A phonetic analysis of obstruent series in Hidatsa*

Jonnia Torres Carolan
University of Colorado Boulder

Ryan M. Kasak
Yale University

Abstract: This work represents a preliminary look at the obstruent series in Hidatsa. Various scholars have described a plain and aspirated series in Siouan (Boyle 2007, Park 2012), but there is a disagreement between scholars as to the status of "pre-aspirated" segments. Quintero (2004) notes that Siouanists have long had a debate over whether these so-called pre-aspirated stops are truly monosegmental or if they are a sequence of segments. This paper examines these previous claims and finds support for two underlying stop and affricate varieties: plain and aspirated. Furthermore, we find that there is no phonemic pre-aspiration in Hidatsa, though there is a distinction between underlying /hC/ clusters and a phonological operation of pre-aspiration of obstruents in the environment of heavy syllables bearing stress.

Keywords: aspiration, pre-aspiration, phonetics-phonology interface, Hidatsa, Proto-Siouan

1. Introduction

In this paper, we address the acoustic characteristics of the obstruent series in Hidatsa [ISO: HID; 47°45′N, 102°32′W], a Siouan language belonging to the Missouri River family. Existing descriptions of Hidatsa rarely contain phonetic analysis, and those that exist prior to the twenty-first century involve minimal sets of data with questionable interpretations of spectrographic information (Bowers 1996), or provide cursory descriptions of its sound system, focusing more on morpho-syntax than on the phonetics-phonology interface (Boyle 2007, Park 2012). Boyle et al. (2016) address the phonetic characteristics of word-level prominence in Hidatsa, but do not give a description of its obstruent series.

This paper is the first to examine the obstruent series of Hidatsa in depth, with a particular focus on plosives and affricates. One salient issue in the discussion of obstruents in Hidatsa is that various authors have commented on the status of frication in combination with certain obstruents in Hidatsa, but these works relied on personal perception (Boyle 2007, Park 2012), or uncertain interpretation of phonetic instrumentation (Bowers 1996). As such, the central question of this

*We would like to extend our thanks to the following Hidatsa speakers for contributing data to this work: Martha Birdbear, Mary Gachupin, Arvella White, Carol-Ann Newman, and Lila Gwin. These individuals have long served as educators in their communities, and we appreciate their contributions to the continuation of the Hidatsa language. In addition, we benefited greatly from the receipt of a Center to Advance Research and Teaching in the Social Sciences (CARTSS) grant at the University of Colorado Boulder, which funded several recording session. We are also grateful to the attendees of SCLC38 for their comments following the presentation of this paper.

work is how do previous analyses of the obstruent series in Hidatsa stand up to an examination of their phonetic characteristics using modern instrumentation?

To address this question, we employ Praat (Boesma & Weenik 2016) to conduct waveform and spectrographic analysis. The data that appear in this work have all been personally collected through fieldwork between 2015 and 2017 on the Fort Berthold Reservation in North Dakota or in the Phonetics Lab at the University of Colorado in Boulder, Colorado. The consultants who participated in these recordings are all L1 Hidatsa speakers who currently reside in Mandaree, North Dakota and have all been long-term educators.

The paper is structured in the following manner: in §2, we provide an overview of previous descriptions of the sound system of Hidatsa, including the vacillating depictions of so-called "pre-aspirated" segments. This description is followed by a typological survey of pre-aspiration in §3, and in §4, we look at the phonetic realization of ⟨hC⟩ elements in the data. In §5, we provide an analysis on whether pre-aspiration is an appropriate term for these particular sounds. We conclude that Hidatsa does not have a pre-aspirated series of obstruents in §6.

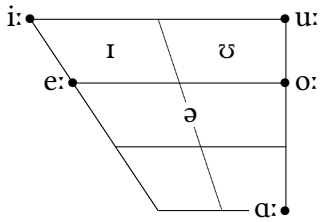
2. Hidatsa sound system

The purpose of this section is to provide a synthesis of previous analyses of the sound system of Hidatsa, given special attention to its obstruents. For the sake of completeness, vowels and fricatives are briefly discussed here, but the primary focus of the following section is to detail the descriptions by other scholars on Hidatsa obstruents. In the introduction to vowels and consonants is a discussion of the sound changes from Proto-Siouan that have resulted in the current phonological inventories we see in modern Hidatsa. The overall goal of this section is to convey the sounds present in Hidatsa to contextualize the controversy over the phonemic status of non-plain stops in the language.

2.1. Vowels

Rankin et al. (1998:366) reconstruct Proto-Siouan with long and short oral vowels for *a, *e, *i, *o, *u, as well as long and short counterparts for the nasal vowels *ą, *į, and *ų. Phonemic nasal vowels were lost in Missouri River Siouan, with each nasal vowel merging with its oral counterpart (Grimm 2012:19). The vowels of Hidatsa are given in Figure 1.

Figure 1: Hidatsa vowels (Boyle et al. 2016)



The vowels above in Figure 1 shows a relative symmetry between vowel lengths in Hidatsa, where non-mid long vowels have a short counterpart: /ɑː/ː/ə/, /iː/ː/ɪ/, and /uː/ː/ʊ/. As

Boyle (2007:33) notes, short [e] and [o] are rare due to Proto-Siouan *e and *o merging with *i and *u in Proto-Missouri River, respectively. Park (2012:26) likewise analyzes Hidatsa as having only underlyingly long mid-vowels. Park (2012:397) additionally remarks that phonetically short mid-vowels may occur due to long vowels optionally contracting before fricatives, as well as when appearing word finally. The short vowels tend to be more centralized than their long counterparts, specially when unstressed. When stressed, short vowels are more likely to be produced as tense (Boyle et al. 2016).

In addition to the monophthongs above in Figure 1, there are also two falling diphthongs: /iə̯/ and /uə̯/. Historically, these diphthongs derive from Proto-Siouan *ihe and *uhe sequences, respectively (Rankin et al. 2015). These diphthongs pattern with long vowels with respect to duration and the tendency to attract primary stress (Boyle et al. 2016).[1]

2.2. Consonants

The purpose of this section is to describe the consonants present in Hidatsa. Both Boyle (2007) and Park (2012) have alternated between describing Hidatsa as having a single obstruent series, only to then describe certain elements as being pre-aspirated or post-aspirated. In the subsections that follow, we discuss previous descriptions of the consonant inventory of Hidatsa, first looking at what changes have occurred from Proto-Siouan, then examining the plosives, fricatives, affricates, and sonorants underlyingly present in modern Hidatsa.

Hidatsa has a drastically reduced consonant inventory when compared to the consonant inventory of Proto-Siouan as reconstructed by (Rankin et al. 1998:366). Most reconstructions of Proto-Siouan include four series of stops: plain, glottalized, pre-aspirated and post-aspirated. Fricatives likewise had multiple series, where there is a distinction between plain and glottalized. Consonants are reconstructed across five places of articulation: bilabial, coronal, palatal, velar, and glottal. The inventory below represents the most commonly cited one, which is used in the Comparative Siouan Dictionary (Rankin et al. 2015).[2]

Hidatsa has a drastically reduced consonant inventory when compared to the consonant inventory of the Proto-Siouan in Table 1 above (Rankin et al. 1998). Most of the stop series underwent mergers, with the pre-aspirated and post-aspirated merging with the plain series in Hidatsa. A formalized rule for this sound change appears in (1a), along with examples that to illustrate how this sound change took hold in modern Hidatsa in (1b) through (1d), where we can see that there is a general collapse of the non-glottalized stops. Each stop underwent a merger with its plain series analog, as we can see below.[3]

[1] Boyle et al. (2016) use a phonetic study of over 500 tokens in Hidatsa, finding that primary stress is assigned through left-aligned, weight-sensitive iambs. Long vowels and syllables ending with a coda /h/ or /ʔ/ are considered heavy syllables. First syllable stress is possible with a heavy syllable, and third syllable stress appears when the first two syllables are light and the third is heavily. Elsewhere, second syllable stress is the default pattern. There are exceptions to this pattern, but unexpected stress is usually found in words that are compounds. Stress assignment in Hidatsa is beyond the scope of the present paper, but is a worthwhile subject of study for future work.

[2] Larson (this volume) argues for at least one additional consonant in Proto-Siouan, a glottalized palatal stop *čʔ, which is not reflected in the table above.

