University of Pennsylvania Working Papers in Linguistics

Volume 23
Issue 2 *Selected Papers from New Ways of Analyzing Variation (NWAV 45)*
Article 6

11-1-2017

Blackfoot Final Vowels: What Variation and its Absence can Tell us about Communicative Goals

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Abstract
This paper investigates variation in the production of word-final vowels in Blackfoot, an Algonquian language spoken by approximately 3350 people in Southern Alberta and Northern Montana. The Blackfoot community perceives the language as partitioning into varieties, based on the age of the speaker; 'old Blackfoot' is richly polysynthetic and spoken by people born in the 1930s and earlier, whereas 'new Blackfoot' is thought to be missing certain inflections, and is spoken by people born in the 1940s or later. Final vowels, which encode a morphosyntactic distinction referred to as obviation, are thought to be particularly susceptible to language loss. Gick et al. (2012) document the phonetic properties of one Blackfoot speaker's final vowels, demonstrating that, for her, final vowels are not absent but instead soundless in some environments, in that there are distinct articulator positions for -a and -i vowels without any corresponding acoustic distinction. We investigate the articulatory, acoustic, and phonological properties of the final vowels of four additional speakers cross-cutting age, dialect, and gender. Using ultrasound, video, and audio recordings, we found that while there is phonetic variation across speakers in the realization of final vowels, not one speaker altogether omits them. In short, there is variation, but of a limited nature. The robustness of the final vowels reflects the fact that they serve an important communicative function in the grammar by encoding obviation.

Blackfoot Final Vowels: What Variation and its Absence Can Tell us about Communicative Goals

Heather Bliss and Bryan Gick*

1 Introduction

What conditions the limits of variation? Where is there an absence of variation, and what can this tell us about the goal(s) of speech production? This paper addresses these questions as they pertain to word-final vowels in Blackfoot, and considers their implications for language revitalization and the expression of communicative goals.

Blackfoot is considered an endangered language, with declining numbers of first language speakers and few second language learners. Final vowels are reported as emblematic of language loss, assumed to be absent in the grammars of younger speakers and/or disappearing from certain dialects (Chatsis et al. 2013, Frantz 2009). Gick et al. (2012) document the phonetic properties of one Blackfoot speaker's final vowels, demonstrating that, for her, final vowels are not absent but instead soundless in some environments, in that there are distinct articulator positions for *-a* and *-i* vowels without any corresponding acoustic distinction. The empirical question investigated in this paper is whether this finding generalizes to other Blackfoot speakers.

Using ultrasound, video, and audio recordings, we investigated the phonetic properties of final vowels of four additional Blackfoot speakers, representing a cross-section of dialects, ages, and genders. We found that, while there is variation across speakers in the phonetic properties of final vowels, not one speaker in our sample altogether omits them. In short, there is variation, but of a limited nature. We propose that this reflects the fact that final vowels serve an important communicative function in the grammar, namely encoding obviation, a morphosyntactic distinction between multiple referents in a discourse.

The paper proceeds as follows. In Section 2, we provide background information on Blackfoot, it's final vowels, and the Gick et al. (2012) study. In Section 3, we outline our methodology for the current study, and in Section 4 we present the results. Section 5 considers the implications of the study, from both theoretical and practical perspectives. In Section 6 we conclude.

2 Background

Blackfoot is an Algonquian language spoken by approximately 3350 people in Southern Alberta and Northwestern Montana. There are four dialects of Blackfoot, corresponding to three reserves in Canada: Siksika, Kainai, and (Amskapi) Pikaani, and one reservation in the United States: Blackfeet (or Aapatohsipikani). Documented dialectal variation is mainly lexical, and generational variation is often discussed in terms of language obsolescence, with younger speakers described as using a variety marked by a loss of grammatical complexity. Blackfoot communities partition the language into "Old Blackfoot" and "New Blackfoot;" the former is spoken by people born in the 1930s or earlier and is characterized by rich polysynthesis, and the latter is spoken by people born in the 1940s or later and is thought to be less morphosyntactically rich (Chatsis et al. 2013, Kaneko 1999).

As for the final vowels, these are ubiquitous, at least in Old Blackfoot. They encode an inflectional contrast, obviation, which serves a reference-tracking function to signals the relative saliency of three person participants in a discourse. Obviation morphology is obligatory on most nouns, verbs, and demonstratives, the three word classes in the language (Bliss 2013). There are two obviation morphemes in the language: proximate *-wa* and obviative *-yi*. Frantz (2009) notes that these morphemes are 'rarely audible' and susceptible to omission due to regular phonological processes of glide deletion and word-final devoicing. The question we are interested in is whether the final vowels - which encode the obviation contrast - are encoded at all in "New Blackfoot," particularly given that obviation morphology is said to be omitted by younger speakers in other Algonquian languages (Artuso 1998, Grenier Mintenko 2001).

