Vowel spaces in Plains Cree

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This paper presents a pilot study of the acoustic correlates of the Plains Cree vowel system. Naturalistic recordings of speakers of mid-20th-century Plains Cree, including one monolingual speaker, provide an empirical test for the general expectations from phonological descriptions. The results demonstrate that, while the hypothesized short/long vowel pairs do indeed have a strong durational contrast, the majority of vowel pairs are also distinguished by their formants. In all cases, the long vowel occupies a more extreme position in the vowel space. Plains Cree thus appears to show both a quantity and a quality contrast in its vowel pairs. The individual speaker data are then normalized to test whether there is intra-speaker variation in these results, with the results showing variation in the relation between vowels in all three parts of the vowel space.

1 Introduction

Plains Cree is an Algonquian language originally spoken in the Northern halves of Alberta and Saskatchewan. It is the westernmost dialect group of a language family, called ‘Cree’ by English speakers, that extends from the Rocky Mountains to Labrador, with languages being distinguishable from each other by morphology, lexical items, phonotactics, syntax, and the shape of a specific Algonquian consonant (*l), which appears as [j] in Plains Cree but [n], [r], [l] or [ð] in other Cree languages.[1] Within this continuum of languages, mutual intelligibility breaks down rather fast, with a boundary for absolute unintelligibility being identifiable around the Manitoba–Ontario border (Wolfart 1973), although speakers from different communities within ‘Plains Cree’ show significant intelligibility issues as well – particularly in terms of speech rate and related morphophonological processes (Wolfart 1973, Cook 2006). In some ways, Plains Cree is the most divergent member of this group, relying far more on complex syntactic constructions, and far less on verbal morphology, than its more eastern relatives.[2]

[1] I avoid the use of the term ‘dialect’ for the Cree language family because it implies a formal similarity that is not present. In terms of their structure, morphology, syntax and semantics, Cree languages differ so significantly that western speakers cannot confidently identify eastern varieties as related languages, and linguists that work on one language cannot directly transfer models to another. Referring to ‘Cree’ as a ‘dialect group’ is, from a linguistic point of view, analogous to referring to ‘Romance’ as a ‘dialect group’.

[2] In the Plains Cree context, the concept of ‘fluent speakers’ is often collapsed with cultural affiliation (Wolfart 1973: 10), which results in simultaneously over-reporting speakers in ‘status’ (i.e. treaty-granted) communities and under-reporting speakers in Métis (non-treaty) areas. Realistic estimates for Plains Cree

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Table 1 The Plains Cree vowel space.

	Front	Mid	Back
High	î, i		ô, o
Mid	ê		
Low		â, a	

Plains Cree is usually described as having three pairs of phonemic vowels that contrast in 'length' or 'quantity' (Bloomfield 1930, Longacre 1957, Wolfart 1973, Pentland 1979), which is marked by the circumflex in the orthography. One additional vowel, *ê*, shows no contrast.[3] This system is typically schematized as seen in Table 1, giving the orthographic representation for each phoneme. There are also a number of diphthongs (*ay*, *aw*, *âw*, *ây*, *oy*, *êw* and *îw*), but these are conceived of as combinations of the more basic phonemes.

As is clear by the 'long/short' terminology, the standard portrait of Plains Cree phonology (e.g. Bloomfield 1930, 1946; Wolfart 1973) suggests that these two sets of vowels are distinguished on the basis of their duration. The vowels termed 'long' are taken to have duration longer than the vowels termed 'short' What is more, this is thought to be the only relevant difference between the long and the short forms of the vowels, with the quality of the vowel remaining the same between the pairs. Typically, then, the vowels are conceived of as having the phonetic values as in Table 2. This would mean that Plains Cree would be placed typologically among languages such as Norwegian (Behne, Moxness & Nyland 1996) and other systems that distinguish vowels on the basis of duration.

Table 2 Phonetic values expected in Plains Cree.

	Front	Mid	Back
High	î /iː/, i /i/		ô /uː/, o /u/
Mid	ê /eː/		
Low		â /aː/, a /a/	

The contrast between 'long' and 'short' vowels appears to be grammatically relevant. Vowels of the short class (*i*, *a* and *o*) will delete when in internal sandhi (i.e. inside of a word) with vowels of the long class (*î*, *ê*, *â* and *ô*), while two vowels of the long class will employ glide epenthesis (Wolfart 1973). Hence, we find pairs like those shown in (1), where the root *wayawî-*, ending in a long vowel *î* is conjoined with either the suffix *-âmo-* or the suffix *-akot-*, which differ in terms of the length of the vowel.

(1) a. wayawî- 'outside' + -âmo- 'flee' = wayawîyâmo- 'flee outside'
b. wayawî- 'outside' + -akot- 'fly' = wayawîkot- 'fly outside'

Thus we see that there are language-internal reasons to suppose that the Plains Cree vowel space is divided into two classes.

This organization, wherein vowel pairs are distinguished purely in terms of duration, differs from that described for the more eastern Cree languages. Early phonetic work done by Marin, Grenier, Martel & Thibaudeau (1977) found that vowel quality played a more significant role in Montagnais than had been expected, and MacKenzie (1980) transcribes the

place the number of fluent speakers at somewhere around 15,000 at present, down from the rough estimate of 20,000 made by Wolfart (1973).

