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How "mixed" is mixed language phonology? An acoustic analysis of the Michif vowel system

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ABSTRACT:
Michif, a severely endangered language still spoken today by an estimated 100–200 Métis people in Western Canada, is generally classified as a mixed language, meaning it cannot be traced back to a single language family [Bakker (1997). *A Language of Our Own* (Oxford University Press, Oxford); Thomason (2001). *Language Contact: An Introduction* (Edinburgh University Press and Georgetown University Press, Edinburgh and Washington, DC); Meakins (2013). *Contact Languages: A Comprehensive Guide* (Mouton De Gruyter, Berlin), pp. 159–228.]. It has been claimed to maintain the phonological grammar of both of its source languages, French and Plains Cree [Rhodes (1977). *Actes du Huitieme congrès des Algonquinistes* (Carleton University, Ottawa), pp. 6–25; Bakker (1997). *A Language of Our Own* (Oxford University Press, Oxford); Bakker and Papen (1997). *Contact Languages: A Wider Perspective* (John Benjamins, Amsterdam), pp. 295–363]. The goal of this paper is twofold: to offer an instrumental analysis of Michif vowels and to investigate this claim of a stratified grammar, based on this careful phonetic analysis. Using source language as a variable in the analysis, the authors argue the Michif vowel system does not appear to rely on historical information, and that historically similar French and Cree vowels pattern together within the Michif system with regards to formant frequencies and duration. The authors show that there are nine Michif oral vowels in this system, which has merged phonetically similar French- and Cree-source vowels.
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I. INTRODUCTION

Michif is a severely endangered language still spoken today by an estimated 100–200 Métis people, situated primarily in Manitoba and Saskatchewan in Canada and in North Dakota in the United States. Michif is generally classified as a *mixed language*, meaning it cannot be traced back to a single language family (Bakker, 1997; Thomason, 2001; Meakins, 2013). It has been claimed to maintain the phonological grammar of both of its source languages, French and Plains Cree (Rhodes, 1977; Bakker, 1997, Bakker and Papen, 1997). The goal of this paper is to investigate this claim based on a careful phonetic analysis of the Michif vowel system, using source language as a variable in the analysis, to ascertain whether the historical source plays a role in determining the vowel space or duration of the particular vowel in Michif. We argue that to the contrary, the Michif vowel system does not appear to rely on historical information and that historically similar French and Cree vowels pattern together within the Michif system with regards to formant frequencies. The Michif vowel system appears to primarily employ a Cree-type vowel system, with the innovation of two extra vowels. In Sec. I, we introduce the Michif language and some aspects of its typology, from the contact literature. In the Sec. II, we discuss the phonetic systems of the source languages, French and Plains Cree. In Sec. III, we discuss the methods used in our study, and in Sec. IV, we present our results. Section V discusses the implications of these results, and Sec. VI gives conclusions and suggests future directions for this research.

II. MICHIF LANGUAGE

The Michif language was created by members of the Métis nation, the descendants of French fur traders and Cree women who married in the late 18th and early 19th century, in what is today the Canadian West. The children of these unions emerged as a new identity by the early 19th century in the Red River Settlements in Manitoba, with a new set of traditions taken from both parents. Likely in part due to their identity as a culturally mixed nation, Métis people were traditionally multilingual, and the Michif language under discussion here was just one of the languages spoken, used primarily as a home language. Today, an exact number of living speakers of this language is unclear: the 2011 Canadian Census lists 445 speakers of Michif in Canada, but this number includes speakers of other Métis languages also called Michif by their speakers (also called Michif French and Michif Cree), and so the actual number of the speakers of the mixed language discussed here is likely to be closer to 100–200 (Mazzoli, 2019), with all known native speakers of the language over 60 yr of age (Gillon and

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Rosen, 2018; Sammons, 2019). Most of these speakers live in parts of Manitoba and Saskatchewan, in Canada, with a few in Alberta (Canada) and North Dakota (United States).

A. Mixed languages

Mixed languages, as outlined in Meakins (2013), are analyzed as different from pidgins and creoles both due to their structural description and the social circumstances from which they develop. Mixed languages are argued to develop from more equal social standing of the two groups mixing than in the case of creoles and pidgins. Mixed languages furthermore tend to arise out of the formation of new ethnicities, often due to mixed marriages, where they are often said to be created as a means to mark identity rather than filling a purely communicative need (Meakins, 2013, p. 186). Michif is a prime example of this social circumstance, as the Métis people are a new nation resulting from mixed marriages between (primarily) Cree women and French men in the late 1700s and early 1800s. Multilingual and multicultural, some Métis had a European education, and they often acted as translators and interpreters in the region and were of a relatively high social standing during the first half of the 19th century.

They were…exceptionally apt linguists. Most of them spoke at least two languages, French and Cree, and many quickly added other Indian tongues and English…**Their own patois**, still spoken by them throughout the West, is a mixture of French and Cree or Chippewa [Ojibwe] with some English words (Howard, 1952, p. 52–53).

As the above quote suggests, Michif was "their own patois," which primarily acted as an identity marker—the multilingual Métis conversed with others in their tongues and used Michif as an in-group language amongst themselves. This was remarked upon in an 1875 issue of *Le Métis (English translation follows)*:

> … **on a dû remarquer b'en souvent, surtout les Métis français qui, en parlant Crie entre eux, ont pris l'habitude d'y mêler une foule de mots français** – A vrai dire ils forment leurs phrases, moitié français et moitie Crie – c'est en quelque sorte une autre langue, qui parait bien risible à ceux qui n'y sont pas habitués. Ordinairement on se sert du Crie pour les verbes, les adjectifs – et du français pour les substantifs. v.g. ki ki wabamaw tchi, mon cheval? *As-tu vu mon cheval?* Kispin ki wi-miyin mon fusil nista mon couteau ki ka miyitin. *'si tu veux me donner ton fusil, je te donnerai mon couteau'*….
>
> [Le Métis, 18 November 1875]

> … **we have often remarked that, especially the French Métis, when speaking Cree amongst themselves, have taken on the habit of mixing in a ton of French words.** If truth be told, they form their sentences half in French and half in Cree – it is in some sense another language, which seems laughable to those who are not accustomed to it. Normally they use Cree for verbs and adjectives, and French for nouns. e.g. ki ki wabamaw tchi, mon cheval? *Have you seen my horse?* Kispin ki wi-miyin mon fusil nista mon couteau ki ka miyitin. *'If you want to give me your gun, I will give you my knife'*….[1]

Discussion of the genesis of Michif in the nineteenth century can be found in Bakker (1997).

