Nasal	CC	8	58.5	18.9	53.5	13.8	103
Nasal	CVC	19	44	4.06	17.7	35.4	61
Word-medial:							
Plosive	CC	59	128	4.72	36.2	119	138
Plosive	CVC	45	126	4.83	32.4	116	135
Nasal	CC	28	131	6.15	32.5	118	143
Nasal	CVC	14	83.1	6.13	22.9	69.8	96.3
Fricative	CC	15	206	14.6	56.4	175	237
Fricative	CVC	18	167	6.03	25.6	155	180

Table 11: ANOVA, C_2 duration

Position	Manner	F statistic	Significant? (F > 3.84?)
Word-initial	Plosive	F(1, 219) = 7.41	**yes**
Word-initial	Nasal	F(1, 219) = 0.98	no
Word-medial	Plosive	F(1, 219) = 0.14	no
Word-medial	Nasal	F(1, 219) = 17.50	**yes**
Word-medial	Fricative	F(1, 219) = 9.94	**yes**

Note: Word-initial fricatives could not be assessed due to lack of data.

5.4.5 *Interim discussion*

My results so far indicate that word position and manner of articulation affect consonant duration but do not explain all of its variance with respect to *initial* consonants; some variation is due to sequential environment. In general, initial consonants in secondary clusters are longer than initial consonants in CVC sequences. However, this is not true for all consonants but only for consonants with certain manners of articulation in certain word-positions; in particular, sequential environment does not significantly affect the duration of word-initial nasals and word-medial plosives. The next sections present further tests I conducted to explore why these particular consonants pattern differently from the others.

5.4.6 *Word-initial nasals*

The lack of sequential environment effect on C_1 duration of word-initial nasals may be due to a separate phonological process of fortition that optionally occurs in NE Cree. In particular, word-initial <m> in secondary clusters is often realized as [p].

For example, *miskumî* is pronounced [pskumiː].[16] I removed all cases of word-initial <m> realized as [p] from the data and reran a 2 × 3 × 2 ANOVA with two levels of position of consonant within word (word-medial, word-initial), three levels of manner of articulation (plosive, nasal, fricative), and two levels of sequential environment (secondary cluster, CVC sequence). Where the descriptive statistics differ from the original ANOVA (see table 6), I have rewritten them in table 12. The ANOVA results in table 13 show that all of the main interactions remained significant.

Table 12: Descriptive statistics, C_1 duration

				95% confidence interval	
Factors	Mean	SE	SD	Lower bound	Upper bound
Nasal	88.5	5.50	46.1	77.6	99.3
Word-initial	63.5	6.24	36.1	51.2	75.8
Secondary cluster	128	5.03	49.8	118	138

Table 13: ANOVA, C_1 duration

Effect	F statistics	p-value
Word position	F(1, 215) = 57.50	**<.001**
MOA	F(2, 215) = 51.80	**<.001**
Environment	F(1, 215) = 33.80	**<.001**
Position*MOA	F(2, 215) = 5.48	**.020**
Position*environment	F(1, 215) = 2.75	.099
MOA*environment	F(2, 215) = 2.40	.094
Position*MOA*environment	F(2, 219) = 1.80	.117

A significant interaction is found between position and manner of articulation (F(2, 215) = 5.48, $p = .02$). This interaction is not investigated because it does not involve the factor of interest, namely, sequential environment. However, the interaction between word position, manner of articulation, and sequential environment disappeared once the examples with fortition were removed from the data (F(2, 215) = 1.80, $p = .177$).

Splitting the data by word-position and manner of articulation, I again ran a one-way ANOVA to determine the effect of sequential environment on the duration of word-initial nasals. Descriptive statistics of the word-initial nasals are shown in table 14. This time I found that word-initial nasals were greater in duration in secondary clusters (M = 96, SD 50) than in CVC sequences (M = 44, SD 17.7) (F(1, 215) = 7.58 > F_{CRIT} (1, 215) = 3.84).

---

[16] A similar process also happens in Mi'kmaq (see Hewson 1982).

Table 14: Interaction descriptive statistics, duration of word-initial nasals

Environment	N	Mean	SE	SD	95% confidence interval Lower bound	95% confidence interval Upper bound
CC	4	96	25	50	16.5	175
CVC	19	44	4.06	17.7	39.3	66.7

5.4.7 *Word-medial plosives*

In order to examine the effect of sequential environment on word-medial plosives, I analyzed the word-medial plosive data separately. I ran a 3 × 2 ANOVA with three levels of place of articulation (labial, coronal, velar) and two levels of sequential environment (secondary cluster, CVC sequence). Descriptive statistics can be found in table 15 and the ANOVA results in table 16.