[3] The orthography used here is the standard Plains Cree orthography employed by all published texts and dictionaries. Some sources, such as Wolvengrey (2001), employ a macron instead of a circumflex to denote 'length', but are identical in all other respects. Orthographic representations are almost exclusively phonemic, with only sporadic recognition of phonetic variation.

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long and short vowels of the Eastern varieties with different vowel qualities (e.g. [a] for *â* and [ə] for *a*). More recent phonetic work by Dyck, Junker & Logan (2009) underscores this quality distinction, and the consensus appears to be that the Eastern Cree languages employ vowel quality distinctions much more robustly than the canonical descriptions would lead us to expect. This being the case for the Eastern languages, we should not treat the purely durational analysis of Plains Cree as a foregone conclusion.

Unfortunately, there is, as yet, no phonetic study to test the durational analysis of Plains Cree. This is because, unlike the more eastern Cree languages, there is currently no descriptive phonetic work on the Plains Cree vowel space or what the acoustic correlates of the contrast implicated by the morphophonology might be. Instead, the space is constructed via a combination of diachronic evidence and the ear of the linguist (see Lacombe 1874, Bloomfield 1930, Pentland 1979). For Algonquian linguistics, this is part of a much broader descriptive challenge; in almost all areas, basic descriptive work on the phonetics of Plains Cree is severely lacking, with only three recent papers having been devoted to the topic (Cook 2006, Muehlbauer 2006, Russell 2008), as well as some work in related languages (e.g. Dyck et al. 2009). This encompasses a 140-year history of grammatical work on the language (e.g. Lacombe 1874, Bloomfield 1930, Edwards 1954, Wolfart 1973, Dahlstrom 1986, Ahenakew 1987, Blain 1997, Hirose 2000, Cook 2008, Muehlbauer 2008, and others), which has tended to focus on the morphology to the exclusion of most other domains of the grammar.

This paper offers an analysis of the vowel system of Plains Cree, employing acoustic data from three female speakers born in the first decades of the 20th century. Using acoustic measurements of token instances of the Plains Cree phonemes, I construct the vowel space of these three speakers and then ask whether the only difference in these vowel pairs is duration. As it turns out, the data show that vowel quality is an important aspect of the system. Duration, while being a systematic and robust cue to vowel differences, is not the only acoustic cue available, with every vowel pair also being different in height (F1) or backness (F2), or both. This results in the phonetic representation as seen in Table 3.

Table 3 Phonetic values found in Plains Cree.

	Front	Mid	Back
High	î /iː/, i /ɪ/		ô /uː/, o /ʊ/
Mid	ê /eː/		
Low		â /aː/, a /ə/	

The picture of the Plains Cree vowel system, then, is more like eastern Cree languages and less like a system based on durational contrast (e.g. Norwegian) than we would expect were the implications of the canonical descriptions correct.

2 Methodology

In this work, I employ naturalistic data collected by native speakers of the language under investigation in monolingual conversational contexts, rather than laboratory data. This has the advantage of not introducing artifacts of the elicitation environment (see Cook 2006, Muehlbauer 2006); there is no priming from English or from the data presentation and no alteration in intonation caused by repetition. It has the disadvantage of limiting our investigation to what is available in the corpus; we cannot construct experimental contexts to test all possible interactions, and we cannot control the recording environment for ideal acoustics. It would be best, then, if the current pilot study became the first of several acoustic studies; in subsequent studies, where we already have a picture of what the older generations used in naturalistic situations, we could be confident of what our laboratory results indicated.

In collecting data, I chose recordings of speakers born in the early 20th century (1907–1919). Since the language is highly endangered, with most communities having only a small number of fluent speakers and often none under the age of sixty, there are essentially no living speakers that have not been fluently bilingual with English for many years (most since childhood), and the use of Plains Cree is highly restricted in the daily life of most speakers. This raises issues of cross-language interactions, and the results are difficult to predict without information on varieties of Plains Cree that do not have English input. By employing recordings from speakers in older generations that are now gone, we attempt to reduce English interference, hopefully gaining a better picture of what the Plains Cree system was like before contact with English reached its current extent. Further, one of the recordings considered here is of the last documented monolingual speaker of the language, who was raised well outside the English-speaking world.[4] This ensures a data set as free from potential linguistic interference as possible.

2.1 Data collection and analysis

The recordings used in this study were mostly made by Freda Ahenakew, herself a native speaker of Plains Cree, and by H. C. Wolfart, in the late 1980s and early 1990s. They were made using a standard tabletop microphone and tape recorder, and were conducted either in the home of the speakers or in public meeting areas. These recordings have been turned into a number of published volumes (Whitecalf 1993, Minde 1997, Ahenakew 2000). Both the interviewer and the speaker speak the language as their first, in some cases only, language, and the interviews were conducted entirely in the language.

Because of differences in fundamental frequency between males and females, I controlled for gender when selecting speakers. Since more recordings were available of women, and from a wider range of speech communities, only recordings of female speakers were used in this study. There are some hints at gender differences in Plains Cree speech, particularly in the case of palatalization (Wolfart 1973), but nothing to indicate a significantly different phonetic system. This sample includes central Alberta and central Saskatchewan, but leaves gaps in Northern Alberta and Northern Saskatchewan, since recordings were not easily available for these regions.