Furthermore, mixed languages combine the grammar of languages to varying degrees. Michif is thought to be an example of one of the more mixed types, far along the continuum, where "both source languages contribute significant amounts of grammar" (Meakins, 2013, p. 179). The characterization is that the division of grammatical labour is fairly evenly split, with the morphosyntactic frame, including verbal grammar, attributed to Cree, while French contributes the DP grammar, such as adjectival agreement and plural marking. This grammar split is claimed to operate right down to the level of phonology as well, and in Sec. II B, we turn to this claim.

B. Stratification claims

One of the strongest claims that has been made about Michif concerns the intertwining of grammars operating at the phonological level. Consider the following characterization of Michif phonological grammar:

> *…it is clear that two separate phonological systems must be posited for Michif…each lexical item must be marked [±French] or [±Cree] in the (mental) lexicon…in order to ensure the item undergoes the right set of phonological rules. Similarly, each rule is marked [±French] or [±Cree].*
>
> [Bakker and Papen 1997, p. 312]

This claim of Michif using stratified phonologies has been taken up in much of the contact language literature since (see for instance, Thomason, 2001; Meakins, 2013). However, there are reasons to question a stratified grammar analysis of Michif, given that it is not obvious how speakers would access French and Cree grammars synchronically, in particular today's speakers, who for the most part did not speak both French and Cree and in fact may not speak either of them (often speaking only English and Michif). Rosen (2007) also argues that inventorial evidence is not strong enough to posit a grammatical split across vocabularies, and that there is no phonological split when observing stress assignment or vowel deletion patterns in Michif; that is, all lexical items pattern together regardless of etymology. Rosen (2006) details stress assignment in particular, showing that the Michif stress system is an amalgam of elements of French stress assignment and elements of Cree stress assignment. Furthermore, there is some recent evidence showing that grammatical rules in Michif across both phonological (Rosen, 2006; Prichard and Shwayder, 2014) and syntactic (Rosen, 2003; Gillon and Rosen, 2018) domains

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follow neither French nor Plains Cree rules, but rather are an amalgam of the two languages which tend to include Michif innovations not found in either historical source language. Crucially, these rules tend to apply across the entire vocabulary, regardless of source language. Finally, a recent acoustic analysis of the Michif plosive system shows little evidence of a phonological split based on source language (Rosen *et al.*, 2019). Their results show that VOT patterns are remarkably similar across source languages, even though French distinguishes between voiced and voiceless stops, whereas Plains Cree does not.

We contend that the default hypothesis is that synchronically, for today's speakers of Michif, who do not speak French and Cree, there is no split phonology in Michif, that the vowels pattern regularly like any other language, and that in the absence of evidence pointing to dual phonologies, we must conclude that Michif operates as a single synchronic system. The primary goal of this paper is to carefully describe and document the phonetic inventory of Michif using instrumental methods. Secondarily, we aim to use this phonetic description to investigate claims of stratification of the phonemic inventory in the language. We ultimately show that Michif does not appear to operate as a dual system based on historical language sources; that synchronically its vowel system can be described as a single coherent system, a system which turns out to be not even as complex as one might anticipate.

III. BACKGROUND TO VOWEL SYSTEMS IN MICHIF SOURCE LANGUAGES

In this section, we outline the phonemic vowel inventories of the two source languages of Michif: we compare the Canadian French and Plains Cree systems, making predictions regarding the Michif system, setting up the analysis section. Then we discuss possible implications of the merging of these systems into the new contact language.

A. Vowel inventories of Michif source languages

The oral phonological vowel inventory of Canadian French as described by Santerre (1974) and Walker (1984) is represented in the vowel chart on the left-hand side of Fig. 1.[2] The chart shows a vowel inventory of twelve phonemic oral vowels distinguished by height and roundness, with eight front vowels that involve rounding and length distinctions, four back vowels that lack those two feature distinctions, and a central schwa.

The Plains Cree vowel system is described by Wolfart (1973) and Muehlbauer (2012), as represented in the chart on the right-hand side of Fig. 1. The Plains Cree vowel system has just seven oral vowels, with no nasal distinction, which includes five front vowels and two back vowels. In the literature they are further distinguished by three levels of height, as well as by phonemic length.

We can see from the vowel charts in Fig. 1 that the inventories of Canadian French and Plains Cree are quite different. The Canadian French oral vowel inventory includes five more vowels than Plains Cree, at twelve as compared to seven. Plains Cree does not have the set of front rounded vowels of French, and it is usually described as distinguishing vowel pairs based on vowel quantity (length) rather than vowel quality (tense/laxness), as in French (cf. Muehlbauer, 2012, discussed below).

B. Implications for the Michif vowel system

While our primary interest is to instrumentally investigate the Michif vowel system, we also seek to use this analysis to test the split grammar hypothesis, to understand the possible results of language contact given the two very different vowel systems in the two source languages of Michif. We can imagine a number of possible scenarios at work in the development of a new "mixed" Michif vowel system, out of two different source languages. In this section, we discuss two of the logical possibilities for the new language's vowel system.

First, Michif could employ the full array of French and Cree phonemes, with French-source words using French phonemes and Cree-source words using Cree phonemes. This is in fact the analysis given in Rhodes (1977); Bakker (1997); Bakker and Papen (1997), who give separate phonemic inventories for each source language. These analyses would result in an inventory of nineteen oral vowels across the dual systems, including a lengthening distinction for Cree-origin vowels only. These inventories include sets of multiple vowels that are quite similar to each other. For example, if we look at the back upper corner of the vowel inventory, it would include the Cree vowels described as "mid-high" /uː/ and /u/ (Wolfart, 1996), the high French /u/, and the mid French /o/. While it is an empirical question as to whether this number of vowels can be sustained in the vowel space, it is certainly highly unusual for languages in the world.