Table 15: Descriptive statistics, C_1 word-medial, plosive duration

Environment		N	Mean	SE	SD	95% confidence interval Lower bound	95% confidence interval Upper bound
/p/	CC	24	117	6.95	28.9	108	136
	CVC	7	112	12.9	13.3	86	137
/t/	CC	15	146	8.8	49.3	128	163
	CVC	23	124	7.1	40.1	110	138
/k/	CC	20	123	7.62	29.9	108	138
	CVC	15	135	8.8	22.6	117	152

Table 16: ANOVA, C_1 word-medial, plosive duration

Effect	F statistics	*p*-value
POA	F(2, 98) = 1.90	.150
environment	F(1, 98) = 0.85	.363
POA*environment	F(2, 98) = 2.10	.125

Note: POA = place of articulation

Consonant duration did not vary significantly according to place of articulation (F(2, 98) = 1.90, $p = .150$) or sequential environment (F(1,98) = 0.85, $p = .363$), and no significant effect of interaction was found (F(2, 98) = 2.10, $p = .125$).

5.5 Summary of results

The purpose of this study was to determine whether consonants adjacent to "deleted" vowels in NE Cree (i.e., those in secondary clusters) are greater in duration than consonants in CVC sequences. If so, this would support my hypothesis that secondary clusters in NE Cree can be reanalyzed as CVC sequences in which lengthened consonants cause the vowel to be difficult to perceive.

To test this, I measured and compared the duration of both consonants in secondary clusters and CVC sequences. I also coded for factors I predicted to influence consonant duration (manner of articulation, word-position, and sequential environment). My purpose was to determine whether sequential environment contributed to variation in consonant duration not explained by other influencing factors.

My results indicate that C_1 in secondary clusters are significantly longer than C_1 in CVC sequences, with the exception of word-medial plosives. This exception is both puzzling and unexpected. In SE Cree, Dyck and colleagues Dyck et al. (2014) found C_1 in secondary clusters to be significantly longer than C_1 in CVC sequences for all manners of articulation. This could be due to methodological differences: Dyck et al. Dyck et al. (2014) included [h]-like frication following a stop-burst as plosive aspiration while I coded this as the C_2 [h]. For example, consider the word *akuhp* [akhp] 'coat': the aperiodic waves following the [k] stop burst were included in the length measurement of [k] in Dyck et al. 2014, while in my study, I coded it as a new segment, [h]. Further investigation is needed to explore what is happpening with word-medial plosives.

The finding that initial consonants in secondary clusters are generally greater in duration than those in CVC sequences supports the hypothesis that an underlying vowel is present in secondary clusters but is not perceived due to gestural overlap of the preceding consonant. This is compatible with a Gestural Model account of vowel devocalization.

6. CONCLUSIONS AND FUTURE RESEARCH

In this article, I examined the issue of secondary clusters in Algonquian. Traditionally, secondary clusters are said to be derived from CVC syllables that have undergone vowel deletion (section 3). In section 3.2, I suggested that the assumption of vowel deletion should be re-examined on both theoretical and empirical grounds. If we assume that secondary clusters arise due to vowel deletion, then the syllable structure of languages like Northern East Cree becomes difficult to describe. Moreover, the data itself, described as containing variation between a deleted vowel, a shortened vowel, and a devoiced vowel, suggested a gradient process and not categorical deletion. I demonstrated that the so-called vowel deletion contributing to secondary clusters in Algonquian closely resembled vowel devocalization reported in non-Algonquian languages — a process involving gradient vowel shortening or weakening as opposed to true deletion (section 4).

In section 4.3, I described the Gestural Model used to account for vowel devocalization. In this model, vowel devocalization is attributed to gestural hiding; the gestures of the adjacent consonants overlap the vocalic gestures, causing the vowel to be perceived as shortened, voiceless, or not be perceived at all. I proposed a method for testing whether gestural hiding could account for the presence of secondary clusters in Algonquian (i.e., comparing the duration of consonants in secondary clusters to the duration of consonants in CVC sequences). If consonants in secondary clusters were longer in duration than those in CVC sequences, it would suggest that the gestures of the consonant(s) in secondary clusters do indeed overlap with and essentially hide the presence of a vowel. I carried out this study using NE Cree data (section 5), and, as predicted, found that the initial consonants in secondary clusters are longer than the initial consonants in CVC sequences, except when the initial consonant was a plosive.