[3] The Proto-Siouan reconstructions that appear throughout this paper come from the online Comparative Siouan Dictionary in Rankin et al. (2015). All proposed Proto-Siouan forms appear as-is, though two changes are made for the sake of making the correspondence between the Proto-Siouan and Hidatsa forms more obvious. Firstly, the reconstructed Proto-Siouan accent is omitted, since accent is not examined in this work. Secondly, long vowels in

Table 1: Proto-Siouan consonant inventory (Rankin et al. 1998:366)

		Bilabial	Dental	Palatal	Velar	Glottal
Plosive	Plain	*p	*t		*k	*ʔ
	Glottalized	*pʔ	*tʔ		*kʔ	
	Pre-Aspirated	*hp	*ht		*hk	
	Post-Aspirated	*ph	*th		*kh	
Fricative	Plain		*s	*š	*x	*h
	Glottalized		*sʔ	*šʔ	*xʔ	
Sonorant		*w	*r	*y		
Obstruent		*W	*R			

(1) Merger of aspirated stops with plain stops

a. Sound change
$$\left\{\begin{matrix}*hC\\ *Ch\\ *C\end{matrix}\right\} > C$$

b. Post-aspirated to plain
PSi *pho 'swell' > *bó(hshahi)* ['pohʃəhɪ] 'popping sound'

c. Pre-aspirated to plain
Psi *hpatE 'butcher' > *(ha)bádi* [hə'pɑtɪ] 'saw, file'

d. Preservation of plain
PSi *pųųšE 'spotted' > *búushi* ['pu:ʃɪ] 'multi-colored, speckled, striped'

In addition to the collapse of the pre- and post-aspirated stop series from Proto-Siouan, the Proto-Siouan glottalized stop series also merged with the plain stops in Hidatsa. Glottalized obstruents, however, metathesized their glottalized element away from the consonant to an opposite position with the neighboring vowel, in effect taking some element from the onset of a syllable and moving it to the coda. This sound change is formalized as a rule below in (2a), which is then followed by examples of reflexes of this sound change in modern Hidatsa in (2b) and (2c). In (2b), the glottal element and the vowel trade positions, rendering what was originally a glottalized stop as a plain stop, and turning a formerly open syllable into a closed syllable.

Proto-Siouan had plain and glottalized fricatives in addition to its contrast between plain and glottalized plosives. This distinction likewise collapses for fricatives, where glottalized fricatives appear to merge with plain fricatives, as we can see in (2c).[4]

Proto-Siouan are represented here with a digraph: e.g., instead of the notation *u• that is used in the Comparative Siouan Dictionary, this long vowel appears as *uu in throughout this work. The purpose of this change is to increase the ease of comparison with modern Siouan forms, given that all Siouan languages with contrastive vowel length have orthographies that denote vowel length with a double vowel digraph: i.e., [a:] as ⟨aa⟩.

[4]Crow has traces of coda glottals with fricatives that were glottalized in Proto-Siouan: e.g., PSi *x?ehe 'drip' becomes Crow *xeé* 'leak' [xé:] and Hidatsa *xée* ['xe:] 'leak.' The high, flat pitch across the entire long vowel in Crow originates in syllables containing a coda glottal stop (i.e., as opposed to a high pitch that falls to a low pitch), as we can see from in Crow word *chií* [t͡ʃí:], which is a reflex of *k?į 'carry on back.' We can, in turn, compare this Crow form to its Hidatsa cognate *gí'* ['kiʔ] as evidence that Hidatsa has preserved coda glottal stops that originate from

(2) Metathesis and mergers in glottalized consonants

a. Sound change
*C?V > CV?

b. Glottalized plosives to plain with glottal stop coda
PSi *k?į 'carry on back' > *gí'* ['ki?] 'pack, carry on back'

c. Glottalized fricatives to plain
PSi *s?įį 'peek' > *cíi(shi)* [t͡si:ʃɪ] 'scout'

The remaining consonants posited in Rankin et al. (1998) show a similar tendency towards mergers. Proto-Siouan *y merges with *r in Missouri Valley Siouan and Mandan. So-called "funny" *W merges with /w/ in Hidatsa, and "funny" *R and *y merging with /r/ (Rankin et al. 2015).[5] The single non-merger sound change from Proto-Siouan to Hidatsa is that PSi *s affricated to *c* [t͡s]. A summary of these sound changes appear in (3) through (5).

(3) Merger of voiced obstruents with sonorants

a. Sound change
$\left\{ \begin{matrix} *W \\ *R \end{matrix} \right\} > \left\{ \begin{matrix} w \\ r \end{matrix} \right\}$

b. *W to *w*
PSi *Waate 'boat' > *máahdii* /wɑ:ti:/ 'boat'

c. *R to *r*
PSi *Rase 'behind, in back' > *(áa)raci* /ɑ:ɾət͡sɪ/ 'at one side'

(4) Merger of non-velar sonorants

a. Sound change
*y > *r*

b. Palatal to coronal
PSi *wiyą 'tree, wood' > *mirá* /wɪɾə/ 'tree, wood'

(5) Affrication of *s

a. Sound change
*s > *c* /t͡s/

b. Fricative to affricate
PSi *sii(-re) 'yellow' > *cíiri* /t͡si:ɾɪ/ 'yellow'

glottalized plosives, but not those that originate from glottalized fricatives. Boyle et al. (2016) find no pitch accent in Hidatsa, and as such, there are no direct reflexes of the glottal element Proto-Siouan glottalized fricatives.

[5]The is no consensus on the phonetic values of "funny" *W and *R. These segments differ from *w and *r in that they often have reflexes that are sonorants in some daughter languages, but plosives in others. See Rankin et al. (1998:371) for additional discussion of these elements. There is some evidence that suggest that *R may have been *r?, as there are some examples of words in Hidatsa that involve /ɾ/ followed by a vowel and glottal stop, similar to the glottal metathesis described above: e.g., PSi *Re 'ache' > *aré'* [ə.ˈɾe?] 'hurt.' There are many other instances of *R being realized as /ɾ/ in Hidatsa and not /ɾV?/: e.g., PSi *Roksi 'armpit' > *nóhci* /ɾoht͡sɪ/ 'armpit.' The existence of two different reflexes with no obvious conditioning factors raises the question of whether *R represents a single proto-form in Proto-Siouan or whether there exists $*R_1$ and $*R_2$, where one proto-form is *r? and the other is some other element with obstruent-like qualities.

All of these mergers yield the consonant inventory below in Table 2. This table reflects the consonant inventory that is proposed in both Boyle (2007) and Park (2012). Compared to the inventory of Proto-Siouan consonants shown in Table 1, the sound inventory in Hidatsa is drastically reduced and has far fewer contrasting segments than its ancestor language.

Table 2: Hidatsa consonant inventory (Boyle 2007:27)

	Bilabial	Dental	Palatal	Velar	Glottal
Plosive	p	t		k	ʔ
Fricative			ʃ	x	h
Affricate		t͡s			
Sonorant	w	ɾ			

This section has provided an overview of how the sound system of Hidatsa evolved from Proto-Siouan. The data in Table 2 above is a consensus of most descriptions of the consonant inventory of Hidatsa from the twentieth and early twenty-first centuries (Stetson 1946, Boyle 2007, Park 2012, *inter alios*). The following subsections serve to describe the obstruents in Hidatsa. Given that this paper addresses the obstruent series in Hidatsa, there will be no discussion of the sonorants /w/ and /ɾ/ here.

2.2.1. Plosives

Modern accounts of the sound system of Hidatsa equivocate somewhat on whether Hidatsa has only one or multiple series of stops: plain, plain and post-aspirated, or plain with post- and pre-aspirated. Most descriptions state that stops may be partially or fully voiced when intervocalic. Boyle (2007:27) holds that there is only a single series of stops, where /h/ can appear as the final element in a consonant cluster. However, he refers to sequences of stops followed by /h/ as being aspirated throughout his description of Hidatsa. This treatment follows similar theoretical positions by Matthews (1965) and Jones (1984).

Park (2012:19) likewise lists only plain stops in his description of the plosive inventory of Hidatsa. Like Boyle (2007), whenever an /h/ follows a voiceless stop, Park (2012) describes this sequence as being post-aspiration.

(6) Post-aspiration in Park (2012)

a. *beericgisdabeedhé* → [ˈpeːɾɪt͡skɪʃtəˌbeːtʰe] ‘sleet’ (lit. ‘raven’s eye secretion’)
b. *idawirúxibhi* → [ɪdəwɪˈɾuxɪˌpʰi] ‘ice cream’
c. *áàbhiru* → [ˈɑːpʰɪˌɾu] ‘neck bone’
d. *aʾghúù* → [ˈɑʔˌkʰuː] ‘to bring it along’

According to Park (2012:66), aspirated stops are “always underlying clusters,” which is the reasoning he provides for why his orthography does not have a unique grapheme for aspirated stops versus unaspirated stops: i.e., ⟨dh⟩ for [tʰ] and ⟨d⟩ for [t], instead of ⟨t⟩ for [tʰ] like other Hidatsa orthographies. The purpose of this paper is not to evaluate why one orthography is better suited for writing Hidatsa than another, but it is worth noting that most writing systems for Hidatsa take into account the fact that there is some distinction between a true voiceless stop and one with a glottal fricative element that follows it.