Vowel tokens for analysis were selected on the basis of specific categorizational criteria. First, tokens were grouped together by the phoneme they were hypothesized to represent. This may, in theory, be the wrong way to group tokens, since there may be significant allophonic variation across contexts, as has been shown for eastern Cree languages (MacKenzie 1980, Dyck et al. 2009). To try to eliminate some of this potential confound, I also controlled the environment of the phoneme's occurrence, limiting all tokens to instances that occur between the phonemes /k/ and /t/, which is a common segmental sequence in the language. This reduced the potential interference of coarticulation effects, since all vowels now occur in the same segmental context. As a second criterion, all tokens in words that are, in some dialects, known to alternate between *î* and *ê* were discarded (e.g. *kîtahtawê*/*kêtahtawê*; see Bloomfield 1930, and others). This is particularly important in the case of Alice Ahenakew from Sturgeon Lake, who shows this alternation sporadically throughout her speech, as the examples in (2) indicate.

[4] Wolfart (p.c.), who spent extensive time with this speaker, affirms that she did not speak more than a few words of English.

(2) a. . . . n**î**tê . . .

nê=	it=	-ê
DEICTIC=	LOC=	-DISTAL

‘over there’ (Ahenakew 2000: Section 1.1)

b. . . . n**ê**tê . . .

nê=	it=	-ê
DEICTIC=	LOC=	-DISTAL

‘over there’ (Ahenakew 2000: Section 1.3)

This alternation is one of the few phonetic alternations that is orthographically represented and is indicative of Sturgeon Lake and surrounding areas (Wolfart p.c.).

To collect measurements of these tokens, the cassette tapes were first digitized at a sampling rate of 22 kHz without using voice compression, and these digitized .wav files were analyzed using Praat (Boersma & Weenink 2009.). In collecting formant values, measurements of F1 and F2 were made for every 1 ms interval across the largest steady state available, for an average of 8 measurements for 75% of the vowel, and these measurements were then averaged. Because of the high-level noise in the older tape recordings, F3 was not available in nearly half of the cases, and was very erratically tracked by Praat in most of the rest of the cases. Measurements to three decimal places were entered into a spreadsheet in tab-delimited format. These data were then averaged, plotted within the NORM vowel normalization suite (Thomas & Kendall 2007), and standard deviation was also calculated, which is given in the tables of data. In addition, duration was recorded in Praat for each vowel token, and is presented here in milliseconds.

For intra-vowel comparison, two-tailed paired *t*-tests were used for each speaker’s set of long/short pairs. To do a paired *t*-test, we have to use an equal number of tokens for the two conditions (long and short), meaning that a condition with more tokens will necessarily have a few removed. For example, if *a* has 17 tokens while *â* has 22, we must remove five from *â*. To understand why a paired *t*-test is the most appropriate here, recall that the operating assumption in these phonemic groupings into long and short is that the two sets represent the ‘same’ vowel acoustically, differing only along one dimension – duration. Hence, we expect that, in the two different conditions (i.e. production of long and short), all other acoustic properties, particularly formant frequency, are the same. Since we have controlled for context (i.e. all vowels are produced in the /kVt/ sequence), and we are comparing two conditions of the same speaker, a paired *t*-test will tell us whether or not the groupings are indeed the same or different in their formant values. This follows other acoustic work done on vowel systems of languages that are hypothesized to distinguish duration, such as Chickasaw (Gordon, Munro & Ladefoged 2000).

Comparing different speakers accurately is not a simple task, because speakers do not all share identical physiology. Hence, comparing one speaker’s vowel space to another’s is not a simple matter of overlaying charts. Larger vocal tracts, higher-pitched voices, and differently shaped articulators all have an impact on the acoustic signal, and thus must be considered in any comparison. For example, in this study, the Saddle Lake speaker has a much higher-pitched voice than the others, and, since formants are a function of F0 (pitch), her vowel space will appear higher in a way that is not thought to be linguistically relevant. Without some way to factor out these differences, we cannot be sure how much of the vowel space differences are actually perceptually and linguistically relevant. There are several mathematical models designed to filter out these differences. For this study, I have chosen the Lobanov method (Lobanov 1971, Nearey 1977, Adank, Smits & van Hout 2004), due to its comparative performance (Adank et al. 2004) and the lack of reliance on F3, which is unreliable in these recordings.

3 The vowel spaces

When we match the proposed phonemic vowels to their surface exponents for the speakers I have studied, we find that the phonemic representations are reliably correlated with phonetic values, such that a coherent vowel space emerges for each speaker. Considering these vowel spaces, a series of generalizations emerges. Every vowel pair is strongly differentiated by duration, for every speaker, confirming the observations in earlier linguistic work on Plains Cree. However, with only one exception, every vowel pair is also differentiated by at least one quality cue – either height (F1) or backness (F2). In the case of *a*/*â*, both cues are present for two of the three speakers, making the vowels completely distinct in their qualities. Thus, quality and duration work together in Plains Cree to distinguish the so-called long and short vowels of the system.

In the following sections, I consider the data from each speaker, beginning with the simpler cases of Emma Minde and Sarah Whitecalf before turning to the more complex case shown by Alice Ahenakew. For each speaker, I first present the full data set, plot the vowels on an x/y axis, and then test the data for statistical significance.

3.1 The vowel space of Emma Minde, Saddle Lake

The first speaker represented in this study, named Emma Minde, was born in 1907 at Saddle Lake, in west-central Alberta. She lived most of her adult life in the Hobbema, Alberta, area (at the extreme southern edge of the Plains Cree range), having married a man from there. She died several years ago. Modern Hobbema speakers claim that Saddle Lake is a different dialect and identify this speaker as exemplifying it. Thus, I will treat her as representative of Saddle Lake speech and not Hobbema. Acoustically, Emma Minde is remarkable for her extremely measured speech rate and quiet voice (see Cook 2006).