The results suggest that many secondary clusters in NE Cree (at least ones beginning with nasals or fricatives) are actually CVC sequences with a difficult-to-perceive vowel. This analysis suggests that phonological representations of CVC sequences can be phonetically realized in (at least) two ways: one realization results in a perceived CVC sequence and the other results in a perceived consonant cluster. In other words, two different modes of gestural timing cause the initial consonant in CVC sequences like <kus> to be realized in two different ways. In both cases, the sequence is produced as [kʊs]. However, in one mode of gestural timing, the phonetically longer C_1 inhibits the perception of the following vowel and the sequence is perceived as [ks]; in another mode, the phonetically shorter C_1 does not inhibit the perception of the following vowel and the sequence is perceived as [kʊs].

Looking at the data in this way accounts for the gradience and variability in the realization of vowels in secondary clusters. Instead of having to explain gradience with a categorical rule of deletion, there is one process, devocalization, which is gradient in nature. This also resolves the issue that NE Cree secondary clusters pose to syllable structure. If we look again to the examples discussed in section 3.2, we find that the syllabification of *chisihîkin* [t^{h}shigɪn] 'broom' and *âpihtuwin* [æphtuːn] 'half' are straightforward. The syllables are now: [t^{h}Vs.hi.gɪn] and [æ.pVh.tuːn], where V represents a difficult-to-perceive vowel.

It further negates the need for abstract or substanceless underlying vowels in secondary clusters, as all of these so-called underlying vowels do, in fact, surface. This would mean that the underlying representation and the surface forms of words would contain the same segments.

This study serves as a proof of concept and, like all such studies, the conclusions we can make are limited. Right now, these results are limited to one speaker in one speech style. Analyzing data from more speakers would allow the results to be generalized to NE Cree and not just a particular speaker. A sociolinguistic study would allow us to investigate the factors influencing whether a vowel is produced audibly or inaudibly. A sociolinguistic interview would also provide tokens from natural speech in addition to the ones in this paper, which are from a word list.

Another limitation of this study is that it uses acoustic data as indirect evidence for an articulatory process. Thus, while the results of this article are compelling, they are not conclusive. I have shown that for Ms. Bobbish-Salt, initial consonants in secondary clusters are generally longer than the initial consonants in CVC sequences. This suggests that secondary clusters can be analyzed as CxC. Based on the similarity to vowel devocalization cross-linguistically, I claim that this "x" is a vowel that is hidden by a phonetically lengthened consonant (e.g., $C \times C = CVC$). Another possible interpretation is that this "x" is actually a result of the doubling of the initial

C (e.g., $C \times C = C_1\ C_1\ C_2$).[17] To determine between these cases, an articulatory study is needed to determine if vowel gestures are present. It is possible that we will find that some secondary clusters are CVC sequences and others are true consonant clusters, consisting of a geminate consonant followed by another consonant.

These results raise questions as regards the relationship between phonetics and phonology. If secondary clusters are derived from vowel deletion, then we need to posit a higher degree of abstraction in mental representations than if secondary clusters are CVC sequences with difficult to perceive vowels. By claiming that this vowel is devocalized, not deleted, the distance between phonology and phonetics is narrowed. This argues against stances like that taken by Hale and Reiss (2000), who draw a clear divide between phonetics and phonology, and argues in favour of a view of phonology that is closely intertwined with phonetics. This leaves open the question of just how tightly phonetics and phonology are intertwined and what their interface might look like in this case.

Another question raised concerns learnability. How are these inaudible vowels learned? What evidence do children have that there are vowels in secondary clusters and not, say, as mentioned above, simply a long consonant followed by another consonant? Perhaps this evidence comes from variation. It is possible that children are able to learn that there are vowels in these clusters because the vowels are sometimes perceived. However, from the literature, it appears that older speakers audibly produce these vowels more frequently than younger speakers in some varieties of Algonquian (e.g., Rhodes 1976a). Is there a certain point at which this variation becomes so infrequent that it can no longer serve as evidence during acquisition? To put it another way, is there a point at which these vowels will fail to be learned by the next generation? And what would that point be? Valentine (2001) explains that something like this has already happened, or is happening, in Nishnaabemwin. Younger speakers have reanalyzed the pronominal prefix system in Nishnaabemwin based on the input they are exposed to. Valentine illustrates this reanalysis with the word *pwaagan* 'smoking pipe'. For older speakers, the representation for this word was *opwaagan* but the initial vowel could be deleted (or devocalized). This vowel was audibly produced when the prefix *nd-* 'my' was added to the word, creating *ndoopwaagan*. Younger speakers, however, have taken the singular form, perceived without an initial vowel, to be the root. Then, faced with words like *ndoopwaagan* 'my pipe', these speakers have understood *ndoo-* to be the pronominal prefix meaning 'my' and have productively used this with other words. To address the questions of learnability and potential reanalysis in NE Cree, a sociophonetic study including speakers of different ages would be useful. We might find that older speakers have a different system than that of younger speakers.