Despite the fact that both Boyle (2007) and Park (2012) agree that there are no true post-aspirated stops underlyingly in Hidatsa, these "aspirated clusters" do not behave like other consonant clusters phonotactically. Namely, Park (2012:30) remarks that there are no word-initial clusters in Hidatsa, with the exception of those who are underlyingly /Ch/. Furthermore, there is little discussion in the literature as to how syllabification works in Hidatsa, and there is nothing explicit pertaining to how word-internal "aspirated" stops are treated, either within words with no obvious morphological boundaries (e.g., *pí* [ˈpʰi] 'be blue' or *káa* [ˈkʰɑː] 'laugh') versus compounds (e.g., *áapiru* [ˈɑːpʰɪˌɾu] versus [ˈɑːp.hɪˌɾu] 'neck bone' from *áaba* 'neck' and *hirú* 'bone').

The other area where previous descriptions of Hidatsa stops varies is in whether there are pre-aspirated plosives. Boyle (2007:34) states that pre-aspiration is lost word initially, but that "word-intern pre-aspiration is always a coda: Vh-CV." Park (2012:150) likewise argues for the existence of a single stop series, but describes clusters beginning with /h/ as being "phonetically pre-aspirated." Boyle (2007:30) admits that he has difficulty discerning this so-called "pre-aspiration" in certain contexts, so we shall utilize data from Park (2012) to look at instances of alleged pre-aspiration in Hidatsa.[6]

(7) Pre-aspiration in Park (2012)

a. *séhbi* → [ˈʃehpɪ] 'be dark'

b. *núhdabi* → [ˈnuhtəˌbi] 'be tight-fitting'

c. *sáhgi* → [ˈʃɑhkɪ] 'be open'

Throughout the literature on Hidatsa plosives, the description of these stops stand at odds with itself over the status of these elements: are they singleton stops that are pre-aspirated or are they truly a consonant cluster? If previous scholars are simply using the terms aspirated and pre-aspirated as a shorthand for these elements, then we should be more specific in how to describe them so as not to confound these phenomena in Hidatsa with terms that are more theoretically grounded in the typology. We evaluate the possibility that they truly are aspirated or pre-aspirated from a phonetic point of view. This issue is central to this paper, which is discussed in detail in §5.

The primary focus of this paper is to examine how many obstruent series exist in Hidatsa, and we pay special attention to plosives, given the four-way distinction that existed in Proto-Siouan. In addition to the plosives described above, Hidatsa also possess an affricate that often patterns with plosives phonologically. This affricate is described below.

2.2.2. Affricates

Hidatsa has a single affricate, ⟨c⟩ /t͡s/. This phoneme is often voiced intervocalically. Park (2012:20) observes that obstruents are most likely to remain voiceless "in morpheme-initial positions and when preceded by a prefix or a proclitic." As such, we should expect word-initial obstruents like /t͡s/ to remain voiceless when word initial. This pattern is indeed what we generally observe in the data for /t͡s/, which can be seen in the examples below.

[6]The phonetic transcription of the data in this section assume Park's (2012) assumption that post-aspirated obstruents are phonetically post-aspirated as well as Boyle's (2007) description of pre-aspiration as being a coda /h/. We expound upon this matter and whether this is the most phonetically and phonologically accurate way to depict such data in §5.

(8) Voicing of /t͡s/ in Hidatsa

a. *cacúgi* → [t͡sə'd͡zugɪ] 'flea'
b. *cagíc* → [t͡sə'git͡s] 'it is good'
c. *có'da* → ['t͡soʔtə] 'be gray'
d. *cíidadagi* → ['t͡si:dədə'gi] 'white-tailed deer'

In addition to patterning like stops, the affricate /t͡s/ also has been described as having an "aspirated" counterpart, [t͡sʰ]. Boyle (2007) depicts this sound in his orthography with ⟨cc⟩, and Park (2012) uses ⟨ch⟩. We can see examples of this sound in the data below.

(9) Post-aspirated affricates in Hidatsa

a. *mé'cci* → ['meʔt͡sʰɪ] 'knife'
b. *naxbícci* → [nəx'pit͡sʰɪ] 'bear'
c. *úuccee* → ['u:t͡sʰe:] 'make something dry'
d. *máacciruwadu* → ['mɑ:t͡sʰɪˌɾuwəˌdu] 'chokecherry'

In addition to the existence of these post-aspirated affricates, there are numerous instances of what both Boyle (2007) and Park (2012) would call pre-aspirated affricates. Examples of these supposedly pre-aspirated elements appear in the data below. These data demonstrate that there is no restriction on the quantity of instances of aspiration that can appear in a single word, as (10c) contains both what Boyle (2007) and Park (2012) would label as pre- and post-aspiration.

(10) Pre-aspiration in Park (2012)

a. *híhci* → ['hihtsɪ] 'pink'
b. *móohcaa* → ['mo:ht͡sɑ:] 'coyote'
c. *gháhcaac* → ['kʰɑht͡sɑ:t͡s] 'he/she smiles'

Almost universally throughout previous descriptions of Hidatsa, the words in (9) have been described as having "aspirated" elements. This pattern is similar to the data in (6), where sounds are described as being aspirated or post-aspirated, but then there is some kind of back-tracking, where the authors deny that there is any underlying aspirated consonants in Hidatsa; all surface post-aspiration reportedly comes from underlying /Ch/ clusters. The affricate /t͡s/ in the data above also mirrors the behavior of plosives in that it is able to appear with sublaryngeal frication before an oral occlusion (i.e., a stop or the stop element of an affricate). We see this frication reflected in the transcriptions of (7) and (10).

2.3. Fricative

Hidatsa fricatives, unlike stops and affricates, typically resist intervocalic voicing (Boyle et al. 2016). Robinett (1955:1) analyzes some Hidatsa words as having fricative plus /h/ clusters, and Boyle (2007:30) goes so far as to suggest that there may be some post-aspirated fricatives in Hidatsa. These descriptions, however, all seem to stem from Stetson's (1946:136) observation that Hidatsa fricatives are much longer in duration than stops. Boyle (2007:30) notes that these

clusters are problematic, with various scholars transcribing certain segments as being sequences of a fricative plus /h/ or /h/ plus another fricative.[7]

Given that the focus of this paper is on stops and fricatives, the information above is the greatest extent to which fricatives shall be discussed in this paper. Park (2012:31) remarks that fricatives that co-occur with /h/ can methathesize and also can be produced as a geminate fricative in casual speech. The interaction between fricatives in clusters involving /h/ is topic that requires explanation beyond the scope of this paper, but is certainly an issue that is worthy of exploration in future work.

2.4. Summary

One fact that we repeatedly observe in the data is that there is glottal frication that interacts with plosives and affricates in Hidatsa. Scholars from the first half of the twentieth century have stated that there is a contrast between plain and post-aspirated (i.e., lenis and fortis) obstruents (e.g., Robinett (1955)), while most analyses in the second half of the twentieth century and those conducted during the twenty-first century are synoptic on the issue of there being a single obstruent series in Hidatsa (e.g., Boyle (2007) and Park (2012)). This concord between modern scholars on this single obstruent series belies the fact that these analyses simultaneously describe various elements as being pre-aspirated or post-aspirated at a phonetic level. The following section delves into the issue of what are the current notions of pre-aspiration so that we can examine whether Hidatsa truly does have pre-aspirated obstruents or if these elements are truly clusters.

3. Typology of pre-aspiration

Pre-aspiration is a rare phonological phenomenon occurring in only 1 percent of the world's languages (Clayton 2010:23; Helgason 2002:32). Pre-aspiration is the glottal friction that "intercedes after a vowel and precedes a consonant" (Clayton 2010:7). Thus, it is the expulsion of air before the release of consonants, much like an English h-sound after the consonants /p, t, k/. This aspirated phase, preceding the closing, has come to be identified as an h-sound or a "puff of air" (Bloomfield 1925:152; Helgason 1998:16, 2002:11). Hejná (2015:73) offers the following definition: "pre-aspiration is often accompanied by breathiness, which presumably serves as a transition from the modal voicing of the vowel to the voiceless pre-aspiration portion." For a geographical distribution of the languages claimed to include pre-aspiration, see Figure 2 below, in which Hidatsa is labeled in red.