A second possibility is that similar phonemes from one source language system could merge with those in the other system. Assuming the two systems carry a certain number of contrasts, we could assume that the new contact language would need to maintain similar types of contrasts. Note that in both Canadian French and Plains Cree, there is a two-way contrast within vowels of similar height and frontness. In French, that contrast is normally described as a *quality*, or tense-lax distinction, while in Cree it is described as a *quantity*, or long-short distinction, though Muehlbauer (2012) shows that Plains Cree does show a quality distinction, that is, similar vowels differ in terms of vowel height and backness, as well as durational distinctions. Empirically, however, no language in Maddieson's (1984) survey of the world's languages makes both a tense-lax and a long-short contrast, and tense-lax already carries a phonetic duration distinction. Duration may not be the most relevant contrastive feature, but we can assume that phonetically there will be a durational distinction between both the tense/lax and the long/short vowel pairs. We can also assume that it would be important to maintain this two-way contrast in Michif.

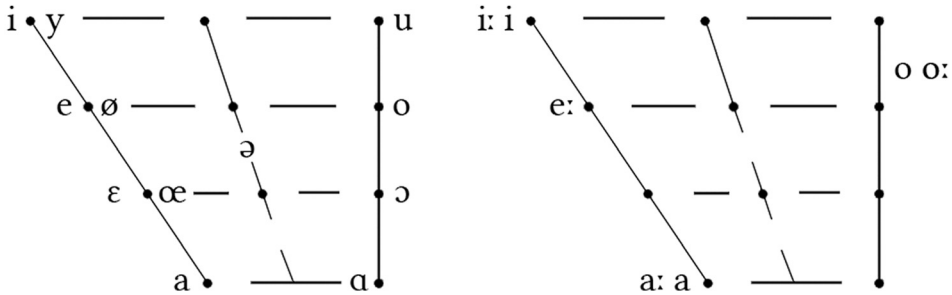

FIG. 1. Comparison of French and Plains Cree phonemic vowel inventories.

In this paper, we use a detailed instrumental analysis to investigate whether the entire array of vowels from both the French and the Cree systems are used across Michif (as claimed in Rhodes, 1977; Bakker, 1997; etc.), or whether some Cree vowels and French vowels are merged in the synchronic Michif grammar (as posited in Rosen, 2007). Furthermore, if there is a merger of Plains Cree- and French-source vowels, we wish to find out which vowels are treated as similar to or different from each other. In order to do this, we use an acoustic analysis to compare vowels in the French-origin items vs those in the Cree-origin items. Specifically, we measure vowel F1, F2, and duration, and employ statistical analysis to see whether vowels of different historical sources are phonetically different or not (Stewart, 2014). If two vowels are significantly different, we consider them to be phonetically distinct vowels. If two vowels show non-statistical difference and substantial vowel space overlap, we consider them to be the same vowel.

IV. METHODS

A. Participants

Ten Michif-English bilingual speakers from Manitoba, Canada, 5 women and 5 men, participated in this study. All participants acquired Michif from birth and began learning English when they started school. Participants were from Gambler Reserve, St. Lazare, Fouillard's Corner, Minnetonas, Binscarth, Russell, and Ste. Madeleine, Manitoba. Participants were between the ages of 61 and 83 at the time of recording, and all speakers were bilingual Michif-English speakers.

B. Procedures

The data used in this study are drawn from a larger corpus of spoken Michif developed by first-language speakers of Michif and the third author (Sammons, 2019). In the case of these recordings, participants were asked to watch the *Pear Story* (Chafe, 1980) on a MacBook Pro laptop. After the video concluded, each participant was asked to retell the story in Michif. They were then asked to narrate the story a second time, while simultaneously watching the video. All instructions were given to participants in English by the third author, a native English speaker. Depending on the particular recording situation, either a Marantz PMD661 or Olympus LS-10 digital audio recorder was used, along with either a Countryman E6i earset microphone, a Countryman B3 or Sony ECM-44B lavalier microphone, or a Rode NT4 tabletop microphone. Recordings were made in 16-bit Waveform Audio File Format (WAV) with a sample rate of 44.1 kHz. These recordings were then orthographically transcribed in Michif and translated into English by Verna DeMontigny, a first-language speaker of Michif, and the third author using ELAN software (Brugman and Russel, 2004; Max Planck Institute for Psycholinguistics, 2016), and subsequently converted into Praat TextGrids for further analysis.

Using Praat v6.0.19 (Boersma and Weenink, 2016), F1 and F2 frequencies were taken from a steady state near the centre of 2469 vowel tokens for this study. A total of 1565 vowels from Cree-origin words were measured, as well as 931 vowels from French-origin words. The vowels under analysis included Cree-origin vowels /aː, a, iː, i, eː, oː, o/ and French-origin vowels /i, e, ə, ɛ, a, ɑ, ɔ, o, u, y, ø/. A Praat script written by the second author was used to extract the formant frequencies. For the purposes of comparing source vowels within Michif, French-origin vowels were analyzed based on their original French pronunciation, i.e., the *in lidiinii* "the dinner" would be considered as /ə/ and not /i/ since its original French pronunciation was /ə/ in (Canadian) French *le diner* /lə dᶻine/ the dinner; likewise the final <ii> in *lidiinii* the dinner would be treated as French /e/. Note that the French source vowel /œ/ was not retained for analysis due to very limited numbers in the sample. This vowel is quite rare generally in Michif, and we will return to its status in the discussion.

The durations of 1598 vowels were also marked up for analysis. 1047 Cree-origin vowels were measured and 551 were measured from French-origin vowels.[3] Vowel durations were consistently marked up at the nearest zero crossing point at the first instance of full formant structure until either an abrupt change in amplitude in the waveform or a change in formant energy indicating the end of the vowel. The same script used in the formant analysis was used to extract the vowel duration data in milliseconds.