The vowel space of Emma Minde, shown in Table 4, appears to be exactly what the linguistic descriptions expect in terms of spatial relation and position. Note that, as expected, *ê* patterns with the long vowels in terms of duration. Values for F1 (Hz), F2 (Hz), and duration (seconds) are means; standard deviations (SDs) are given in separate columns. Plotting these vowels on an x/y axis (see Figure 1) yields a vowel space much like the one schematized in Table 1 above for Plains Cree.[5]

Using paired *t*-tests on the long/short pairs, some interesting generalizations emerge. In Table 5, the ✔ indicates a significant difference, while ✘ indicates that there was no significant difference in the value tested.

In general, Emma Minde has the most robust quality contrasts of all the speakers. First, we see that all long vowels are significantly longer in duration than the short counterparts, with all long/short pairs tested yielding a *p*-value of less than .0001. Secondly, we see that every single long/short pair has at least one significant difference in formants (i.e. a quality difference). For *î*/*i*, the difference is height, with *i* being higher than *î*, while for *ô*/*o*, the difference is in backness, with *ô* being farther back than *o*. Strikingly, the pair *â*/*a* differs significantly in both formants. In all cases, the short vowel is more central to the vowel space than the long vowel.

3.2 The vowel space of Sarah Whitecalf, Greater Sweetgrass

The second recording I analyse was made of a woman born in 1919 at *môsômininêw-âskîhkânihk*, northwest of Battleford, Saskatchewan, named Sarah Whitecalf (Wolfart 1993). The group of Cree people that she comes from are sometimes called the *sîpîwiyiniwa*k ‘river

[5] The long vowels in the graph are doubled, using the Ojibwa/Blackfoot orthography, rather than marked with circumflexes, because the graphing program does not accept circumflexes.

Table 4 Emma Minde's vowels.

Vowel	N	F1	SD	F2	SD	Duration	SD
a	26	638.43	46.38	1705.40	118.64	0.045	0.011
â	27	709.02	34.64	1605.77	65.56	0.099	0.014
o	25	511.77	40.88	1287.026	89.98	0.042	0.009
ô	26	512.321	32.72	1173.092	81.12	0.097	0.015
i	11	460.299	40.55	2024.481	178.28	0.039	0.008
î	23	390.644	24.43	2330.721	201.09	0.072	0.017
ê	25	475.788	20.31	2088.006	92.199	0.080	0.0149

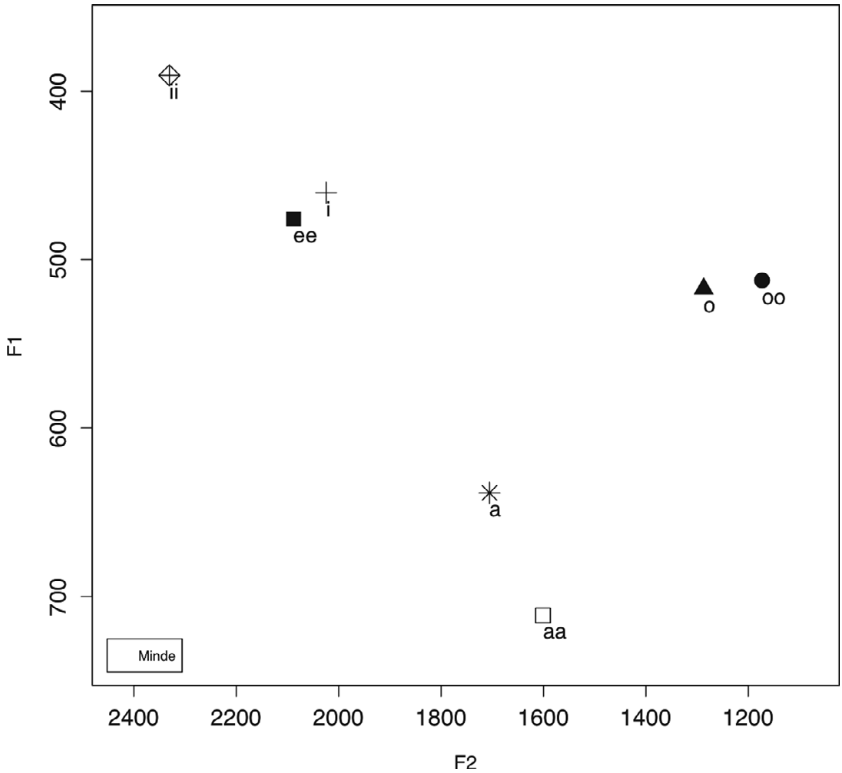

Figure 1 Emma Minde's vowel space.

Table 5 Statistics from Emma Minde's vowels.

Vowel	F1	F2	Duration
i/î	✔ $p = .0003$	✘ $p = .0640$	✔ $p < .0001$
a/â	✔ $p < .0001$	✔ $p = .0002$	✔ $p < .0001$
o/ô	✘ $p = .9668$	✔ $p = .0005$	✔ $p < .0001$

people' (Mandelbaum 1940, Wolfart 1993), and the area will be called 'Greater Sweetgrass' for this study (see Wolfart 1993). Sarah Whitecalf was the last documented monolingual speaker of Plains Cree, having never learned English because she was kept out of the residential schools and raised in the bush. In these recordings, audience members who ask questions in English require translation for her to understand them.