Gick et al.'s (2012) finding regarding soundless vowels was for one speaker of the "Old Blackfoot" variety of the Siksika dialect. Using ultrasound recordings of the speaker's tongue, they found that there was a distinction in tongue height between *-a* and *-i* vowels at one position, around the

middle of the tongue. Using close-up video of the speaker's lips, they found that there was a lip aperture distinction between the two vowels, with a wider aperture for *-a* than for *-i*. However, there were no significant differences in the acoustic recordings for these vowels. There was no auditory signal detected for the vowels, and there were no coarticulation effects on preceding segments. These results were confirmed via a perception experiment; a second Blackfoot speaker could not distinguish the vowels through acoustic recordings alone.

Our goal in this paper is to extend Gick et al.'s findings to other Blackfoot speakers, in order to assess the range of variation across speakers in the production of Blackfoot's final vowels.

3 Methodology

Four additional speakers participated in this study, as summarized in Table 1.

	Old/New Blackfoot	Dialect	Gender
NB	New	Siksika	F
TB	Borderline	Kainai	M
NC	New	Kainai	F
BB	New	Kainai	F

Table 1: Participants.

The recording procedure involved taking simultaneous recordings using ultrasound (for the tongue), video (for the lips), and audio. The recording apparatus included a CHISON portable ultrasound machine, a Panasonic camcorder mounted on a tripod, and a MacBook Pro laptop computer running iMovie. For each speaker, we recorded 10-20 tokens of each vowel in a carrier phrase, plus three to five tokens of additional words. The carrier phrases were agreed upon in advance and differed slightly for each speaker depending on their own preferences. In each case, however, the final vowel was produced following a disyllabic noun ending in a nasal *-n*. The additional words collected included examples of proximate and obviative morphology in other morphophonological environments. Prompts were given in English, and we took breaks between tokens as needed.

We used Adobe Premiere to synchronize the ultrasound, video, and audio streams, and ELAN to extract the fourth frame following the last audible and visible acoustic information in order to capture the final vowel at midpoint. For the each of the extracted frames, we used ImageJ to measure the distance from the ultrasound probe to the tongue at seven regular intervals (as shown in Figure 1a below). We also measured the vertical and horizontal distances between the vermillion borders of the lips (as shown in Figure 1b below). To test for coarticulation effects, we used Praat to measure F1 and F2 values of the preceding vowel. Statistical analysis was performed using R; results were fit to a series of linear models with the measurement in question as the dependent variable and the vowel as the independent variable.

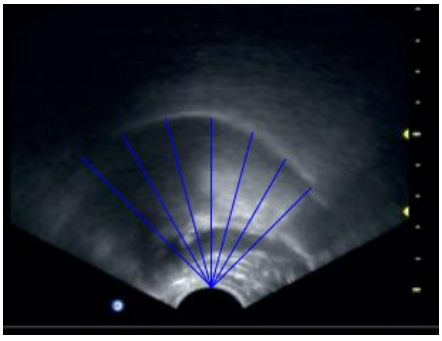

Figure 1: (a) Measurements of ultrasound frames from probe to tongue surface; (b) Horizontal and vertical measures of lip aperture.

In addition to the phonetic analysis, we also analyzed the phonological properties of the three to five tokens of additional words in order to determine how final *-a* and *-i* may interact with surrounding segments, and whether they participate in regular phonological processes.

4 Results

The cumulative finding is that, although there is variation in the phonetic properties of final vowels, there is a robust *-a/-i* distinction across all participants in the study. This is summarized in Table 2 (which includes, for comparison, the speaker from Gick et al.'s 2012 study), and is followed by detailed discussion of each participant. (Phonological effects are discussed for BB only; the phonological generalizations observed for her extend to all participants.)

	RE	NB	TB	NC	BB
Tongue height	✓	✓	✓	✓	×
Lip aperture	✓	✓	×	×	×
Coarticulation	×	×	×	✓	×
Phonological effects	✓	✓	✓	✓	✓

Table 2: Summary of Results

First regarding NB, her results were similar to those of RE (from Gick et al. 2012) in that she exhibited a distinction between *-a* and *-i* in terms of tongue height and lip aperture, but with no acoustic correlates, including coarticulation effects. However, whereas RE had a tongue height distinction at one of seven points along the tongue, NB had a tongue height distinction at four points – two near the front of the tongue and two near the back. The articulatory data is presented in Figure 2, and the acoustic data in Figure 3. (differences that are statistically significant are noted with asterisks).