The map below highlights that many of the languages that have been described as having pre-aspriation are found in the Americas. However, there are numerous European languages that include language varieties where pre-aspriatation is present. Pre-aspiration may appear to be an areal feature of indigenous languages of the Americas (North America with Mesoamerica

[7]None of the previous accounts of the sound system of Hidatsa have used any kind of instrumentation to back up their analyses, though Bowers (1996:80) does try to argue in favor of the existence of laryngealized and glottalized fricatives, but the spectrographic data he employs does not lead us to the same conclusion. Further obscuring Bowers's (1996) case is that he relies on numerous non-standard diacritics in his transcriptions without defining what these diacritics mean. While his dissertation represented the first published phonetic work on Hidatsa, that work is largely not taken into account in this paper due to the points raised here.

in particular), but the fact remains that pre-aspiration is likely underdocumented, and additional work on languages of Africa and Asia may yield more instances of pre-aspiration.

Figure 2: Geographical distribution of languages claimed to have pre-aspiration[8]

This section has served to give a formal definition of pre-aspiration. This definition is somewhat vague, in that these definitions of pre-aspiration can be interpreted as being /h/ segments that occur before another consonant, or glottal frication that occurs with a consonant that renders that consonant phonologically distinct in that language. Thus, a consonant cluster like /ht/ could be called pre-aspiration, but so could the frication present that distinguishes /t/ from /^{h}t/. Our question is whether Hidatsa possesses "true" pre-aspiration (i.e., [^{h}C] segments), or if all the elements described in the literature on Hidatsa as being pre-aspirated are solely consonant clusters (i.e., [hC] sequences).

4. Phonetic analysis of pre-aspiration in Hidatsa

To investigate the status of pre-aspiration in Hidatsa, we gathered audio recordings from L1 Hidatsa speakers and analyzed the recordings using instrumentation. This section serves to walk the reader through the process we used to test the question of whether Hidatsa has a single obstruent series or if there are phonemic pre-aspirated obstruents. We discuss the results, which lead to our discussion of pre-aspiration in Hidatsa in the following section.

[8]This map is a compilation of the languages and language varieties discussed throughout Clayton (2017) and Silverman (2003) as having pre-aspiration. Its purpose is to show that Hidatsa is geographically proximate to a number of languages that exhibit pre-aspiration.

4.1. Participants

Study participants include four female L1 speakers of Hidatsa above the age of 60. All had been monolingual in Hidatsa until attending boarding school, and all continue to use the language regularly in their adult lives at home. Each participant currently resides in Mandaree, North Dakota and have all been long-term educators. All speakers currently live on the Fort Berthold Reservation in North Dakota, in Mandaree or New Town.

4.2. Stimuli

Stimuli included elicited words and careful reading of two children's stories ("Prarie Dog Goes to School" and "The Buffalo and the Bullboat").[9] The elicited word list came from a combination of the Hidatsa dictionary project that took place on Fort Berthold between 2014 and 2016, and from elicited word lists and sentences recorded at the University of Colorado Boulder through a CARTSS grant. These stimuli illustrate the Hidatsa clusters (h+C) in medial position. Cross-linguistically, pre-aspiration usually occurs in medial position (name source about initial position). Table 3 below is an example of the stimuli used in this study.

Table 3: Sample stimuli

Preceding vowel	Consonant cluster	IPA	Word	Gloss
í	⟨hb⟩	[ˈt͡sihpə]	*cíhba*	'prairie dog'
áa	⟨hd⟩	[ˈɑːhʊ]	*áahdu*	'head'
í	⟨hg⟩	[ˈpuːʃihke]	*búushihge*	'cat'
óo	⟨hc⟩	[ˈpuːʃihke]	*moːhʔ͡sɑː*	'coyote'
í	⟨hsh⟩	[ˈhihʃuə̯]	*híhshua*	'mint'
ó	⟨hsh⟩	[ˈohxɑːdɪ]	*óhxaadi*	'white'

We included stimuli where previous scholars have identified a glottal fricative preceding an obstruent. These sources include items present in Boyle & Gwin (2006), Boyle (2007), Park (2012), Boyle et al. (2016), as well as personal fieldwork conducted by the present authors.[10]

4.3. Recording and analysis

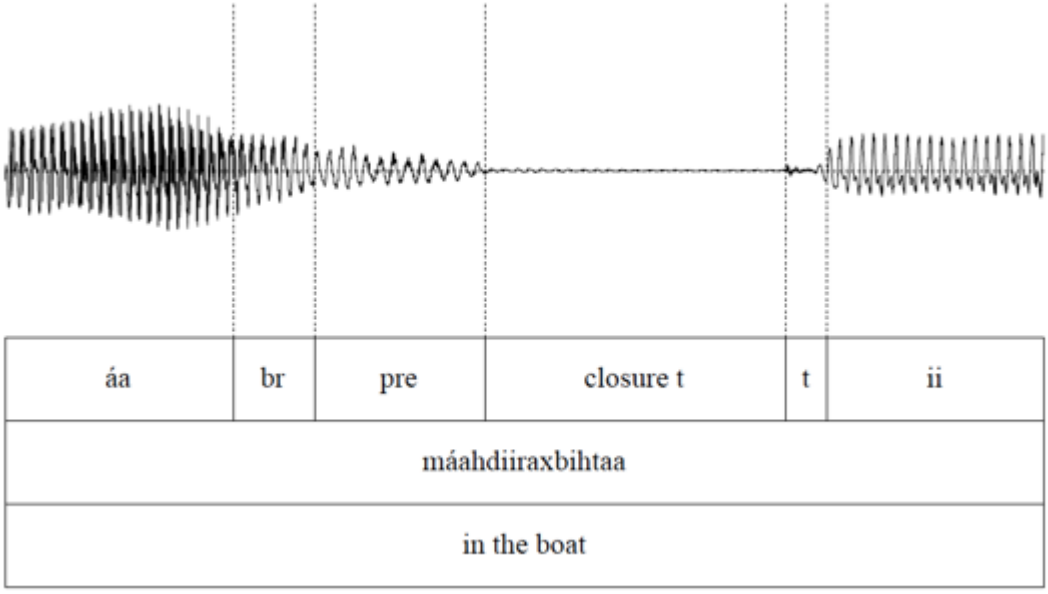
Recordings were made throughout several summers between 2015 and 2017 on the Fort Berthold Indian Reservation in North Dakota at Nueta Hidatsa Sahnish College or in the Phonetics Lab at the University of Colorado Boulder. The recordings were made using a Blue Shure microphone in a constructed sound-proof room and saved as waveform audio format (.wav) files. The data were

[9] Videos that contain the visuals of these stories with a speaker reading along can be found at https://www.youtube.com/watch?v=RB5M1-1ZWQo and https://www.youtube.com/watch?v=EeYeywXvsPI.

[10] There were instances of data that were sought out that had to be discarded due to the fact that we could not corroborate the presence of any glottal frication or other phonetic elements aside from a vowel and a supralaryngeal obstruent where a previous scholar had transcribed a ⟨h⟩. The overtranscription of ⟨h⟩ scholars for Hidatsa could be due to the perception of breathiness on the part of the speaker that is non-linguistically salient (i.e., a speaker might just have a particularly breathy style of phonation across the board rather than trying to use breathy voice to indicate the presence of ⟨h⟩.

analyzed with Praat (Boesma & Weenik 2016) to conduct waveform and spectrographic analysis. The segmentation of pre-aspiration was made according to current practice, a narrow approach, labeling pre-aspiration as two components: segmenting both breathiness and pre-aspiration (Hejná 2015, 2016). Hejná (2015:43) believes that by applying the narrow approach, it provides a better understanding of how pre-aspiration develops historically. Each token, including an obstruent series, was segmented and labeled, as shown in Figure 3.

Figure 3: Example of the identification and segmentation of *máahdiiraxbihtaa* [ma:^{h}ti:ɾaxpi^{h}ta:] "in the boat" in word-medial position showing breathiness; br = breathiness; pre = pre-aspiration; closure = closure



The beginning of the pre-aspiration segmentation was labeled similarly to the segmentation throughout Hejná (2015), where there is focus on segmenting the components of pre-aspiration narrowly. Boundary lines were labeled where there are increasingly less quasi-sinusoidal ripples in the waveform, this is the indicator of an articulatory gesture associated with voicing cessation. The breathy interval was segmented to end where these high quasi-sinusoidal ripples terminate (Hejná 2015:75).