V. RESULTS

The results of this study are presented in four sections. The first section tests the hypothesis that Michif speakers have merged the majority of French-origin vowels with Cree vowels in similar constriction locations. This analysis is undertaken with a statistical analysis of F1 and F2 formant frequencies. The second section summarizes the findings and the final section, which extends the same merger hypothesis, but using vowel duration as the cue.

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A. Regression analysis of formants

Two linear mixed effects models were built to test whether F1 (model 1) and F2 (model 2) frequencies differ across each potential vowel category based on language of origin (see Appendix A). Cree-origin vowels are used as the intercepts in both models since we are interested in knowing whether their formant frequencies differ significantly from vowels of French origin. Since there is more than one Cree-origin vowel, we opted to analyze each vowel as the reference/ baseline of the intercept[4] to better understand its relationship to the potential categories under comparison. Normalisation of the vowel data for the statistical analysis was not implemented since we are only interested in within-speaker comparisons. Because each speaker receives their own intercept in a mixed effects regression (as a random effect), the normalisation of unequaled variances is unnecessary (see Drager and Hay, 2012 for a comprehensive overview).

Mixed-effects models were created in R 3.5.2 with the *lmer* function of the *lme4* package (Bates *et al.*, 2015), and confidence intervals were calculated using the *confint* function from the same package. P-values were estimated using the *lmerTest* package (Kuznetsova *et al.*, 2016). All the models included *speaker* and *word* as random effects. Based on a reviewer recommendation, both models were kept maximal (i.e., all predictors were included, significant or not).

The following predictors were included in the models as they could affect the formant frequencies of the vowels under analysis: *sex* (male or female), *stress* (was the vowel in question in a stressed or unstressed position?), *utterance position* (was the word containing the vowel in question found at the beginning, in the middle, or at the end of an utterance?), *syllable type* (open vs closed) and *pre*-and *post-vowel environments* (including voiced consonants, continuant consonants, and dorsal consonants). Because of the amount of data included in the model (see Appendix A for the full model results), we elaborate on portions of the models based on three general areas of constriction [upper front vowels (Sec. I), upper back vowels (Sec. II), and low vowels (Sec. III)]. This allows us to (1) focus on areas where critical overlap in the vowel systems is most likely to occur (e.g., French /i/ and Cree /i:/) and (2) avoid areas where inconsequential overlap is most likely to occur (e.g., F1 frequencies of Cree /e:/ and Cree /o:/). Tables in Secs. V A 1 and V A 3 include the coefficient estimates (β) of significant results (p-value <0.05) from the summary of each mixed-effects model; non-significant results are marked as *ns*. When a result is significant, we are most interested in the coefficient estimate, which is a conservative estimate of the average frequency distance in Hertz between the intercept vowel and the other vowels under analysis.

1. Upper front vowels

The portion of the two statistical models reported in this section is intended to answer the question: is there a statistically significant difference among the following vowels: Cree-origin /iː/, /i/, /eː/, French-origin /i/, /e/, /ə/, /ɛ/, /y/, and /ø/? These vowels are considered broadly of similar quality based on constriction location such as suggested in Wood (1979).

The results from Table I reveal there are clear and significant F1 and F2 differences between French-origin /ɛ/ and Cree-origin front vowels. Cree-origin front vowels (/iː/, /i/ and /eː/) also clearly differed significantly from each other with the exception of /i/ and /eː/ on the F2 (suggesting a similar degree of fronting, but differences in tongue body height). However, non-significant differences in both F1 and F2 frequencies were produced by the model, suggesting there was not enough deviation in French-origin /ə/ to distinguish it significantly from Cree-origin /i/. Similarly, the differences in formant values between French-origin /y/ and Cree-origin /eː/ were also returned as non-significant by the model. The model also returned non-significant differences in F1 frequency between French-origin /e/ and Cree-origin /i/. Non-significant F1 differences were also returned with French-origin /ø/ when compared to both Cree-origin /i/ and /eː/. For Cree-origin /iː/ and French-origin /i/, non-significant differences were returned for F1; however, the model returned significant F2 differences. The vowels with lower F2 frequencies from this pair were not centered nor differed in roundedness in their language of origin. Given this, and the fact that F1 differences in vowel categories in similar constriction locations (e.g., /e/–/ɛ/) is a largely decisive perceptual cue in labeling performance (see, e.g., Hoemeke and Diehl, 1994), we posit that these differences are not meaningful—a point to which we will return below.

The non-significant (*ns*) results in Table I suggest any deviation revealed in the formant frequencies among those vowels could be due to chance. As F1 corresponds to vowel height, this means, for example, that Cree /i:/ could not be set apart from French /i/ in terms of vowel height.

Note that while historically, Plains Cree has been described as making a quantity distinction, it must be said that recent phonetic work suggests that this may be misleading, or at least not the whole story. Both Muehlbauer (2012) and Harrigan and Tucker (2015) find evidence of both quality and quantity distinctions in the vowels of the Plains Cree speakers that they measured. This would mean, for example, that the Cree long-short distinction could also be described as a tense-lax distinction, and a merger between a French tense vowel /i/ and a Plains Cree long (or tense) vowel /i:/ in Michif would perhaps be unsurprising. Therefore, we are not surprised that our analysis shows that these vowels have merged, in fact, but it is important to remember that traditional Michif descriptions *do* claim that they pattern differently (Bakker and Papen, 1997).

Note that the French-source front rounded vowels /ø/ and /y/ were found to be indistinguishable from Cree-source /e:/ in terms of F1 and F2. However, in terms of formant frequencies, rounding is most distinguishable by F3, and so future study of F3 is needed to ascertain whether there is a separate front rounded vowel in Michif or not. There is some reason to believe there could be a merger between front rounded and unrounded vowels in Michif, however, as lexical items which include French-source /ø/ and /y/ are

TABLE I. Statistical results of the F1 and F2 frequencies of the Michif front vowels based on language of origin.