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As seen in Table 6, the vowel space of Sarah Whitecalf roughly approximates the system of the Saddle Lake speaker, Emma Minde. Again, the vowel *ê* groups with the 'long' vowels, rather than the 'short' ones. Plotting the formant values on an x/y axis yields the vowel space shown in Figure 2. The crucial contrasts for vowel pairs appear to be duration, backness, and (in one case) height.

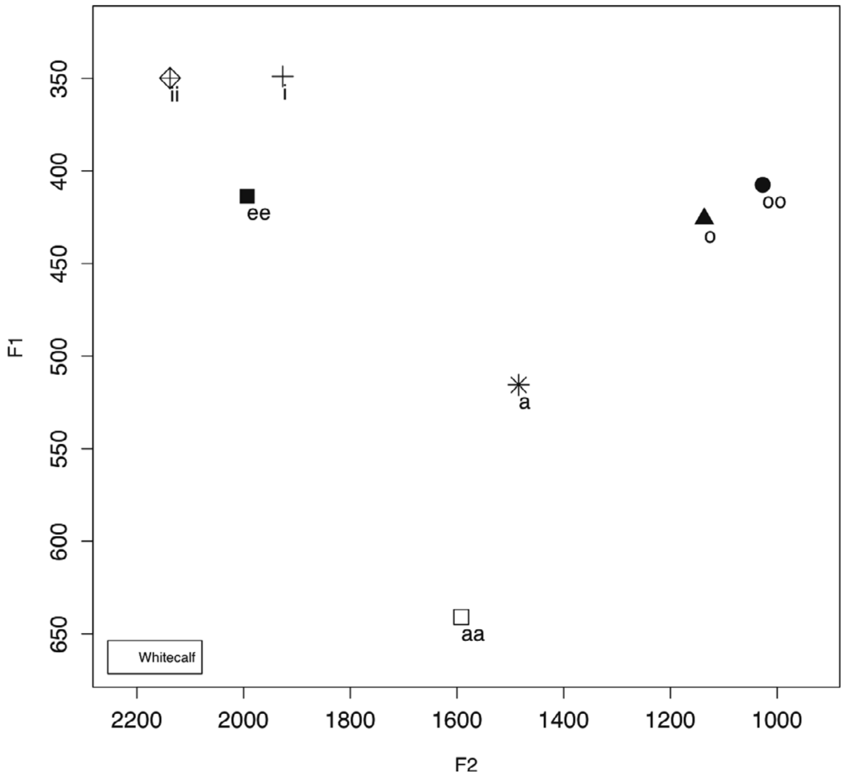

Figure 2 Sarah Whitecalf's vowel space.

Table 6 Sarah Whitecalf's vowels.

Vowel	N	F1	SD	F2	SD	Duration	SD
a	9	515.518	62.07	1484.492	197.02	0.045	0.018
â	10	640.873	27.15	1592.042	49.60	0.099	0.023
o	15	425.832	31.53	1136.728	150.398	0.036	0.021
ô	15	407.436	29.078	1027.216	92.96	0.080	0.013
i	14	348.883	36.197	1926.728	175.76	0.032	0.014
î	13	349.806	33.76	2137.926	224.26	0.109	0.021
ê	8	413.642	53.41	1993.269	153.45	0.098	0.024

Once again, we can see the statistical significance of this data set by using paired *t*-tests (Table 7).

Much like in the case of Emma Minde, all long/short vowel pairs are strongly distinguished by duration, but the quality contrasts are weaker – though still significant. In addition, every long/short pair is also distinguished by at least one formant, with the mid vowel pair *a/â* being distinguished in height and the two high vowel pairs *i/î* and *o/ô* being distinguished in

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Table 7 Statistics on Sarah Whitecalf's vowels.

Vowel	F1	F2	Duration
i/î	✘ $p = .9954$	✔ $p = .0309$	✔ $p < .0001$
a/â	✔ $p = .0006$	✘ $p = .1505$	✔ $p = .0007$
o/ô	✘ $p = .1545$	✔ $p = .0250$	✔ $p < .0001$

backness. Different from the other two speakers, *â* and *a* are only distinguished in height, not backness. Again, all 'short' vowels are more centralized than their 'long' counterparts.

3.3 The vowel space of Alice Ahenakew, Prince Albert

The third recording I used for data collection is of a speaker named Alice Ahenakew, who was born in 1912 and raised by adoptive grandparents at Sturgeon Lake, Saskatchewan. She married into the important Ahenakew family from Sandy Lake and travelled widely across Plains Cree territory with her husband. Her speech is extremely fast and dynamic (see Cook 2006), and she alternates between the /e/ and /i/ pattern discussed in (2) above.

As can be seen in Table 8, Alice Ahenakew's vowel space shows little differentiation in the high/front vowels, as well as the greatest variation in their production. Plotting these vowels on an x/y axis (Figure 3, next page) yields a vowel space much like Emma Minde's, but with more condensing in the high/front area.

Table 8 Alice Ahenakew's vowels.