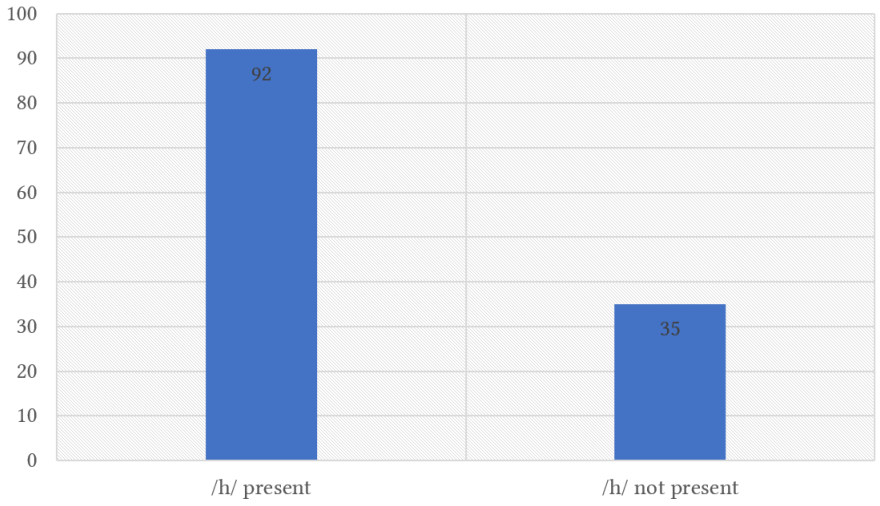
4.4. Results

The main goal of acoustically analyzing the Hidatsa obstruent series is to understand the status and manifestations of the series. We find that speakers either preserve, omit, or insert an alternative surfacing manifestation in replacement for the /h/ segment in h+C clusters. In this subsection, we provide a preliminary description of these occurrences.

Of the 127 analyzed clusters for this study, we find a division between the number of /h/ occurrences (n=92) and the number of instances when /h/ was not present in the cluster (n=35). Figure 4 presents this divide. These numbers represent a strong tendency in Hidatsa to preserve

underlying /h/ in the output. This strong tendency, however, still has a large number of tokens in which the /h/ is omitted.[11]

Figure 4: Number of of tokens when /h/ was either present or not in h+C sequences for speakers



Below, additional acoustic evidence is provided in Figures 5 and 6 to support the preservation of /h/ and the omission of /h/ in h+C clusters. In Figure 5, an arrow is given to display the timing of the production of /h/ in the word *íihga* [íːhkə] 'chi.' (62.71ms). Figure 6 represents the word for 'eight,' *núubahbi* [nuːbapi] (107.24ms).

Figure 5: Preserved /h/ in *íihga*

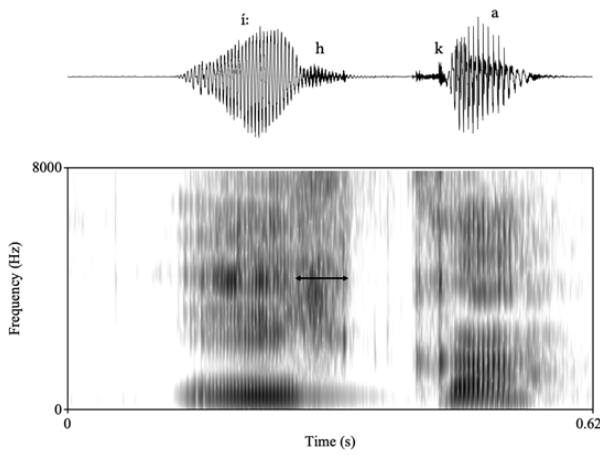
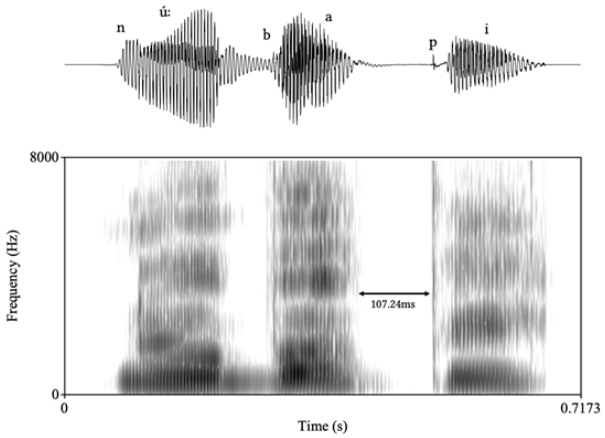


Figure 6: Omitted /h/ in *núubahbi*

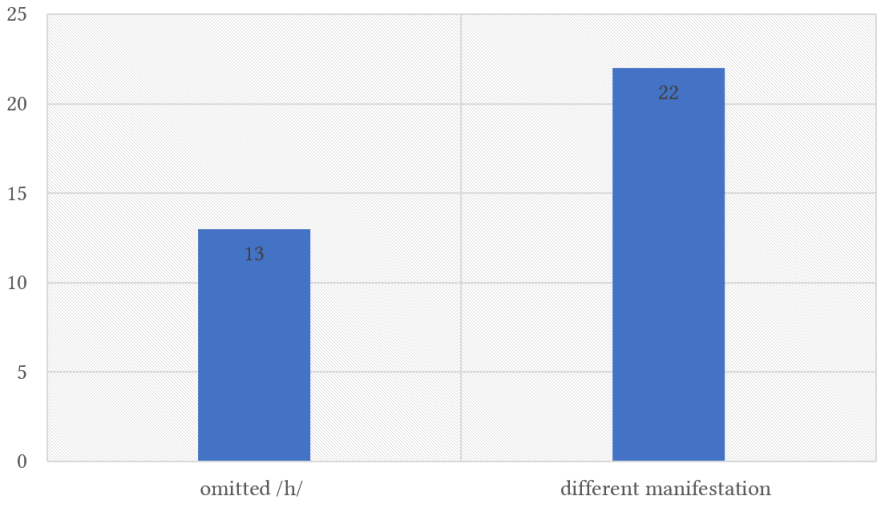


Notice in Figure 5, the given arrow is a selection of friction noise, with aperiodic noise, that represents aspiration. Here we see a preservation of the /h/ phoneme in the h+C cluster. Oppositely, in Figure 6, there is evidence of silence in the spectrogram. This is represented by

[11]These omissions are never systematic: i.e., in certain productions of a token, the /h/ is present, while in others, it is not. Thus, we are not relying purely on the transcriptions of previous scholars, but investigating whether there is a /h/ there in the first place.

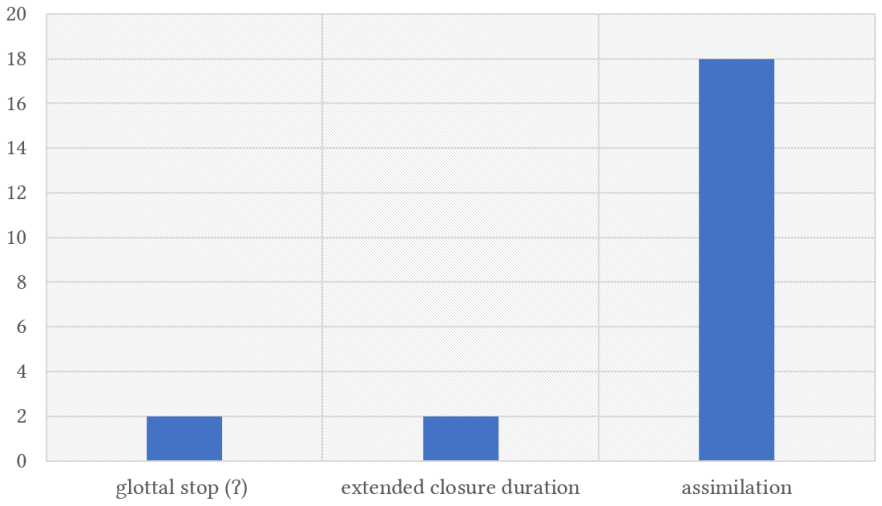
the arrow. The waveform displays a flat line which supportingly indicates a missing segment in the h+C cluster. For the occurrences where /h/ was not present, some were omitted (n=13) or surfaced with entirely different manifestation (n=22). Figure 7 displays this distribution.

Figure 7: Number of /h/ omissions or alternative surfacing manifestations of h+C



We find an outcome of three-way division for the tokens that presented with different surfacing outcomes other than /h/ in h+C cluster sequence. This three-way division is represented below in Figure 8. The alternative surfacing manifestations included glottal stop insertion (n=2), an extended closure duration (n=2), and evidence of /h/ assimilating to the following segment in the cluster (n=18).

Figure 8: Number of occurances for alternative surfacing manifestations



Figures 9-12 offer acoustic evidence for this three-way division. Figure 9 shows evidence of glottal stop insertion for /h/ in the word *áhgagoori* [ˈʔɑʔkəgoːrɪ] 'thousand.' Notice in the spectrogram of this figure, a quick transient burst indicated by a vertical line after the production

of the vowel. This indicates that the phoneme replaced here in this cluster is something other than a glottal fricative /h/. Figure 10 displays extended closure duration (173.60ms) in the word *xúhdi* [ˈxutɪ] 'gloves.' The period of this closure can be compared to that of Figure 6 where the closure duration measures less (107.24ms). Similarly to Figure 6, Figure 10 also omits the /h/ segment in the word *xúhdi*. Like our previous observation of Figure 6, Figure 10 shares the same characteristics of a flat line in its waveform, proving the omission of the /h/ segment.