Finally, this article also leaves open the question of whether the same analysis I have used for secondary clusters in NE Cree could be extended to other Algonquian languages. The data described in section 4 suggest that this is likely the case for several Algonquian languages. More extensive phonetic descriptions of these languages

---

[17] Special thanks to the anonymous reviewer who pointed out this other possible interpretation.

are needed in order to address the question. However, if this analysis can be extended to other Algonquian languages, then we also have an explanation for why pitch is sensitive to these "deleted" vowels in secondary clusters, as mentioned in section 3.1.3. Words such as Plains Cree *nâpê(w)-sis*, which are perceived as disyllables, share the same pitch pattern as trisyllables because they are, in fact, trisyllables with a difficult-to-perceive vowel.

REFERENCES

Beckman, Mary E. 1996. When is a syllable not a syllable? In *Phonological structure and language processing: Cross-linguistic studies*, ed. Takashi Otake and Anne Cutler, 95–123. Berlin: Mouton de Gruyter.

Beckman, Mary E. and Atsuko Shoji. 1984. Spectral and perceptual evidence for CV coarticulation in devoiced /si/ and /syu/ in Japanese. *Phonetica* 41:61–71.

Boersma, Paul and David Weenink. 2009. Praat: Doing phonetics by computer (version 5.1). Available at: http://www.praat.org/.

Borden, Gloria J., Katherine S. Harris, and Lawrence J. Raphael. 2007. *Speech science primer: Physiology, acoustics, and perception of speech.* Philadelphia: Lippincott Williams and Wilkins.

Browman, Catherine P. and Louis Goldstein. 1989. Articulatory gestures as phonological units. *Phonology* 6:201–251.

Browman, Catherine P. and Louis Goldstein. 1990. Gestural specification using dynamically-defined articulatory structures. *Haskins Laboratories Status Report on Speech Research* SR-103/104:95–110.

Browman, Catherine P. and Louis Goldstein. 1992. Articulatory phonology: An overview. *Haskins Laboratories Status Report on Speech Research* SR-111/112:23–42.

Cedergren, Henrietta J. and Louise Simoneau. 1985. La chute des voyelles hautes en français de Montréal: "As-tu entendu la belle syncope?". In *Les tendences dynamiques du français parlé à Montréal*, ed. Monique Lemieux and Henrietta J. Cedergren, 57–144. Montréal: Office de la langue française.

Clark, John Ellery, Colin Yallop, and Janet Fletcher. 2007. *An introduction to phonetics and phonology*. 3rd ed. Oxford: Blackwell.

Coleman, John. 2001. The phonetics and phonology of Tashlhiyt Berber syllabic consonants. *Transactions of the Philological Society* 99:29–64.

Dalby, Jonathan Marler. 1986. Phonetic structure of fast speech in American English. Doctoral dissertation, Indiana University.

Dauer, Rebecca M. 1980. The reduction of unstressed high vowels in Modern Greek. *Journal of the International Phonetic Association* 10:17–27.

Davidson, Lisa. 2006. Schwa elision in fast speech: Segmental deletion or gestural overlap? *Phonetica* 63:79–112.

Delattre, Pierre. 1951. Le jeu de l'*e instable* intérieur en français. *French Review* 24:341–351.

Delforge, Ann Marie. 2008. Unstressed vowel reduction in Andean Spanish. In *Selected Proceedings of the 3rd Conference on Laboratory Approaches to Spanish Phonology*, ed. Laura Colantoni and Jeffrey Steele, 107–124. Somerville, MA: Cascadilla Press.

Dell, François and Mohamed Elmedlaoui. 1988. Syllabic consonants in Berber: Some new evidence. *Journal of African Languages and Linguistics* 10:1–17.

Derrick, Donald. 2007. Syllabification and Blackfoot /s/. *Simon Fraser University Working Papers in Linguistics* 1: *Proceedings of the 22nd Northwest Linguistics Conference (NWLC)*, ed. Nicole Carter, Loreley Marie Hadic Zabala, Anne Rimrott, and Dennis Ryan Storoshenko, 62–76.

Dyck, Carrie, Julie Brittain, and Marguerite MacKenzie. 2006. Northern East Cree accent. In *Actes du congrès annuel de l'Association canadienne de linguistique 2006/ Proceedings of the 2006 annual conference of the Canadian Linguistic Association*, ed. Claire Gurski et Milica Radišić. Available at: westernlinguistics.ca/Publications/CLA2006/Dyck_Brittain_MacKenzie.pdf.

Dyck, Carrie, Alethea Power, and Kevin Terry. 2014. Syncope in East Cree: Phonological or phonetic? In *Papers of the 42nd Annual Algonquian Conference Proceedings*, ed. Monica Macaulay and J. Randolph Valentine, 120–133. Albany: State University of New York Press.