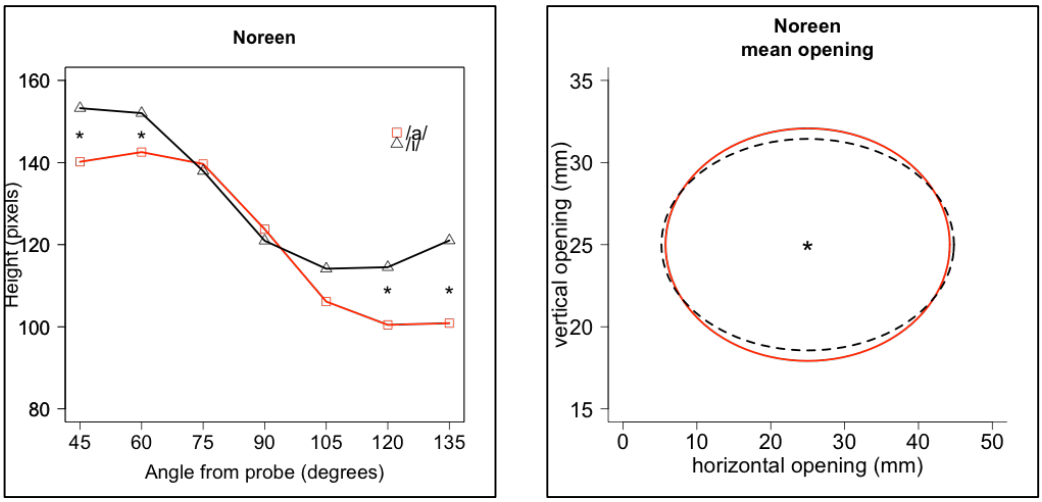

Figure 2: (a) Tongue height distinctions for NB; (b) Lip aperture distinction for NB.

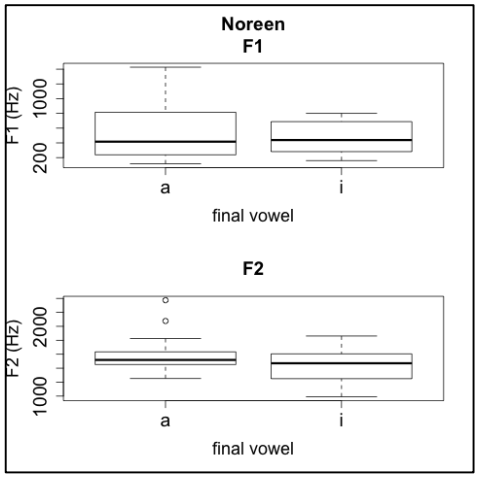

Figure 3: F1 and F2 values of preceding vowel (NB).

Turning now to the results for TB, he had a distinction between *-a* and *-i* at two midpoints on the tongue, but no statistically significant distinction in lip aperture. Like RE and NB, he also did not exhibit any coarticulation effects. The results are presented in Figures 4 and 5 below.

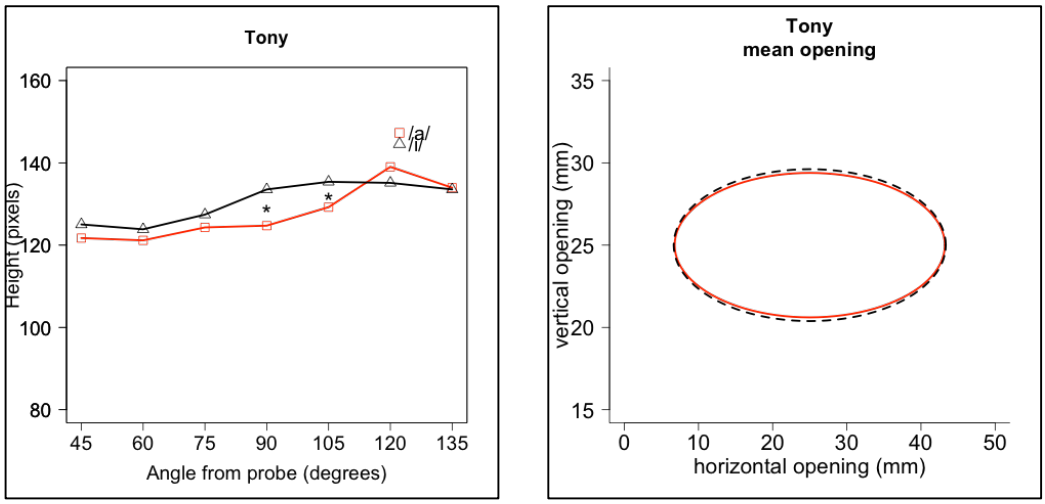

Figure 4: (a) Tongue height distinctions for TB; (b) Lip aperture distinction for TB.