		Cree F1			Cree F2		
Vowel	Vowel/Factor	iː	i	eː	iː	i	eː
Intercept (Hz)		395	464	536	2399	2042	2039
Cree-origin (Hz)	iː	—	−69	−141	—	357	360
	i	69	—	−72	−357	—	*ns*
	eː	141	72	—	−360	*ns*	—
French-origin (Hz)	i	*ns*	−44	−116	−203	120	157
	e	62	*ns*	−79	−162	185	199
	ə	*ns*	*ns*	−97	−475	*ns*	*ns*
	ɛ	188	119	47	−432	*ns*	*ns*
	ø	101	*ns*	*ns*	−637	−281	−277
	y	193	123	*ns*	−533	*ns*	*ns*
Other significant factors (Hz)	Sex: M		−77			−213	
	Syllable: Open		−16			*ns*	
	Pre-voicing		*ns*			−45	
	Post-voicing		13			*ns*	
	Pre.Doral		ns			−59	

TABLE II. Statistical results of the F1 and F2 frequencies of the Michif back vowels based on language of origin.

		Cree F1		Cree F2	
Vowel	Vowel	oː	o	oː	o
Intercept (Hz)		556	480	1278	1174
Cree-origin (Hz)	oː	—	76	—	*ns*
	o	−76	—	*ns*	—
French-origin (Hz)	o	−94	*ns*	*ns*	*ns*
	u	−58	*ns*	*ns*	*ns*
	ɔ	58	135	*ns*	*ns*
Other significant factors (Hz)	Sex: M	−77		−213	
	Syllable: Open	−16		*ns*	
	Pre-voicing	*ns*		−45	
	Post-voicing	13		*ns*	
	Pre.Doral	ns		−59	

often written with the same orthographic convention "eu." Furthermore, these vowels are quite rare in the language, and have a low functional load, and so it remains unclear whether rounding is consistently present and perceivable in the language. For the time being, we recognize the vowels to pattern similarly to their unrounded counterpart and have posited them as all merged, recognizing that future work may find these to be differentiated from each other.

2. Upper back vowels

The portion of the two statistical models reported in this section is intended to answer the question: is there a statistically significant difference among the following vowels: Cree-origin /oː/, /o/ and French-origin /o/, and /u/?

The results from Table II reveal there are clear F1 differences between Cree-origin /oː/ and Cree-origin /o/, suggesting a quality distinction between the two vowels. The model results also reveal that French-origin /u/ and /o/ are non-significantly different from Cree-origin /o/, suggesting that these three vowels are merged. The only vowel which differed significantly from the Cree-origin back vowels was French-origin /ɔ/, which showed to be higher in F1 frequency, suggesting this vowel is consistently produced with greater aperture, placing it between the high back vowels and low vowels (see Appendix A for significant differences between French-origin /ɔ/ and Cree-origin /a/ and /aː/).[5] While non-significant F2 differences were revealed for French-origin /ɔ/, this could be expected due to the tongue's limited mobility often associated with back vowel production; especially since neither language of origin has a rounding contrast or back vowel fronting.

3. Low vowels

The portion of the two statistical models reported in this section is intended to answer the question: is there a statistically significant difference among the following vowels: Cree-origin /aː/, /a/, and French-origin /a/, /ɑ/, /ɛ/, /ɔ/, and /ə/?

The results from Table III reveal that there are clear F1 and F2 differences between Cree-origin /aː/ and Cree-origin /a/. However, the model results also reveal that the F1 and F2 frequencies of French-origin /a/ are non-significantly different from those of Cree-origin /a/. Similar non-significant F1 and F2 results were also revealed for French-origin /ɑ/ and Cree-origin /aː/. French-origin mid vowels (/ɛ/, /ɔ/, and /ə/) were also included to see how they interact with low vowels. The F1 of French-origin /ɔ/ was also revealed to be non-significantly different when compared to Cree-origin /a/. However, the F2 was significantly lower by nearly 200 Hz, suggesting that French-origin /ɔ/ could be produced substantially further back in the vocal tract compared to Cree-origin /a/, and/or rounded, which is also known to lower F2. The models also revealed that /ɛ/ and /ə/ were both significantly different from Cree-origin low vowels [though not from upper front vowels (see Sec. I and

TABLE III. Statistical results of the F1 and F2 frequencies of the Michif low vowels based on language of origin.

		Cree F1		Cree F2	
Vowel	Vowel	aː	a	aː	a
Intercept (Hz)		729	656	1447	1525
Cree-origin (Hz)	aː	—	73	—	−77
	a	−73	—	77	—
French-origin (Hz)	a	−49	*ns*	*ns*	*ns*
	ɑ	*ns*	63	*ns*	*ns*
	ɔ	−115	−42	−177	−254
	ɛ	−146	−73	519	442
	ə	−290	−217	476	399
Other significant factors (Hz)	Sex: M	−77		−213	
	Syllable: Open	−16		*ns*	
	Pre-voicing	*ns*		−45	
	Post-voicing	13		*ns*	
	Pre.Doral	ns		−59	

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Appendix A)]. Overall, the results from this model suggest that there is little evidence to argue that Michif contains more than two low vowels (/a/ and /aː/).

B. Formant summary

The results from the formant analysis suggest that vowels from both source languages are produced in a single system that reflects that of Cree to a large extent. The only exceptions are French /ɛ/ and /ɔ/, which are significantly different from neighbouring vowels with large enough distances in the F1 and F2 space to be perceptually distinct from other vowels.

The F1×F2 bagplot of the raw data in Fig. 2 is delimited based on the statistical results. The vowel clusters represent 50% concentrations in the data, while the centre asterisk represents the mean averages. These results provide evidence that Michif does not make use of the entire French source vowel inventory, but rather the Michif vowel system more closely resembles the Plains Cree system, with a limited number of extra French-source vowels. In other words, when comparing phonetically similar vowels from historically French and Cree vocabulary, we find many overlapping vowels. Figure 2 represents the nine Michif vowels, once we collapse non-statistically significant vowels into each other.