Ellis, C. Douglas. 1983. *Spoken Cree: West coast of James Bay*. 2nd ed. Edmonton: Pica Pica Press.

Fokes, Joanne and Z.S. Bond. 1993. The elusive/illusive syllable. *Phonetica* 50:102–123.

Fougeron, Cecile and Donca Steriade. 1997. Does deletion of French schwa lead to neutralization of lexical distinctions? In *Proceedings of Eurospeech'97*, vol. 2, ed. by George Kokkinakis, Nikos Fakotakis, and Evangelos Dermatas, 943–946. International Speech Communication Association. Available at:www.isca-speech.org/archive/eurospeech_1997/e97_0943.html.

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

Gick, Bryan, Heather Bliss, Karin Michelson, and Bosko Radanov. 2012. Articulation without acoustics: "Soundless" vowels in Oneida and Blackfoot. *Journal of Phonetics* 40:46–53.

Gordon, Matthew. 1998. The phonetics and phonology of non-modal vowels: A cross-linguistic perspective. *Berkeley Linguistics Society* 24:93–105.

Hale, Mark and Charles Reiss. 2000. "Substance abuse" and "dysfunctionalism": Current trends in phonology. *Linguistic Inquiry* 31:157–169.

Hall, Tracy A. 1992. *Syllable structure and syllable-related processes in German*. Tübingen: Max Niemeyer Verlag.

Hardcastle, William J. 1985. Some phonetic and syntactic constraints on lingual coarticulation during /kl/ sequences. *Speech Communication* 4:247–263.

Hewson, John. 1982. Fundamentals of Micmac phonology and morphology. In *Languages in Newfoundland and Labrador*, ed. Harold J. Paddock, 200–214. St. John's: Memorial University of Newfoundland.

Hooper, Joan B. 1978. Constraints on schwa-deletion in American English. In *Recent Developments in Historical Phonology*, ed. Jacek Fisiak, 183–207. The Hague: Mouton.

Jannedy, Stefanie. 1994. Rate effects on German unstressed syllables. *Working Papers in Linguistics* [Ohio State University] 44:105–124.

Jun, Sun-Ah and Mary E. Beckman. 1994. Distribution of devoiced high vowels in Korean. In *Proceedings of the 1994 International Conference on Spoken Language Processing* vol. 2, 479–482. Yokohama: Acoustical Society of Japan.

Kohler, Klaus. 1990. Segmental reduction in connected speech in German: Phonological facts and phonetic explanations. In *Speech production and speech modeling*, ed. W.J. Hardcastle and Alain Marchal, 69–92. Dordrecht: Kluwer Academic.

Kondo, Mariko. 1993. The effect of blocking factors and constraints on consecutive vowel devoicing in Standard Japanese. Poster presented at the Fourth Conference on Laboratory Phonology, Oxford.

Laver, John. 1994. *Principles of phonetics*. Cambridge: Cambridge University Press.

LeSourd, Philip S. 1993. *Accent and syllable structure in Passamaquoddy*. New York: Garland.

MacKenzie, Marguerite. 1982. Towards a dialectology of Cree-Montagnais-Naskapi. Doctoral Dissertation, University of Toronto.

Manuel, Sharon Y., Stefanie Shattuck-Hufnagel, Marie K. Huffman, Kenneth N. Stevens, Rolf Carlson, and Sheri Hunnicutt. 1992. Studies of vowel and consonant reduction. *Proceedings of the 1992 International Conference on Spoken Language Processing* vol. 2, ed. John Ohala, Terry M. Neary, Bruce L. Derwing, Megan M. Hodge, and Grace E. Wiebe, 943–946. Edmonton: University of Alberta.

Michelson, Truman. 1939. Linguistic classification of Cree and Montagnais–Naskapi dialects. *Bureau of American Ethnology* Bulletin 123, Anthropological Papers, No. 8, 67–95. Washington, DC: Smithsonian Institution.

Mühlbauer, Jeffrey. 2006. Pitch as accent in Plains Cree nominals. In *Actes du 37e congrès des algonquinistes*, ed. H.C. Wolfart, 229–268. Winnipeg: University of Manitoba.

Nagano-Madsen, Yasuko. 1995. Effect of accent and segmental contexts on the realization of vowel devoicing in Japanese. *Proceedings of the 13th International Congress of Phonetic Sciences* vol. 3, ed. Kjell Elenius and Peter Branderud, 564–567. Stockholm: KTH/Stockholm University.

Patterson, David, Paul C. LoCasto, and Cynthia M. Connine. 2003. Corpora analyses of frequency of schwa deletion in conversational American English. *Phonetica* 60:45–69.