Figure 9: /h/ as [ʔ] in *áhgagoori*

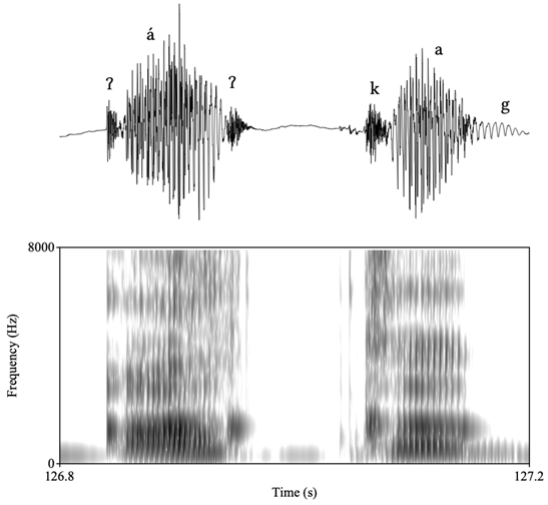
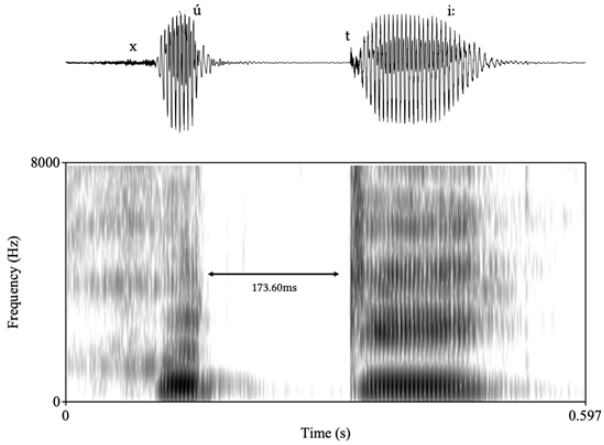


Figure 10: /h/ as extended closure in *xúhdi*



Figures 11 and 12 represent *híhshu* [ˈhiʃ·ʊ] 'mint' and *híhci* [ˈhis͡tsɪ] 'pink,' respectively. These tokens show evidence of the first component of the cluster (underlyingly /h/) assimilating to the second component of the group. Here in Figure 11, we see a lengthened aperiodic production of the /ʃ/ phoneme with slighlty lower frequency than the /s/ phoneme in Figure 12. Evidence for /s/ in the output for *híhci*, rather than an /h/ phoneme seen in Figure 5, is proven through the high frequency turbulent airflow.[12] The surfacing outcomes of this connected speech is that 1) the cluster becomes one long phoneme, evidencing a similar waveform structure to a geminate phoneme, and 2) the first component becomes more like one of the components from the affricate.

It should be noted that there were three occurrences in the data where *h*+*c* (/t͡s/) preserved the /h/ component in the cluster, though alternative realizations of /h/ were more common in the environment of the affricate. Another factor we examined was the interaction of stress and the manifestation of /h/ for h+C clusters. Figure 13 displays a breakdown of the distribution of the effect of stress upon the realization of /h/ in a h+C cluster. We find that preceding stress plays no no statistical significance role in /h/ deletion or assimilation.

One may argue for a geminate phoneme for the waveform structure of Figure 10, since a language is said to have a geminate contrast when the contrast affects the duration of the sound (Blevins 2008). However, it is not uncommon to find surface geminates derived by some phonological processes, most often by assimilation like we see happening in Figures 11 and 12 (Ridouane

[12] An /h/ phoneme in a spectrogram appears with faint formant bands. A glottal frictive generates its turbulence in the same place where voicing originates so the turbulence of /h/ is subject to the same filter as a vowel (Freeman 2012:89).

Figure 11: /h/ assimilating in *híhshu*

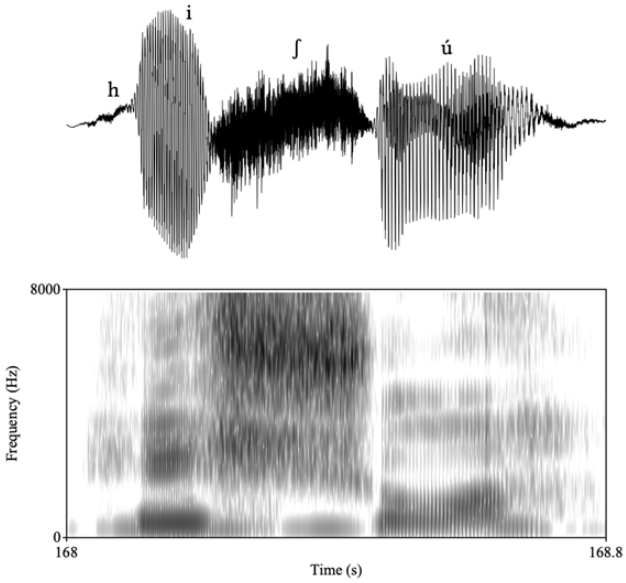


Figure 12: /h/ assimilating in *híhci*

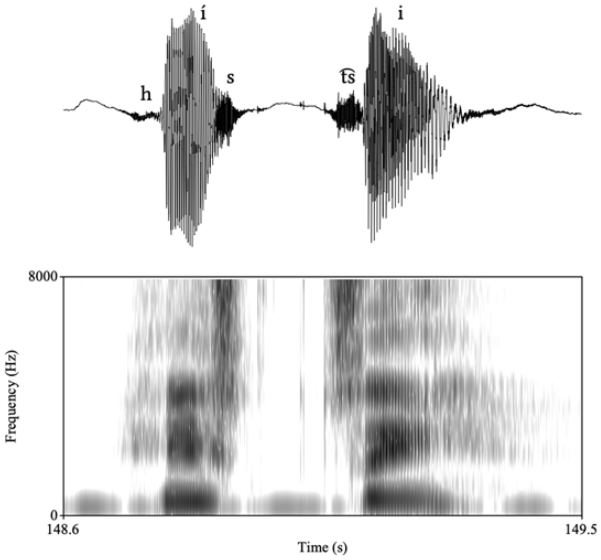
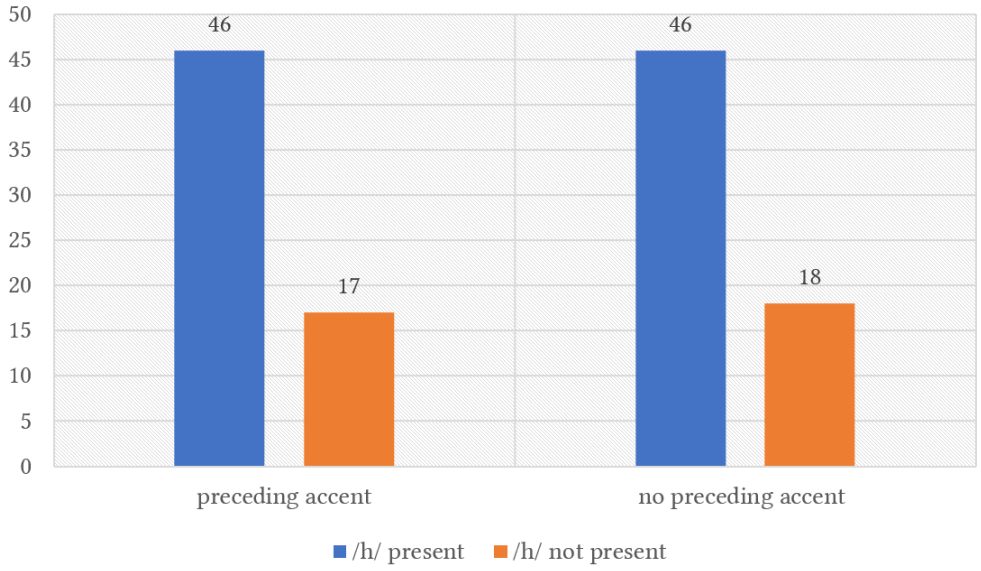


Figure 13: Influence of preceding stress on the presence of /h/ in h+C cluster



2007). For this reason, we do not suggest that Hidatsa has geminate consonants, as well as because these false geminates represent a minority of the manifestations of /h/ in a cluster.[13] Of the 127 tokens used in this study, only 20 tokens exhibited an assimilation pattern. Additional work is needed to further corroborate this analysis, but an analysis that posits underlying geminates

[13]Some scholars have proposed that Hidatsa has geminates, but those observations are not borne out in the data. Graczyk (2007) certainly describes Crow, Hidatsa's nearest relative, as having a contrast between singleton and geminate obstruents, but the phonetic data for Hidatsa here does not suggest that gemination is an inherited trait for both languages.

would need to somehow account for the fact that assimilatory processes (i.e., /h/ assimilating to either the place and/or manner of articulation of the following obstruent) make up approximately one-sixth of the observed data. The most parsimonious analysis is that Hidatsa has an underlying /h/ that has a higher degree of phonetic realization, and that assimilation represents only one possible manifestation of those glottal fricatives.