Vowel	N	F1	SD	F2	SD	Duration	SD
a	25	696.856	58.73	1709.73	104.22	0.061	0.083
â	27	778.255	54.75	1565.84	94.62	0.107	0.020
o	35	554.431	52.84	1312.25	172.04	0.037	0.012
ô	17	529.29	34.22	1279.748	119.73	0.066	0.011
i	11	439.744	46.79	2258.68	119.24	0.034	0.009
î	17	415.963	34.99	2252.98	249.02	0.079	0.024
ê	33	474.088	47.04	2167.19	312.29	0.098	0.022

Looking more closely at the high/front vowels *ê* and *î*, we see that *ê* has a large F2 variation (>300 Hz), which translates to the frontness/backness of the vowel. This is higher than that found in other vowels and the high/front vowels of other speakers, as can be seen by comparing data sets. However, I can find no phonological context to condition this variation; vowels with widely different F2 values appear to occur freely in the same morphemes, in the same positions in words, and with the same pitch accents.

I again used paired *t*-tests on the 'long/short' pairs, which produced the data shown in Table 9 below. As can be seen, Alice Ahenakew has the same durational contrast between 'long' and 'short' vowels as the other two speakers, but the weakest quality contrast. As is evident, the long/short pair members *î*/*i* are only differentiated in duration, while all the other vowels are differentiated, minimally, by at least one quality cue as well as duration. As with Emma Minde, the pair members *â*/*a* are completely distinct in all values. All 'short' vowels are again more central than their 'long' vowel counterparts.

3.4 Summarizing the data

All descriptions of the Plains Cree vowel system have a 'long' and 'short' contrast (e.g. Longacre 1957, Wolfart 1973, Pentland 1979). In phonetic terms, this translates into 'duration' (Ladefoged 2005). In this pilot study, we have indeed found that duration is a strong contrast in the two sets of vowels, with every contrast being extremely statistically significant,

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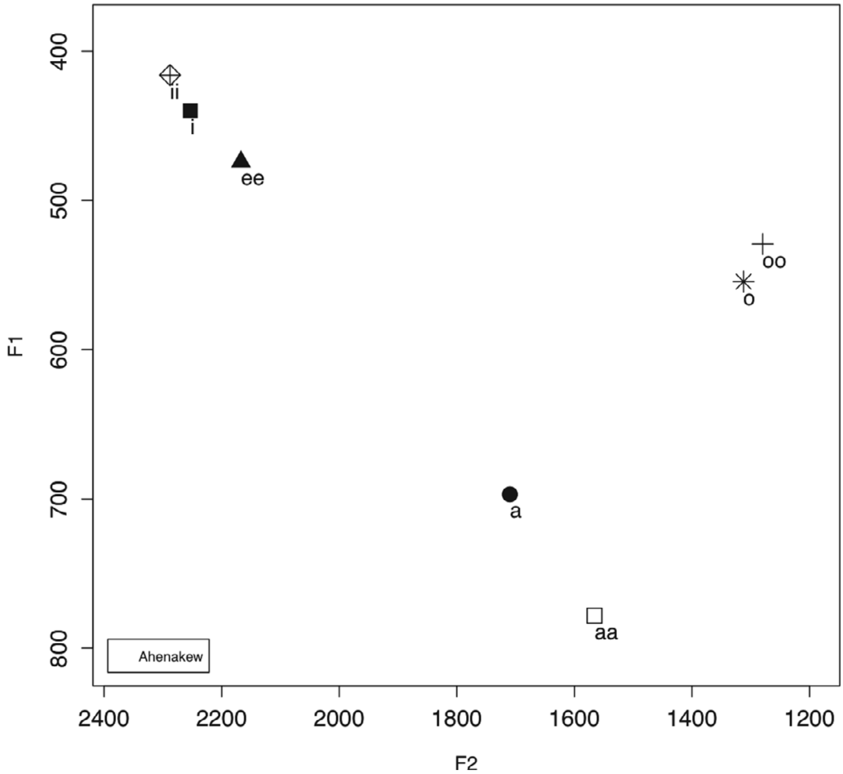

Figure 3 Alice Ahenakew's vowel space.

Table 9 Statistics on Alice Ahenakew's vowels.

Vowel	F1	F2	Duration
i/î	✘ $p = .0606$	✘ $p = .7980$	✔ $p = .0006$
a/â	✔ $p < .0001$	✔ $p < .0001$	✔ $p = .0200$
o/ô	✔ $p = .0372$	✘ $p = .2961$	✔ $p < .0001$

see Table 10. It is probably safe to conclude, then, that the Plains Cree spoken by these women uses robust durational distinctions.

Table 10 Durational averages for all speakers (in seconds).

Speaker	î	i	ê	â	a	ô	o
Minde	0.072	0.039	0.080	0.099	0.045	0.097	0.042
Whitecalf	0.109	0.032	0.098	0.099	0.045	0.080	0.036
Ahenakew	0.079	0.034	0.094	0.107	0.061	0.066	0.037

This is not the whole story, however. With the exception of Alice Ahenakew's *i/î* contrast, every single vowel pair also has, at minimum, one quality contrast as well. In some cases, pairs of vowels contrast in both F1 and F2 (e.g. *a/â* for Ahenakew and Minde). Further, all cases of long/short pairs put the long vowel on the perimeter of the vowel space. The 'long' vowels exist at the edges of the articulatory space, while the 'short' vowels are always more centralized. What this observation means in terms of articulatory phonetics and phonology is

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better left to subsequent research, but it is relevant in light of similar findings for Chickasaw (Gordon et al. 2000).