Pentland, David H. 1979. Algonquian historical phonology. Doctoral dissertation, University of Toronto.

Price, Patti Jo. 1980. Sonority and syllabicity: Acoustic correlates of perception. *Phonetica* 37:327–343.

Rhodes, Richard A. 1976a. The morphosyntax of the Central Ojibwa verb. Doctoral dissertation, University of Michigan.

Rhodes, Richard A. 1976b. A preliminary report on the dialects of Eastern Ojibwe-Odawa. In *Papers of the 7th Algonquian Conference*, ed. William Cowan, 129–156. Ottawa: Carleton University.

Rhodes, Richard A. and Evelyn M. Todd. 1981. Subarctic Algonquian languages. In *Handbook of North American Indians*, vol. 6: *Subarctic*, ed. June Helm, 52–66. Washington, DC: Smithsonian Institution.

Salt, Luci, Elsie Duff, Marguerite MacKenzie, and Bill Jancewicz, ed. 2004. *Eastern James Bay Cree Dictionary, Northern Dialect: Cree–English*, vol. 1. Chisasibi, Quebec: Cree School Board. See www.eastcree.org for English–Cree version.

Sherwood, David F. 1983. Maliseet-Passamaquoddy verb morphology. Doctoral dissertation, Yale University.

van Son, Rob J.J.H. and Jan P.H. van Santen. 1997. Strong interaction between factors influencing consonant duration. In *Proceedings of Eurospeech'97*, vol. 1, ed. George Kokkinakis, Nikos Fakotakis, and Evangelos Dermatas, 319–322. International Speech Communication Association. Available at: http://www.isca-speech.org/archive/eurospeech_1997/e97_0319.html.

Strauss, Steven L. 1982. *Lexicalist phonology of English and German*. Dordrecht: Foris.

Teeter, Karl V. 1971. The main features of Malecite-Passamaquoddy grammar. In *University of California Publications in Linguistics*, vol. 65: *Studies in American Indian Languages*, ed. Jesse Sawyer, 191–249. Berkeley: University of Californian Press.

Umeda, Noriko. 1977. Consonant duration in American English. *Journal of the Acoustical Society of America* 61:846–868.

Urbancyzk, Suzanne. 2001. *Patterns of reduplication in Lushootseed*. New York: Garland.

Valentine, J. Randolph. 1996. Phonological parameters of Ojibwe dialect variation. In *Papers of the 27th Algonquian Conference*, ed. David H. Pentland, 287–323. Winnipeg: University of Manitoba Press.

Valentine, J. Randolph. 2001. *Nishnaabemwin reference grammar*. Toronto: University of Toronto Press.

Verluyten, S. Paul, ed. 1988. *La phonologie du schwa français*. Linguisticae Investigationes Supplement. Amsterdam: John Benjamins.

White, Laurence. 2002. English speech timing: A domain and locus approach. Doctoral dissertation, University of Edinburgh. Available at: http://www.cstr.ed.ac.uk/projects/eustace/dissertation.html.

Wolfart, H.C. 1996. Sketch of Cree, an Algonquian language. In *Handbook of North American Indians*, vol. 17: *Languages*, ed. Ives Goddard, 390–439. Washington DC: Smithsonian Institution.

Wolfart, H. Christoph and Janet F. Carroll. 1981. *Meet Cree: A guide to the Cree language*. 2nd ed. Edmonton: University of Alberta Press.

Zwicky, Arnold M. 1972. Note on a phonological hierarchy. In *Linguistic Change and Generative Theory*, ed. Robert P. Stockwell and Ronald K.S. Macaulay, 275–301. Bloomington: Indiana University Press.

A PRAAT MEASUREMENTS

A.1 Stops

Spectrogram settings:

View range (Hz): 0–5000
Window length (s): 0.005
Dynamic range (dB): 70.0

Measurements for stops began at the offset of the previous segment. A boundary was placed just before the loss of spectral energy, at the point where the waveform lost complexity and was flat or near-flat. Measurements ended after the noise burst, before the onset of the following segment. In the case of vowels and nasals, this was before formants began. In the case of fricatives, this was just before high spectral energy and large aperiodic waves. Two examples are provided below, the first in a CVC sequence (figure A-1), and the second in a consonant cluster (figure A-2).