5. Discussion of pre-aspiration versus consonant clusters

Overall, the data examined for this paper found that there is a degree of variability with respect to the phonetic realization of consonants that have been described as "pre-aspirated" in Hidatsa. Given the consistency of how post-aspirated elements are described throughout the literature, we have not examined phonetic characteristics of said obstruents, though this is a topic that future work should focus on. The results of our analysis showed us that the status of /h/ that is part of consonant clusters is not easily explained. Furthermore, these data did not conclusively show that "pre-aspiration" occurs uniformly for all speakers.

5.1. Impact of study

This paper is a preliminary descriptive sketch of the obstruent series h+C in Hidatsa. The methodology pursued this analysis is discussed in this section. One possible objection a reader may have relies heavily on elicited text for acoustically describing the obstruent series h+C. Using elicited tokens that were collected for learning materials could have an impact on the production of the series i.e., hyper-articulation. As a result, one may claim that implications cannot be drawn on the description of these clusters based solely on this analysis. While we acknowledge here that this report is preliminary, it still provides insight to any unanswered questions regarding the status of pre-aspiration for any future studies of the series in Hidatsa.

5.2. Areas for future research

One major issue throughout this study is that the /h/ in h+C clusters had a wide range of realizations. One factor that was not controlled for was looking at individual speakers. It is possible that some of this variation is idiolectal or familylectal. While all the speakers we worked with were cousins and have shared close ties throughout their lives, different households could be influenced by other members that were not part of this study. Further work is needed to divide the data by speaker and see what patterns emerge.

Another issue to be examined further is that of closure duration in h+C clusters. Extended closure duration measured for Figure 8 averaged 229.19ms. Although, on average closure duration appears to be long for speaker of Hidatsa or again it could be that the speakers were conscious that the elicited words would become the database to an online dictionary. All of the consultants involved in this work are also educators, which could be a confounding factor, as individuals may have tried to model words for future learners to discern their pronunciation. That is to say, there may be a question of how natural the speech we collected was. Follow-up work is needed to rule out any possibility of hypercorrection being a confound for closure duration.

Figure 14: Speaker 1's *máahci* 'pine'

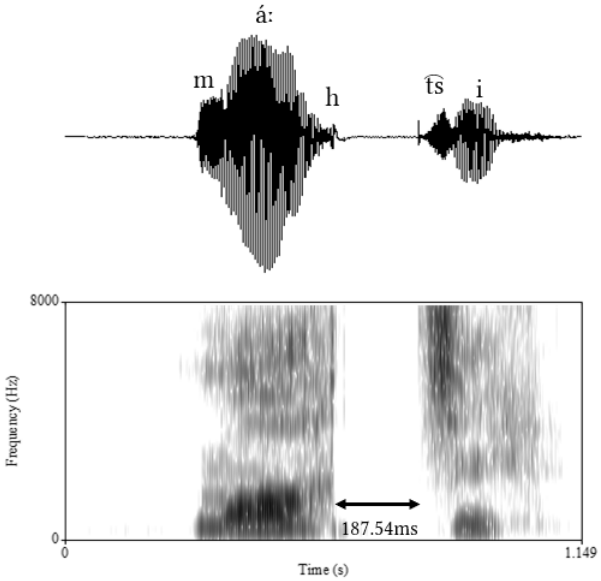
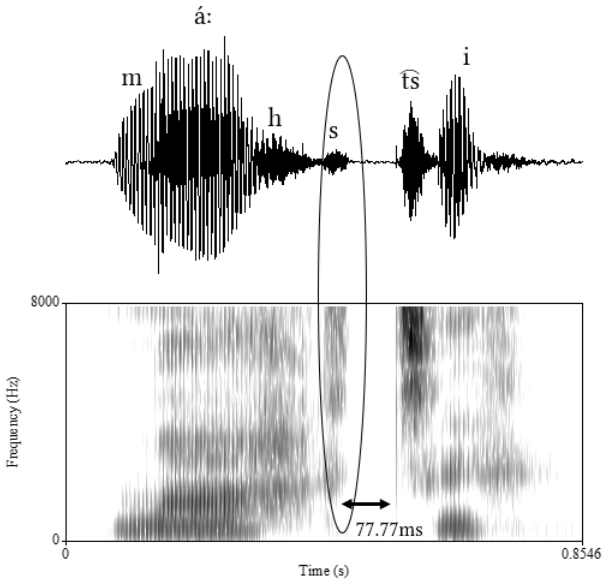


Figure 15: Speaker 2's *máahci* 'pine'



In particular, we can compare the difference in closure duration in Figure 14 above and compare it to Figure 15. Above, we see two examples of the same token from two different speakers for *máahci* ['mɑːht͡sɪ] 'pine.' In Figure 14, an arrow is provided to display the lengthened closure duration (187.54ms) in comparison to the speaker in Figure 15. In addition, Figure 15 displays a circle to show the production *h+c* [hst͡s]. We can see that Figure 14 has a slightly longer closure duration than all others in all examples shown in this paper, and Figure 15 mirrors Figure 12 in that there is some assimilation of the /h/ to the following obstruent, but the /h/ does not assimilate completely; there is a transition from [h] to [s], raising the question of gestural timing.

Ultimately, one factor that seems to be playing a decisive part in creating this variability is the many viable phonetic possibilities for how /h/ is realized when part of a cluster. Boyle et al. (2016) made the case that Hidatsa is a stress accent language where primary stress is assigned through weight-sensitive left-aligned iambs. Furthermore, coda glottal elements added to syllable weight, attracting stress. If these /h/ segments are really underlyingly present in the input, then it makes sense that there is a large range of possible gestures for /h/, as speakers are simply trying to fill a timing slot with some indicator that there is a mora present. We can see this process at work in the pronunciation of two different speakers for the word *cíhba* 'prairie dog' in the figures below.

Figure 16 shows ommision of the /h/ in the h+C cluster series. Recall from Figures 5 and 10, that a flat line and silence are indicators for an omitted segment. Here in Figure 16, we see identical acoustic evidence where the /h/ is omitted in the h+C cluster series. Oppositely, Figure 17 preserves the /h/ segment. Furthermore, Figure 17 displays the effects of breathiness moving leftward into the vowel and the preservation of /h/ in the cluster. In addition to the waveforms and spectrograms in Figures 16 and 17, a schematic representation is provided of the laryngeal opening gesture that is variably aligned relative to the oral articulators. The gestural figure is adapted from diagrams appearing throughout Beddor (2007).

Figure 16: Speaker 1's *cíhba* 'prairie dog'

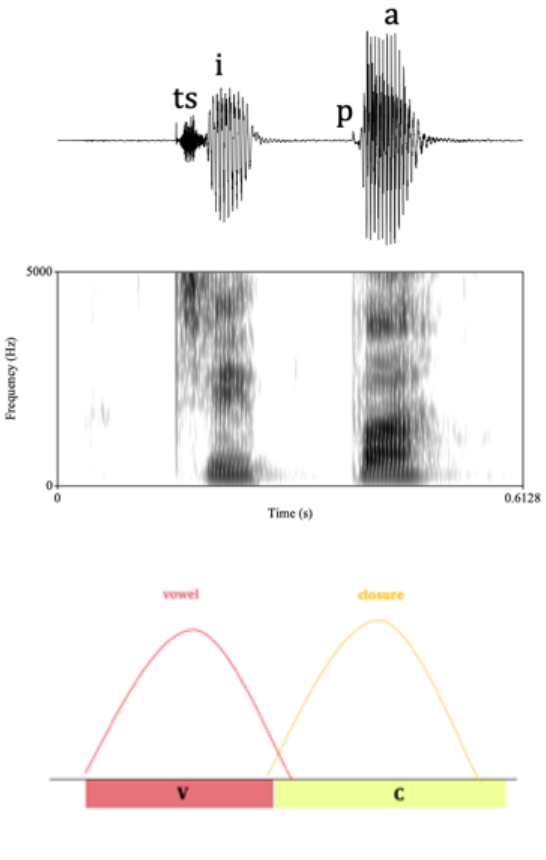
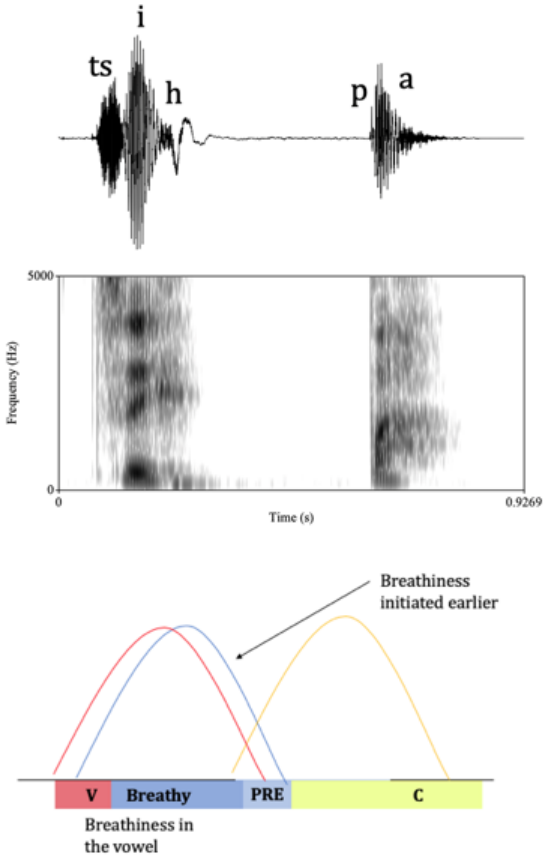