Note that we have marked the Michif vowels primarily as making a long-short distinction (/iː, i, oː, o, aː, a/), with two additional quality distinctions among the mid-low vowels (/ɛ, ɔ/). The motivation for this durational distinction is explained in Sec. V C, where we discuss our results for vowel duration in Michif.

C. Vowel duration

We have focused thus far on vowel formant information as the crucial dimension in which to categorize Michif vowels, finding that overall, phonetically similar vowels of historically French and Cree vocabulary are non-significantly different from each other with respect to vowel formant information. This leads us to analyze phonetically similar Cree- and French-source vowels as a single Michif vowel. These Michif vowels appear to pattern as a tense-lax

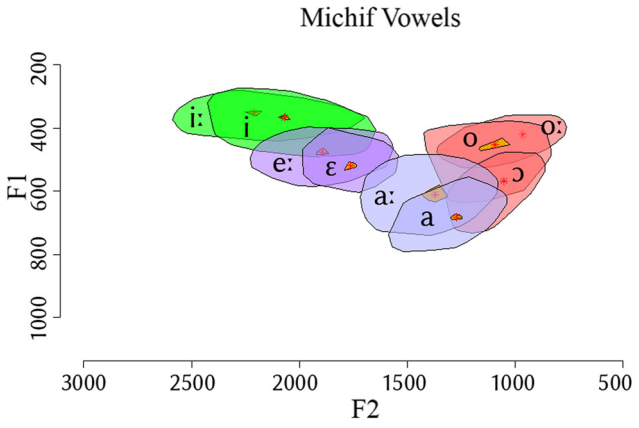

FIG. 2. (Color online) F1 and F2 formant plot of the Michif vowel system.

distinctive system in terms of their formants. However, for completeness, given that Cree contrasts long and short vowels, we also investigate the role played by duration in the Michif vowel system, for example, to see whether although historically Cree and historically French vowels are statistically similar based on vowel formants, since it is possible that they may differ from each other in terms of duration. We therefore now add vowel duration as another point of analysis, to ascertain whether even though historically Cree and French do not appear to be distinguishable based on formants, they could be so based on duration.

A linear mixed effects model was built to analyse possible durational differences across each potential vowel category. Cree-origin vowels were rotated through the intercept since we are interested in whether or not their durations differ significantly from those of French-origin vowels. The model was created using the same model-building strategy and predictors as described previously.

Our results reveal that, like in the formant analysis, the majority of phonetically similar vowels from historically French and Cree vocabulary in Michif are non-statistically different from each other in terms of duration. In fact, we see that the duration analysis yields mostly non-significant results when we look at the vowels that were collapsed together based on formant information. For clarity, we include only the most relevant results here in Table IV, but the complete statistical results are given in Appendix B.

Focusing on the phonetically similar French- and Cree-origin vowels which surfaced in Michif as non-significantly different, we see that nearly all are non-significantly different in duration as well. Raw averages with standard deviation for individual vowels tested are given in Appendix C, but we focus on the statistical results here. In Table IV, the first column is the Cree vowel, the second is the phonetically similar French vowel(s) according to the above analysis, the third column is the statistical durational difference, and the fourth column is the Michif vowel label we have assigned the vowel in Fig. 2. In the fifth column, we have given the statistical averages of the duration of the Michif vowels in milliseconds.

The results initially show that Michif does maintain a statistically significant difference between long and short vowels of Cree origin. Specifically, Michif /iː/ was significantly longer than the Michif /i/ by 21 ms on average, while Michif (/eː/) was significantly longer than Michif /iː/ by 21 ms on average (42 ms longer than the Michif /i/). For both the mid back vowels (/oː/ and /o/) and the low vowels (/aː/ and /a/), the long vowel was on average 37 ms longer than the short vowel. Note, however, that these durational differences, while statistically significant, are more consistent with intrinsic durational differences between vowels contrasting in quality, rather than vowels contrasting purely by length, where we would expect larger differences between the vowels, such as in Norwegian (Behne *et al.*, 1996). Note that Muehlbauer (2012) shows that in Plains Cree, long-short vowel pairs also demonstrate formant contrasts consistent with a quality distinction, in addition to

TABLE IV. Statistical results for phonetically similar Cree- and French-origin vowels.

Cree vowel	French vowel(s)	Difference (in ms)	Michif vowel	Duration (ms)
/iː/	/i/, /e/	*ns*	/iː/	80
/i/	/i/	*ns*	/i/	59
/eː/	/e/, /ɛ/	*ns*	/eː/	101
/oː/	/u/, /o/	*ns*	/oː/	111
/o/	/ɔ/	*ns*	/o/	74
/aː/	/ɑ/	*ns*	/ɑ/	115
/a/	/a/	20	/a/	77/97

durational distinctions. These findings are supported as well by Harrigan and Tucker (2015), investigating vowel reduction in Plains Cree.

The duration results then do support an analysis where the Cree-origin and French-origin vowels are conflated into a single Michif vowel, with the caveat that the short /a/ carries with it a significant durational difference between French-origin /a/ and Cree-origin /a/.

VI. DISCUSSION

We now return to the original research question regarding the claim of phonological stratification along historical language sources in Michif. First, we argue that the evidence provided in Sec. V supports a unified vowel inventory for Michif. We then touch on some remaining questions and discuss some limitations of the study and future work to be completed.