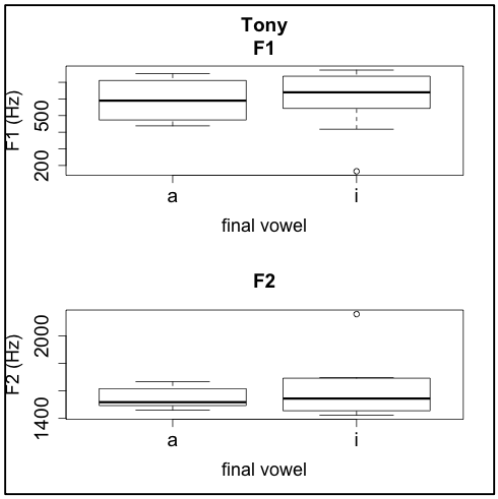

Figure 5: F1 and F2 values of preceding vowel (TB).

As for NC, she exhibited a contrast between *-a* and *-i* in terms of tongue height (at four locations, front and back), but not in terms of lip aperture. These results are shown in Figure 6. Unlike the preceding three participants, NC also exhibited coarticulation effects; the preceding vowel had significantly higher F1 values and significantly lower F2 values in the presence of the final *-a* vowel, as compared with the same preceding vowel in the presence of the final *-i* vowel. This is shown in Figure 7.

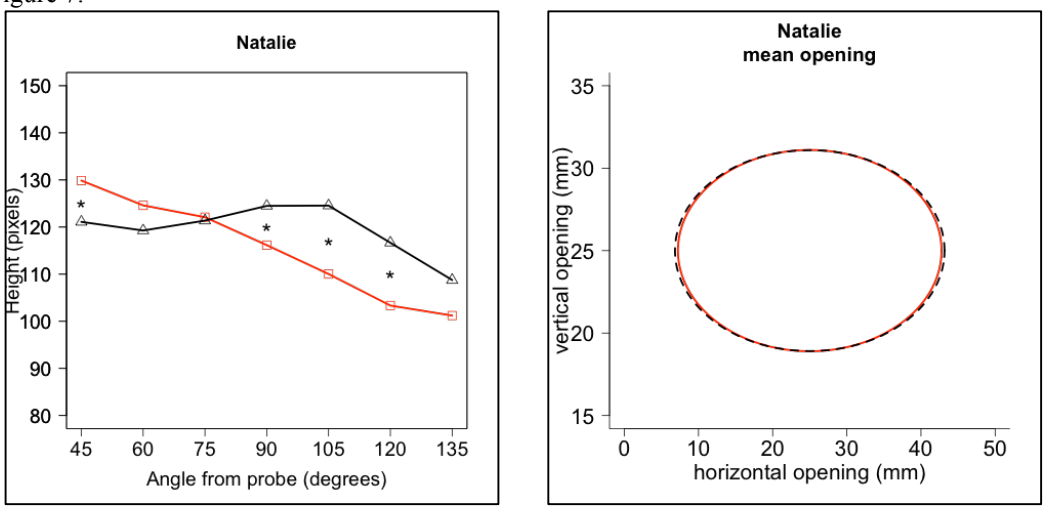

Figure 6: (a) Tongue height distinctions for NC; (b) Lip aperture distinction for NC.

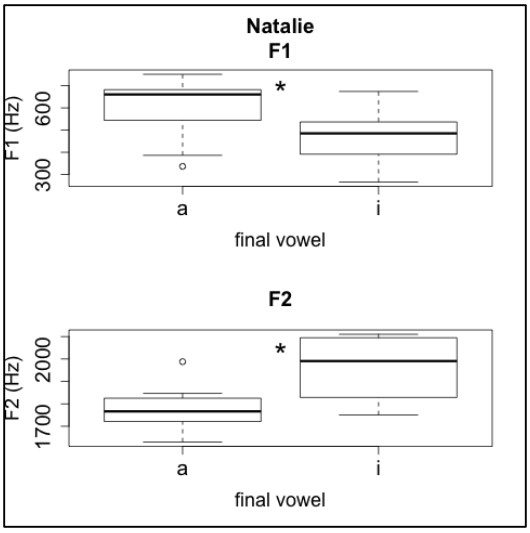

Figure 7: F1 and F2 values of preceding vowel (NC).