Figure 17: Speaker 2's *cíhba* 'prairie dog'



Figures 16 and 17 give supportive schematic representations of the re-alignment of the laryngeal opening gesture in pre-aspiration. The laryngeal opening gesture is evenly sized for both occurrences in Figure 16 and Figure 17, but the initiation of the onset of breathiness in Figure 17 occurs earlier in the vowel (anticipatory pre-aspiration). We see the gestural feature of aspiration become anticipatory for the speaker and move leftward into the vowel in Figure 17.

Figure 16 gives a schematic representation of the omission of /h/, showing the deleted laryngeal gesture. Additional work is needed with current speakers along with examining older recordings to determine the directionality of this variability. Namely, is one realization of /h/ becoming more common over time, or have these variable productions of /h/ in h+C clusters existed since the time of the earliest Hidatsa recordings in the first half of the twentieth century. If this variability is a newer phenomenon, then Hidatsa could be undergoing a sound change with respect to the realization of coda /h/.

6. Conclusion

While other work has been done on areas of the sound system of Hidatsa, such as the work by Boyle et al. (2016) on primary stress and syllable weight, much more work needs to be done. This study represents an initial attempt to look at the obstruent series in Hidatsa. We cannot

conclude that Hidatsa has phonologically distinct pre-aspirated obstruents from these data. What our study adds to current understanding of Hidatsa is that we can now have a discussion on the ways that speakers differ in their use of Hidatsa without resorting to anecdotes or impressionistic generalizations. We can extrapolate from these data that Hidatsa has h+C clusters where speakers realize coda /h/ as something other than [h] more than 25 percent of the time. However, there is a limited number of ways in which non-[h] manifestations of /h/ can appear in the output.

Additional work is needed to examine where Hidatsa fits in the typology of coda glottal consonants and their behavior in consonant clusters, but for the time being, it appears we can rule out these elements being "true" pre-aspiration (i.e., phonologically distinct singleton obstruents that begin with glottal frication). Crow likewise has clusters that have been described as being pre-aspriation, so a comparative Hidatsa-Crow phonetic survey could shed light on whether this variation in the production of /h/ in h+C clusters is unique to Hidatsa or if it is a shared feature between the two languages.

References

Beddor, Patrice Speeter. 2007. The phonetics and phonology of nasal gestures. Paper presented at Haskin Staff Talk series. Haskins Laboratory: New Haven, CT. (Available online at http://www.haskins.yale.edu/PowerPoint/Beddor_2007-09-27.ppt).

Blevins, Juliette. 2008. Explaining diversity in geminate consonant inventories: An evolutionary approach. Lecture delivered during Leipzig Spring School on Linguistic Diversity. Max Planck Institute for Evolutionary Anthropology: Leipzig, Germany. (Available online at https://www.eva.mpg.de/lingua/conference/08_springschool/pdf/course_materials/blevins_evening_lecture.pdf).

Bloomfield, Leonard. 1925. On the sound-system of Central Algonquian. *Language* 1(4). 130–156.

Boesma, Paul & David Weenik. 2016. Praat: Doing phonetics by computer. [Computer program]. Version 6.0.42, retrieved 11 December 2018 from http://www.praat.org/.

Bowers, Norman. 1996. *Hidatsa suprasegmentals: A phonological analysis of a Siouan Native North American language.* Moscow, ID: University of Idaho Press.

Boyle, John P. 2007. *Hidatsa morpho-syntax and clause structure.* Chicago, IL: University of Chicago dissertation.

Boyle, John P. & Alex Gwin. 2006. English-Hidatsa and Hidatsa-English wordlist. Ms. Mandaree, ND. (Preliminary version).

Boyle, John P., Ryan M. Kasak, Sarah Lundquist, Armik Mirzayan, Jonnia Torres & Brittany Williams. 2016. A preliminary study on accentuation in Hidatsa. Paper presented at the annual meeting of the Society for the Studies of the Indigenous Languages of the Americas at the Linguistic Society of American annual meeting. Washington, DC.

Clayton, Ian. 2010. *On the natural history of preaspirated stops.* Chapel Hill, NC: University of North Carolina, Chapel Hill dissertation.

Clayton, Ian. 2017. Preaspiration in Hebrides English. *Journal of the International Phonetic Association* 47(2). 155–181.

Freeman, Valerie. 2012. Linguistics 450/550: Introduction to phonetics. Lecture slides for Fall 2012 Linguistics 450/550 class. University of Washington: Seattle, WA. (Available online at https://freemanvalerie.weebly.com/uploads/7/6/7/8/76788261/450_lectures_fall12.pdf).

Graczyk, Randolph. 2007. *A grammar of Crow*. Lincoln, NE: University of Nebraska Press.

Grimm, Thaddeus C. 2012. *The Siouan languages*. Newton, KS: Mennonite Press.

Hejná, Michaela. 2015. *Pre-aspiration in Welsh English: A case study of Aberystwyth*. Manchester, UK: University of Manchester dissertation.

Hejná, Michaela. 2016. Pre-aspiration: Manual on acoustic analysis 1.1. Ms. New Castle, UK: University of Newcastle. (Available online at https://ling.auf.net/lingbuzz/003184.).

Helgason, Petur. 1998. Preaspiration in Swedish and its implications for historical sound change. In Peter Branderund & Hartmut Traunmüller (eds.), *Proceedings of FONETIK 98*, 16–19. Stockholm, Sweden: Stockholm University Department of Linguistics.

Helgason, Petur. 2002. *Preaspiration in the Nordic languages: Synchronic and diachronic aspects*. Stockholm, Sweden: Stockholm University dissertation.

Jones, A. Wesley. 1984. Hidatsa consonants. Paper presented at the 1st Workshop on Comparative Siouan Grammar. Boulder, CO: University of Colorado.

Larson, Rory M. this volume. Glottalized consonants in Mississippi Valley Siouan. In Ryan M. Kasak (ed.), *Proceedings of the 38th Siouan and Caddoan Languages Conference*, 35–42. Chicago, IL: Northeastern Illinois Linguistics Department.

Matthews, G. Hubert. 1965. *Hidatsa syntax*. London, UK: Mouton & Co.

Park, Indrek. 2012. *A grammar of Hidatsa*. Bloomington, IN: Indiana University dissertation.

Quintero, Carolyn. 2004. *Osage grammar*. Lincoln, NE: University of Nebraska Press.

Rankin, Robert L., Richard T. Carter & A. Wesley Jones. 1998. Proto-Siouan phonology and grammar. In Xingzhong Li, Luis Lopez & Tom Stroik (eds.), *Papers from the 1997 mid-america linguistics conference*, 366–375. Columbia, MO: University of Missouri-Columbia Press.

Rankin, Robert L., Richard T. Carter, A. Wesley Jones, John E. Koontz, David S. Rood & Iren Hartmann (eds.). 2015. *Comparative Siouan dictionary*. Leipzig, Germany: Max Planck Institute for Evolutionary Anthropology. (Available online at http://csd.clld.org/, Accessed on 2018-05-25.).

Ridouane, Rachid. 2007. Gemination in Tashlhiyt Berber: An acoustic and articulatory study. *Journal of the International Phonetic Association* 37(2). 119–142.

Robinett, Florence M. 1955. Hidatsa I: Morphophonemics. *International Journal of American Linguistics* 21(1). 1–7.

Silverman, Daniel. 2003. On the rarity of pre-aspirated stops. *Journal of Linguistics* 39(3). 575–598.

Stetson, Raymond H. 1946. An experimentalist's view on Hidatsa phonology. *International Journal of American Linguistics* 12(3). 136–138.