A. The Michif vowel system: Stratified or not?

The goal in undertaking this study was to determine the synchronic situation of the Michif vowel inventory. In order to investigate the claims that the Michif grammar (and in particular, the phonology) is stratified by source language, we sought to describe and analyze the oral vowel system to determine whether (a) the Michif oral vowel inventory includes all French and Cree oral vowels, or (b) whether during the process of Michif developing out of French and Cree, there was a mapping of oral vowels from one language's system onto the other, or (c) whether there is some other unexplored possibility. Our study compared similar oral vowels with different historical origins to ascertain degree of similarity based on overlap and statistical non-significance between the vowels. As Sec. V outlines, the results show that when we compare similar oral vowels of different historical source languages, there is a high degree of overlap of vowels throughout the system, both along the formant and the durational dimensions, providing strong evidence that historical source is not a relevant distinguishing predictor of vowel category. In other words, the overwhelmingly overlapping vowel spaces and durations of similar oral vowels from both Cree and French tell us that there is a merger of phonetically similar Cree and French oral vowels in the new Michif vowel system, and it is best to consider them as *Michif* oral vowels in a *Michif* vowel inventory, rather than French oral vowels and Cree vowels in a French-Cree stratified vowel inventory. Based on the acoustic analyses we conducted, we can analyze the Michif oral vowel system as a single system as in Fig. 2 above. Here we now discuss some questions arising from the findings, as well as some implications for the description of the Michif vowel system.

B. Remaining questions

1. F2 as a cue

As noted above, despite strong F1 and durational evidence for overlapping French and Cree vowels, we found some statistically significant differences in F2 for vowels of similar quality. The question is however, whether these differences are salient enough to posit them as separate in the inventory. We argue that they are unlikely to be separate, given that F2 is usually only salient across large spans (e.g., front vowels to back vowels), and that in Michif, given that there are no vowels between the front and back vowels, this dimension is less important than height for differentiating between vowels. Put another way, since the relevant contrast between the phonetically similar vowels studied is one of height, it is reasonable to assume that the F1 plays a much more important role than F2 in contrasting the vowels.

2. Limitations of the study

There were a few limitations to this study which we mention here. First, and most importantly, the chart in Fig. 2 should not be seen as a complete vowel chart for Michif. We did not analyze nasalized vowels, which we have planned for a future study. Furthermore, not all French-origin vowels were included in the analysis due to their rarity. The missing vowel is the front round vowel /œ/, which is relatively uncommon in French but even rarer in Michif, where the French vocabulary is limited primarily to nouns and a few adjectives. Although we hypothesize that /œ/ will also collapse into a Michif mid-vowel category, further study would be necessary to confirm this hypothesis and our tentative conclusion that round and unround vowels may have merged more generally in Michif. Our motivation for this analysis, however, is twofold. First, this merger would follow the pattern of the other French mid and high vowel pairs, which collapse into a single vowel (French /y/ > /eː/, and French /o, u/ > o). Second, the speaker-designed writing system of the Turtle Mountain Michif dictionary represents words with both French /y/ and /ø/ with "eu" (Laverdure and Allard, 1983). Therefore, although this constitutes the most detailed existing acoustic analysis of Michif vowels, work remains to complete the analysis of the full Michif vowel inventory.

C. Implications

Our instrumental study reveals a system which has merged phonetically similar French- and Cree-source

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vowels, contrary to the literature which suggests Michif maintains a stratified phonology (Bakker and Papen, 1997). The present analysis provides a view of the language based on concrete acoustic data rather than impressionistic observations and theoretical accounts of the Michif phonology system (e.g., Rosen, 2007; van Gijn, 2009). It also strengthens the acoustic findings of Pritchard and Shwayder (2014), who argue against a split phonology of Michif, also based on acoustic analysis.

The results of this analysis may also reflect other studies which suggest that Michif follows a primarily Algonquian grammar. For example, Gillon and Rosen (2018) show that Michif nominal phrase structure, which has claimed to be French, is only so on the surface. They argue that the majority of the nominal syntax derives from Plains Cree, and that French vocabulary is borrowed into essentially a Cree structure. Similarly, the single vowel inventory posited here appears to fold some phonetically similar French-source vowels into the Plains Cree system, as evidenced for example by the lack of significant difference between the two back French vowels /u, o/ and Cree /o:/. Note that in this case, the French vowels have merged into the Cree vowel, rather than the Cree vowel merging with one of the French back vowels.

The results also reflect the findings of other mixed languages in which the phonology is primarily of the substrate language. Gurindji Kriol, a mixed language spoken in Northern Territory, Australia, and Media Lengua, a mixed language spoken in Ecuador, both have the potential of containing large stratified vowel inventories, yet the results from F1 and F2 analyses (see Jones *et al.*, 2011 for Gurindji Kriol; Stewart, 2014 for Media Lengua) show that vowels of the superstrate language often merge or exist in highly overlapping acoustic spaces with vowels from the substrate language. Such vowel arrangements cause these mixed languages to sound more like their substrate language when spoken—findings which corroborate the results of the current study.

VII. CONCLUSIONS

Overall, our instrumental study shows that, based on F1, F2, and vowel duration, Michif uses a mostly merged phonological system where phonetically similar vowels pattern together as a single item in most cases. Given this, we posit a single overarching phonological inventory rather than two distinct inventories based on source language. This inventory has collapsed the larger French-source inventory into a smaller system, with French vowels collapsing into single vowels where they overlap to a great degree with a Plains Cree vowel. This analysis supports other phonetic work on mixed languages such as Gurindji Kriol and Media Lengua, where the substrate languages also appear to play a more important role in the structure of the new language (Jones *et al.*, 2011; Stewart, 2014).

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APPENDIX A: STATISTICAL RESULTS FROM TWO MIXED EFFECTS MODELS.

The left column shows results from the model run the F1 formants and the right column shows results from the model run on the F2 formants. Fixed effects are presented below the vowels.