These significant formant contrasts mean that, although duration is a reliable cue to vowel differences, quality is equally reliable. The traditional account of the Plains Cree vowel space, by focusing exclusively on duration, misses a crucial aspect of the vowel system, and future descriptions must include vowel quality as a relevant contrast.

3.5 Alice Ahenakew's durational system

In general, Alice Ahenakew employs much more variation in duration than either Minde or Whitecalf (see Cook 2006). In particular, the mid vowel *a* stands out. It has a standard deviation of 83 ms – greater than the mean value of the vowel (61 ms) – while the other vowels all have a standard deviation of between a third and a fifth of the vowel's mean duration value. The longest of the *a* tokens is as long as the shortest of the *â* tokens – a situation that is not mirrored in any other vowels in this speaker's inventory, or any other's. Interestingly, this is also the vowel pair that shows a complete contrast in quality. It may be, then, that a robust quality contrast in a system that otherwise shows little contrast allows duration to vary more freely, since it is not as crucial a cue. Hence, it may be that Alice Ahenakew here shows a trading relation between duration and quality, where the speakers employ the same duration/quality logic across the board.

Since Emma Minde shows the same quality contrast in *a/â* that Alice Ahenakew does, and yet does not show this durational variation, the two speakers make an important contrast. Surveying the contexts of occurrence for the two speakers' tokens of *a*, we find that they are in the same morphological and phonological contexts – all come from roots or early syllables in words. Hence, the two data sets appear to be equivalent, and yet there is strong variation in *a* for Ahenakew but not for Minde. As Cook (2006) has shown, one difference between the two is their general pattern of durational variation; Emma Minde speaks in a very level, steady voice, which does not show much durational dynamicity, whereas Alice Ahenakew shows great dynamicity. On the basis of the evidence from its standard deviation, we could understand one of the loci of this dynamicity to be the duration of *a*. Because this vowel qualitatively differs from *â* so clearly, Alice Ahenakew is free to manipulate duration to increase her dynamicity without sacrificing any phonemic contrasts. Hence, the greater variation in duration that has been documented for Alice Ahenakew (see Cook 2006) may be a result of her greater freedom to manipulate *a*/*â*.

A further durational issue arises for Alice Ahenakew's data when we see that *ê* and *î* also differ in length, with *ê* being significantly longer. This can be seen using an unpaired *t*-test on these vowels, in Table 11.

Table 11 Statistics on vowel duration.

Speaker	î Duration	ê Duration	*p*-value
Minde	0.072	0.080	✘ $p = .0754$
Whitecalf	0.109	0.098	✘ $p = .3129$
Ahenakew	0.079	0.094	✔ $p = .0096$

Alice Ahenakew is the only speaker that appears to have a length distinction here, among the three speakers tested. Checking where the *ê* tokens appear in the word, 31 tokens appear in the final syllable, while only two do not. In contrast, 15 of the *î* tokens appear in non-final position, with only two appearing in the final syllable. This is because, in the context /kVt/, the most common occurrence for *ê* is in the animate intransitive verb finals *-ikê-* and *-ê-*, with third person pronominal affixes (e.g. *ê-atoskêt* 'he works'). The two examples of *î* in final position both show a durational value equivalent to the 94 ms mean of *ê* (98 ms and 100 ms), which is much higher than the mean for *î* (79 ms). For comparison, only 50% of Sarah

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Whitecalf's *ê* tokens are word-final, and none of her *î* tokens are. However, all but one of Emma Minde's *ê* tokens are in word-final position (and in the same morphemes), and none of her *î* tokens are, meaning that her data set matches Alice Ahenakew's and yet does not show this durational contrast. While this may point to Alice Ahenakew again employing durational variation where other speakers do not, her other long vowels do not show a word-final pattern; *â* does not differ significantly between word-final and non-final contexts (paired *t*-test *p*-value of .73). Thus, if there is a word-final lengthening effect for Alice Ahenakew, it would appear to involve some vowels (e.g. high/front), but not others. This issue demands further research, falling beyond the scope of the current pilot study.

4 Comparing vowel spaces

Aside from the descriptive gap in the phonetics of the vowel system, there are other reasons to suppose that phonetic studies may yield important data for the study of Plains Cree. Plains Cree covers one of the largest territories of any language in North America, and speakers from different areas are typically quite isolated from one another. It is not surprising, then, that fieldworkers and speakers alike have noticed for some time that there is a fair amount of variation within what is conventionally called 'Plains Cree' (*nêhiyawêwin* to speakers). MacKenzie (1980) identifies significant inter-speaker variation for vowel production in Eastern Cree and suggests that it be a primary target for phonetic work on the Cree languages. Hence, any study of vowel spaces in Plains Cree ought to simultaneously be a study of inter-speaker variation.

Using the Lobanov method on these data sets produced the non-scaled results shown in Figure 4. Because it is not scaled, vowels are represented not in terms of Hertz, but in terms of standard deviations from the mean.