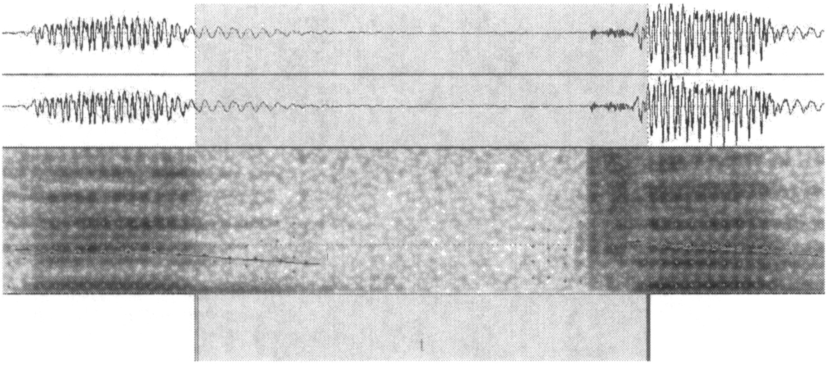

Figure A-1: Measuring [t] in a CVC sequence in the word *atipis* [atips].

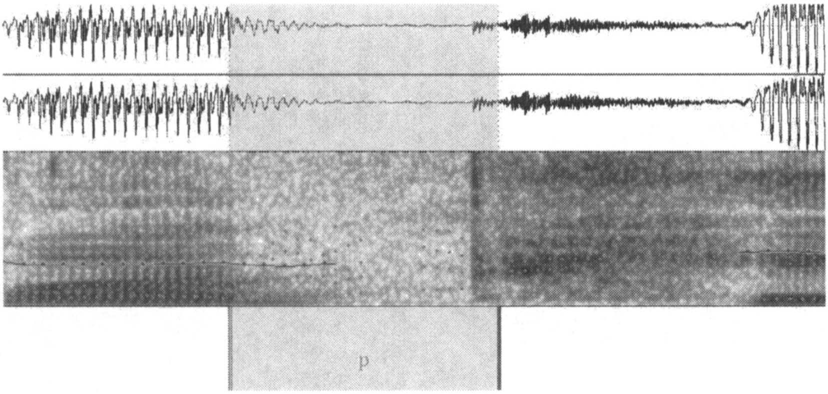

Figure A-2: Measuring [p] in a consonant cluster in the word *wâpihîkin* [waːphiːgin].

A.2 Nasals

Spectrogram settings:

View range (Hz): 0–5000
Window length (s): 0.005
Dynamic range (dB): 70.0

Measurements for nasals began at the offset of the previous segment, marked by a change in or appearance of formant structure. A nasal band can be found in the spectrograms in figures A-3 and A-4. Measurements ended based on similar cues.

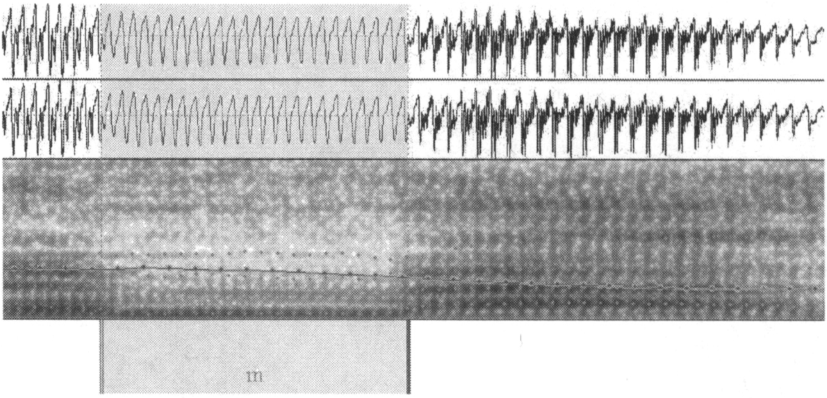

Figure A-3: Measuring [m] in a CVC sequence in the word *nimâs* [nimaːs].

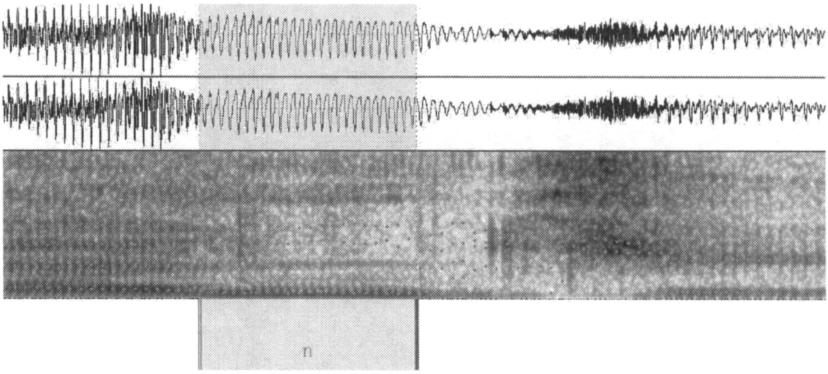

Figure A-4: Measuring [n] in a consonant cluster in the word *kânichî* [kaːntʃiː].