		Cree-origin F1 (Model 1)							Cree-origin F2 (Model 2)						
Vowel	Vowel/Factor	iː	i	eː	oː	o	aː	a	iː	i	eː	oː	o	aː	a
Intercept (Hz)		395	464	536	556	480	729	656	2399	2042	2039	1278	1174	1447	1525
Cree-origin (Diff. in	iː	—	−69	−141	−161	−85	−335	−261	—	357	360	1121	1225	951	874
Hz from the intercept)	i	69	—	−72	−92	*ns*	−265	−192	−357	—	*ns*	765	868	595	517
	eː	141	72	—	*ns*	56	−193	−120	−360	*ns*	—	761	864	591	514
	oː	161	161	20	–	76	−173	−100	−1121	−765	−761	—	*ns*	−170	−247
	o	85	*ns*	−56	−76	—	−250	−176	−1225	−868	−864	*ns*	—	−273	−351
	aː	335	265	193	173	250	—	73	−951	−595	−591	170	273	—	−77
	a	261	192	120	100	176	−73	—	−874	−517	−514	247	351	77	—
French-origin (Diff. in	i	*ns*	−44	−116	−136	−60	−309	−236	−203	120	157	919	1022	749	671
Hz from the intercept)	e	62	*ns*	−79	−99	*ns*	−272	−199	−162	185	199	960	1063	790	712
	ə	*ns*	*ns*	−97	−117	*ns*	−290	−217	−475	*ns*	*ns*	646	749	476	399
	ɛ	188	119	47	*ns*	104	−146	−73	−432	*ns*	*ns*	689	792	519	442
	ø	101	*ns*	*ns*	*ns*	*ns*	−234	−161	−637	−281	−277	484	587	314	*ns*
	y	193	123	*ns*	*ns*	108	−142	*ns*	−533	*ns*	*ns*	589	692	419	*ns*

Continued

Vowel	Vowel/Factor	Cree-origin F1 (Model 1)							Cree-origin F2 (Model 2)						
		iː	i	eː	oː	o	aː	a	iː	i	eː	oː	o	aː	a
	o	68	*ns*	−73	−94	*ns*	−267	−194	−1222	−865	−861	*ns*	*ns*	−270	−348
	u	104	*ns*	−38	−58	*ns*	−231	−158	−1244	−887	−884	*ns*	*ns*	−292	−370
	ɔ	220	150	79	58	135	−115	−42	−1128	−772	−768	*ns*	*ns*	−177	−254
	a	285	216	144	124	200	−49	*ns*	−858	−502	−498	263	367	*ns*	*ns*
	ɑ	324	255	183	163	239	*ns*	63	−919	−562	−558	203	306	*ns*	*ns*
	Sex: M				−77							−213			
	Unstressed				*ns*							*ns*			
	Initial				*ns*							*ns*			
	Medial				*ns*							*ns*			
	Syl. Open				−16							*ns*			
	Pre.Vcing				*ns*							−45			
	Post.Vcing				13							*ns*			
	Pre.Fric				*ns*							*ns*			
	Post.Fric				*ns*							*ns*			
	Pre.Doral				*ns*							−59			
	Post.Doral				*ns*							*ns*			
	Pre.V/App				*ns*							*ns*			
	Post.V/App				*ns*							*ns*			

APPENDIX B: STATISTICAL RESULTS FROM A MIXED EFFECTS MODEL DESIGNED TO TEST VOWEL DURATION MEASURED IN MILLISECONDS

Language		Cree (ms)						
	Vowel	iː	i	eː	oː	o	aː	a
	Intercept	80	59	101	111	74	115	77
Cree-origin (ms)	iː	—	21	−21	−30	*ns*	−35	*ns*
	i	−21	—	−41	−52	−14	−22	*ns*
	eː	21	41	—	−10	26	−14	24
	oː	30	52	10	—	37	*ns*	34
	o	*ns*	15	−26	−37	—	−41	*ns*
	aː	35	56	15	*ns*	42	—	38
	a	*ns*	17	−23	−33	*ns*	−38	—
French-origin (ms)	i	***ns***	*ns*	−26	−36	*ns*	−40	*ns*
	e	***ns***	33	***ns***	*ns*	*ns*	−22	*ns*
	ɛ	28	49	***ns***	*ns*	34	*ns*	31
	ɔ	*ns*	37	*ns*	***ns***	***ns***	*ns*	*ns*
	o	37	58	*ns*	***ns***	**43**	*ns*	40
	u	*ns*	*ns*	*ns*	***ns***	***ns***	−32	*ns*
	a	17	38	*ns*	*ns*	23	**−18**	**20**
	ɑ	42	63	*ns*	*ns*	48	***ns***	**45**

APPENDIX C: MEAN (LEFT) AND STANDARD DEVIATIONS (RIGHT) OF THE RAW VOWEL DATA PRESENTED IN MILLISECONDS

Language	Vowel	Raw Mean (ms)	Raw SD (ms)
Cree-origin	iː	78.08	42.91
	i	61.59	35.87
	eː	95.06	37.76
	oː	97.92	34.29
	o	70.11	37.16
	aː	109.5	45.66
	a	77.81	36.08
French-origin (ms)	i	72.76	47.89
	e	93.04	43.34
	ɛ	101.4	47.88
	ɔ	102.8	41.65
	o	120	52.55
	u	75.48	14.13
	a	101.7	54.66
	ɑ	142.4	36.38

[1]Thanks to Michael Iannozzi for finding this excerpt and bringing it to our attention. Translation by Nicole Rosen.

[2]Although French has a phonological oral-nasal distinction, only the oral vowels are analyzed here. We intend to analyze the nasal vowels in a future study, as their status in Michif remains unclear.

[3]Not all vowels were measured for both formant frequency and duration due to difficulties in determining duration boundaries in some vowels.

[4]Viewing each vowel as the reference/baseline of the intercept (i.e., re-parameterization) essentially involves changing the perceptive of the model (not the model itself), allowing one to view the results from the standpoint of each vowel (see Millar, 2011 for an overview of re-parameterization in regression modeling). Since the model itself is not changed, any variation attributed to the fixed and random effects remains constant.

[5]*Post hoc* analyses, with French /ɑ/ and French /a/ as the intercept, also revealed significant differences from French /ɔ/: [F1 - French /ɑ/ intercept β = 719 Hz; French /ɔ/ β=-104 Hz; P-value = 0.0002]; [F2 - French /ɑ/ intercept β = 1480 Hz; French /ɔ/ β = −209 Hz; P-value = 0.03]; [F1 - French /a/ intercept β = 680 Hz; French /ɔ/ β = −65 Hz; P-value = 0.002]; [F2 - French /a/ intercept β = 1540 Hz; French /ɔ/ β = −270 Hz; P-value = 0.0005].

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