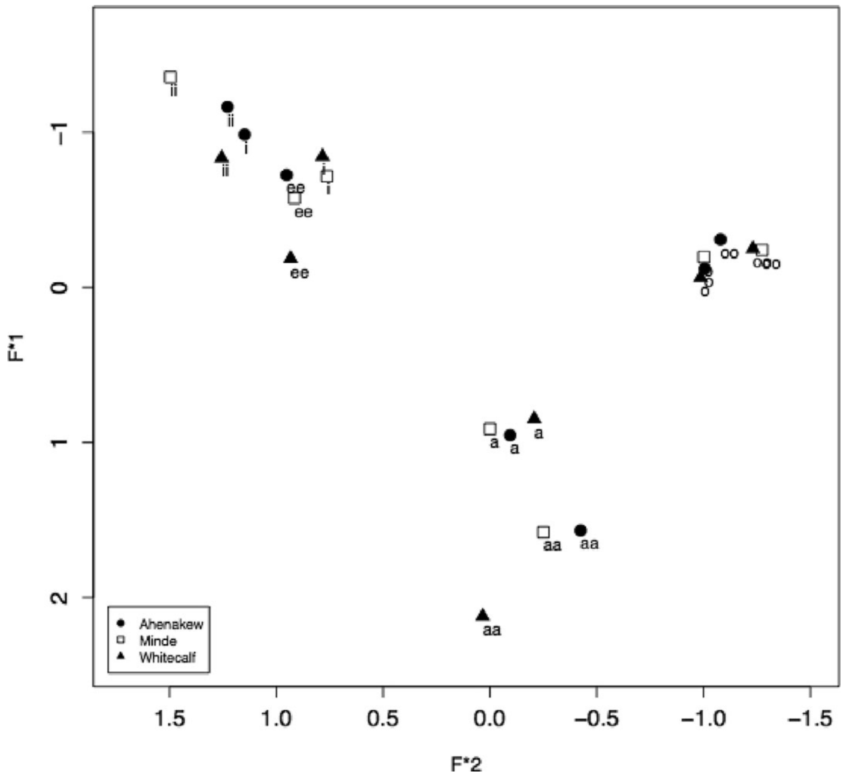

Figure 4 Normalized vowel spaces.

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In terms of what is shared, *a*, *ô* and *o* occupy a very similar space for the three speakers. Ahenakew and Minde share both *ê* and *â*, while Minde and Whitecalf share *i* and Ahenakew and Whitecalf share *î*. The vowel â stands out for Whitecalf, being lower and more central than the other two. Whitecalf's *ê* is also lower, while Minde's *î* and Whitecalf's *i* are higher and farther forward than the others. In terms of the way the vowel pairs relate, Minde distinguishes *o* and *ô* by backness, whereas the other two speakers have more height differentiation. Whitecalf's *î* and *i* are also distinguished primarily by backness rather than height. These differences may be perceptually relevant to speakers, and could implicate dialect divisions, but more research is needed.

5 Conclusion

This pilot study has provided the first phonetic detail of the Plains Cree vowel space. As the data have shown, mid-20th-century Plains Cree used a combination of duration and vowel quality to distinguish pairs of vowels in three spaces: high front *i/î* and *ê*, low mid *a/â*, and high back *o/ô*. This picture supports the standard descriptions in terms of the shape of the vowel space, the number of phonemes, and the strong use of duration to contrast long and short pairs of phonemes. However, the study has also shown that all vowel pairs also differ in terms of their quality – either F1, F2, or both. While the durational contrast is often posited but has not previously received acoustic confirmation, the quality contrast has never been documented at all – acoustically or otherwise. Future descriptions of the Plains Cree sound system can now rely on better phonetic support.

One of the core differences among the speakers appears to be the nature of this quality relation between vowel pairs. Vowel pairs are distinguished in terms of backness, as in the *i/î* contrast of Sarah Whitecalf and the *o/ô* pair of Emma Minde. Only the *a/â* vowel pair of Sarah Whitecalf is distinguished purely in terms of height. Interestingly, the 'long' vowel always occupies a more extreme position in the vowel space than the 'short' variant. Long vowels are higher, further back, and lower than their 'short' vowel counterparts, which are always more central.

We can now begin to consider the place of Plains Cree in the typology of vowel systems. The standard description, where Plains Cree has a vowel duration distinction that does not appear to impact vowel quality, would make it resemble the Norwegian vowel system typologically (Behne et al. 1996). However, the generalizations based on the present study suggest that Plains Cree is more analogous typologically to the vowels in German. In German, vowels are distinguished by duration and quality in tandem, with complex trading relations occurring across contexts (Jessen 1998). Plains Cree vowels are not completely analogous to German (leaving aside the number of vowels) typologically, however, because vowel quality interacts with stress in German. There does not appear to be any interaction between vowels and prominence in Plains Cree (Muehlbauer 2006), although English and German speakers often hear such an effect in Plains Cree (Edwards 1954). In several ways, the Plains Cree system also resembles the vowel space of Chickasaw, as described by Gordon et al. (2000). As in Chickasaw, there is a length distinction, a centralizing of the 'short' vowels, and in both systems the high/front vowels are much higher than the high/back vowels.

Future work in Plains Cree phonetics needs to both concretize and contextualize these results. Other consonantal environments need to be checked, data need to be gathered from speakers of different genders, ages, and regions, and laboratory-based study of Plains Cree vowel production needs to be done as well. Other parts of the vowel system that need to be included in a full description of Plains Cree phonetics include the interaction with labialization, voicing, pre-aspiration, morphophonological alternations, and diphthongs. In addition, much anecdotal evidence indicates that Plains Cree speakers of English have a 'Cree accent'. Now that we have some understanding of the phonetics of the Plains Cree vowel system, we can begin to consider the development of the English spoken by Plains Cree speakers or their descendants.

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