A.3 Fricatives

Spectrogram settings:

View range (Hz): 0 - 15000

Window length (s): 0.005

Dynamic range (dB): 70.0

Measurements for fricatives began at the onset of high frequency spectral energy and aperiodicity in waveform. In the case of fricatives following stops, the measurement began after the noise burst. The measurement ended when the high spectral energy ended and the waveform became periodic (nasal or a vowel) or flat (stop). A common consonant cluster was [ʃʃ]. In this case, as it was impossible to tell where C_1 ended and C_2 began, the full consonant cluster was measured and both C_1 and C_2 were considered to be half the length of the consonant cluster. Three figures are provided: (A-5) contains [ʃ] in a CVC sequence, (A-6) contains [ʃ] followed by a non-identical consonant, and (A-7) contains [ʃ] followed by [ʃ].

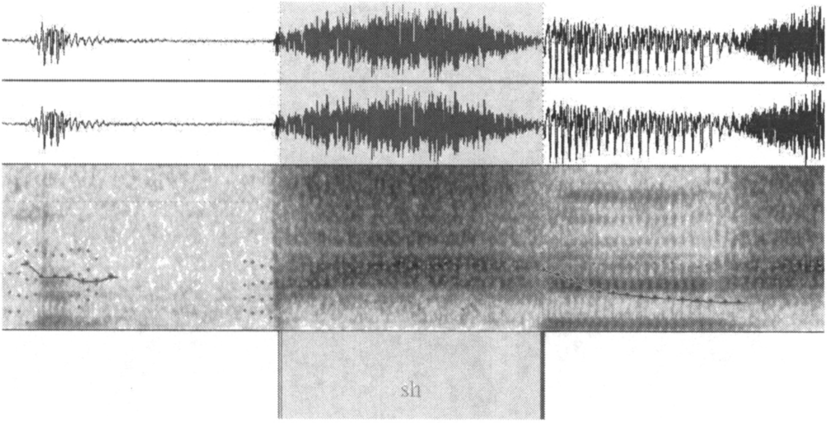

Figure A-5: Measuring [ʃ] in a CVC sequence in the word *apishîsh* [apʃiːʃ].

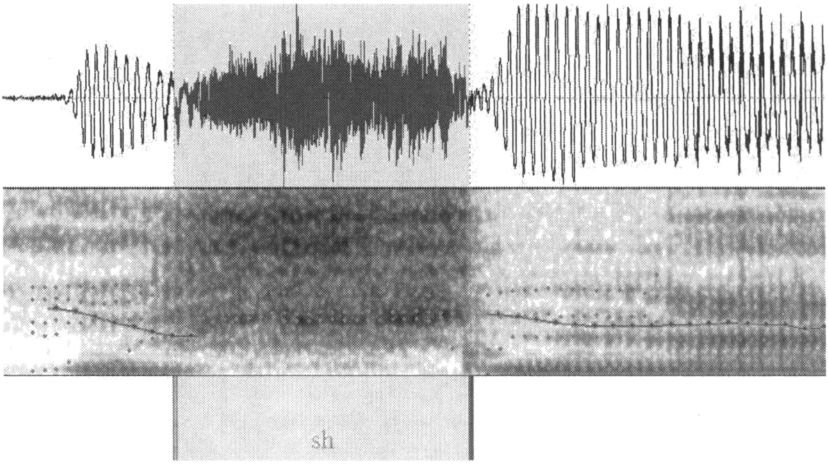

Figure A-6: Measuring [ʃ] in a consonant cluster in the word *ishinâkukupinâ* [iʃna:kukupina:].

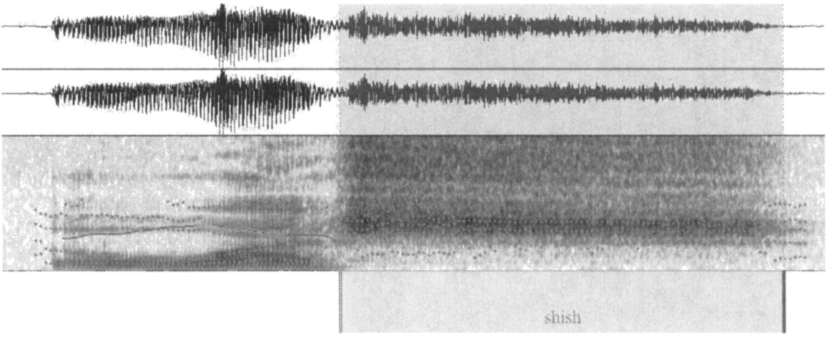

Figure A-7: Measuring [ʃ] in a consonant cluster in the word *awâshish* [awa:ʃʃ].