For all participants considered thus far, the final vowels are phonetically distinguished following nasals – either by articulatory measures alone (tongue height and, for some participants, also lip aperture), or by articulatory measures and co-articulation effects on the preceding vowel. However, for the final participant in our study, BB, there is no articulatory or acoustic realization of the vowels in the same environment whatsoever. However, there is phonological evidence of their existence. In other phonological environments, the vowels participate in regular processes, even though they are not phonetically realized. We refer to these as "ghost vowels" (Szpyra 1992).

Notably, the same phonological phenomena observed in BB's grammar are also attested for the other four participants. But whereas the other participants exhibit phonetic evidence of the vowels as well, this is not the case for BB. In BB's grammar, the vowels are phonologically active but phonetically null. For example, final *-i* triggers assibilation, a regular phonological process schematized in (1) and illustrated in (2).

(1) /t/ → [ts] / __ i

(2) a. niksis:**t**
n-iksis:t-wa
1-mother-PROX
'my mother'

b. oksis:**ts**
w-iksis:t-yi
3-mother-OBV
'his/her mother'

Moreover, 'ghost' final vowels block the otherwise regular process of word-final devoicing, even though they are not phonetically realized in BB's grammar. The process is illustrated in (3) and exemplified in (4). Because proximate and obviative suffixes are not used with intransitive predicates with first person subjects, we can observe the difference between the presence and absence of the suffix.

(3) /V/ → [V̥] / __#

(4) a. nitaʔpoʔtak**i**
nit-aʔpoʔtak**i**
1-work
'I worked.'

b. aʔpoʔtaki̥
aʔpoʔtaki-wa
work-OBV
'S/he worked.'

5 Implications

5.1 Theoretical Implications

In the context of speech production, it is often claimed that articulatory goals are themselves important independent of goals in other dimensions (e.g., Guenther 2006, Tremblay et al. 2003). Part of the evidence for this claim comes from variation along acoustic versus articulatory dimensions; in some cases where variation in the acoustic signal is attested, articulation is less variable (Stuart-Smith et al. 2014). Blackfoot's soundless vowels have been used to provide further support for the hypothesis that articulatory goals are independent of acoustic goals in speech production; their existence speaks to the fact that natural languages can systematically encode articulatory targets without acoustic consequences (Gick et al. 2012).

How does the observed variation across speakers in the production of final vowels inform theories of speech production or communicative goals? According to the Minimal Intervention Principle (Todorov and Jordan 2003), variation is a necessary ingredient of motor behavior; for optimal control over a primary task, variation must be allowed in redundant dimensions. Under this model, the absence of variation in some region of action space can be seen as a diagnostic for identifying the primary task(s) or goal(s) of that system. Cross-speaker variation in the production of final vowels, and in particular the presence of 'ghosts' suggests that the primary task in this context is not to reach an articulatory target, but rather to express the vowel, even if only indirectly. We propose that the reason for this is that the final vowels encode important morphosyntactic information, namely obviation. In the context of the Minimal Intervention Principle, we suggest that a primary task can be conceived of more broadly, in terms of the communicative goal of expressing meaningful grammatical distinctions.

5.2 Practical Implications

Our findings indicate that the final vowels, and the proximate/obviative contrast that they encode, are robust and salient aspects of both Old and New Blackfoot. Despite anecdotal claims about the loss on inflection amongst younger speakers, this finding is in some sense predictable, as obviation plays a major organizational role in the grammar (Bliss 2013) and is culturally important for artistic expression (Thomason 2015), particularly narrative structuring. We contend that soundlessness is not a sign of disappearing inflection but an integral part of the grammar. Many speakers perceive soundlessness as the "proper" pronunciation of final vowels. However, this can be challenging for language learners, and neither the standard orthography (Frantz 1978) nor provincial curricula (e.g. Alberta 1991) distinguish between voiced versus soundless vowels. By shedding light on variation in the pronunciation of final vowels, we can inform teaching about obviation in Blackfoot.

6 Conclusions

In this paper, we documented the articulatory and acoustic properties of word-final vowels of five Blackfoot speakers cross-cutting distinctions of dialect, gender, and age. We found that, despite anecdotal claims that final vowels are perhaps disappearing from the grammars of younger speakers, final vowels remain a robust and salient feature of Blackfoot, attested in the grammars of all five speakers. For most participants in our study, the vowels are "soundless," articulatorily distinguished but not acoustically realized. For one participant, the vowels are phonetically null but nevertheless phonologically active. We argued that variation in the final vowels speaks to the primary task associated with their production: communicating the proximate/obviative contrast. Moreover, we suggested that a clear understanding of this variation can inform pedagogical materials for Blackfoot language revitalization.

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