

Vowel Devoicing and Tone Recoverability in Cheyenne

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Abstract. Cheyenne has both vowel devoicing and tone. The resolution of the conflict between these two phenomena differs depending upon the position of the vowel in the word. The tone of a non-final devoiced vowel is lost completely (or, in some contexts, is inferable because of a particular tonal restriction on devoicing), whereas the tone of a final devoiced vowel is always recoverable. Leman [1981] claims that the mechanism of recoverability is special sandhi tones on the penult, which result from tonal assimilation rules applying prior to devoicing. In this paper I will present phonetic evidence that Leman's sandhi tones do not exist, and therefore that his analysis cannot correctly characterize the nature of tone recoverability in Cheyenne. An alternative autosegmental analysis will be proposed in terms of tone spreading, and an independently motivated accent will be suggested as an explanation for the difference in behavior between final and non-final tones.

Introduction

The phonology of Cheyenne¹ has two prominent characteristics which are in apparent conflict with one another. On the one hand, there is extensive vowel devoicing, as described by Leman and Rhodes [1978], and, on

¹ Cheyenne is an Algonquian language now spoken in Montana and Oklahoma. The group in Montana are called 'Northern Cheyennes' (NCh), and those in Oklahoma 'Southern Cheyennes' (SCh). The language of the two groups is essentially the same.

the other hand, a tone system² in which a vowel bears one of two contrastive pitch levels.

The vowel devoicing results from two different devoicing processes. These processes may be described informally as follows:

- (1a) **Final devoicing.** The vowel of the final syllable devoices unless followed by a glottal stop in the same word.
- (1b) **Prepenultimate devoicing.** A vowel earlier in the word than the penultimate syllable devoices if (i) followed by a voiceless continuant, (ii) word initial or preceded by a consonant other than h, and (iii) if HIGH-toned, the vowel must be immediately preceded by another syllable with a HIGH-toned vowel.

(The vowel of the penultimate does not devoice.) These devoicing processes are exemplified by the following forms (where capital letters signify devoiced vowels):³

²Tone is not characteristic of the Algonquian family, but Frantz [1972b] has argued that the distinction between long and short vowels in proto-Algonquian was replaced by a contrast between HIGH and LOW tone when vowel length was lost in Cheyenne.

³The vowel of the initial syllable of 'eagles' and of 'bead' does not meet condition (i), and so remains voiced. In 'twin girl' and 'twin' the vowel of the initial syllable does not devoice since condition (ii) is not met. Note that the a that devoices in 'twin girl' remains voiced when found in penultimate position in 'twin'. Condition (iii) is not met in the second syllable of 'bead', nor is the condition for devoicing the final vowel o in this word because of the following glottal stop (which I take to be [+sonorant], following Clements and Halle [1983]. The superscript e is inserted by a relatively late epenthesis rule to be discussed below.) When the above conditions are met, however, devoicing does occur, and is completely regular.

- (2) [hestAhkEhá?E] 'twin girl'
 [hestahkE] 'twin'
 [MOheNEšÉMO] 'ladybug'
 [netseo?O] 'eagles'
 [onéhawo?k^e] 'bead'

The tone system is one in which a vowel bears one of two contrastive pitch levels ('HIGH' and 'LOW'). The following minimal pairs illustrate the tonal contrast:⁴

- (3) énaa?e 'he died'
 énaá?e 'he doctored'
 matana 'milk'
 matána 'breast'
 éstsema?e 'gopher'
 éstsemá?e 'gophers'
 tséhetanéveto 'you who are a man'
 tséhetanévéto 'I who am a man'

These two phenomena of vowel devoicing and tone are in conflict because the phonetic correlate of tone is pitch, which is primarily a function of fundamental frequency (F₀), which in turn is a function of the rate of vocal cord vibration in voicing. When a tone-bearing vowel devoices, therefore, the pitch of that tone can no longer be a property of the vowel.

⁴Examples not enclosed in brackets or slashes are given in Cheyenne orthography. An acute accent indicates HIGH tone, and LOW tone is left unmarked.

A language with both vowel devoicing and tone has recourse to four ways of resolving the conflict:

- (4a) The tone may be realized on the devoiced vowel by some other 'secondary' phonetic cue, such as length or vowel quality.
- (4b) The tone of a devoiced vowel, being unrealizable as the pitch of the vowel, may be lost.
- (4c) Vowels with a certain tone may be blocked from devoicing, so that the tone of a devoiced vowel, although phonetically unrealized, can be inferred phonologically by a process of elimination.
- (4d) The tone may be redistributed on the word, being realized in some way on a voiced vowel adjacent to the devoiced vowel.

Option (4a) is not attested in Cheyenne, as there is no noticeable difference in formant structure or duration between devoiced vowels that can be correlated with different underlying tones. Leman [1981:284] asserts that certain HIGH-toned vowels are also 'more tense', but he gives no examples or evidence, and moreover makes the claim only for voiced vowels.

Prepenultimate devoicing in Cheyenne involves in part option (4b) and in part option (4c). Option (4c) is involved because a HIGH vowel does not devoice except after another HIGH-toned vowel (condition (iii) in (1b)). Thus a devoiced vowel not preceded by a syllable with a HIGH-toned vowel can only be underlyingly LOW itself. This is the case for the prepenultimate devoiced vowels in the following examples:

- (5) [oʔkOhomeh0] 'coyotes'
- [hestAhkEháʔE] 'twin girl'
- [kAsowááh] 'young man'

When a devoiced prepenultimate vowel is preceded by a HIGH tone, however, option (4b) is involved. The devoiced vowel may be underlyingly HIGH or LOW, and the tone is not recoverable on the basis of any phonetic or phonological information present. This is the case for the prepenultimate

devoiced vowels in the following forms:

- (6) [háMEŠkoNO] 'beetles'
 [náhkOheoʔO] 'bears'
 [heváfAhkeMA] 'butterfly'

As the above discussion suggests, the interaction of tone and devoicing in prepenultimate syllables is reasonably straightforward. The rest of this paper therefore will be concerned instead with the final syllables of words, where there is no restriction comparable to condition (iii) concerning the tone which a vowel undergoing devoicing may have.

The behavior of the tone of the final vowel appears to be quite different from that of tones earlier in the word. Leman [1981] posits a set of assimilation rules by which the tone of the final syllable affects the tone of the penultimate prior to final devoicing. This creates a special sandhi tone on the penult, which he claims renders the underlying tone pattern of the last two syllables phonologically recoverable, despite the lack of any phonetic realization of the final tone:

Cheyenne pitch sandhi is closely related to Cheyenne devoicing phenomena. From a functional viewpoint, the pitch sandhi indicates what the phonemic pitches of devoiced [final] vowels are [Leman 1981:293].

This analysis can be considered a variant of option (4b), with the twist that the unrealized tone of the devoiced vowel is nevertheless completely recoverable by virtue of its effect on an adjacent tone at an earlier stage of the derivation.

In this paper I intend to demonstrate that Leman's pitch sandhi analysis is phonetically inaccurate, and that his characterization of the interaction of tone and vowel devoicing in final syllables is thus inadequate both in terms of the extent of recoverability and in terms of the mechanism responsible for the recoverability. The following discussion will be divided into two major sections. In the first section, I will review Leman's claims and provide phonetic evidence against those claims. In the second section, I will present a phonological analysis of the devoicing and tonal

processes based on the phonetic facts. I will argue that final devoicing involves a variant of option (4d), and will propose an explanation for the different behavior of the tones of devoiced final and prepenultimate vowels.

To begin with, however, it is necessary to present a brief summary of Cheyenne segmental phonology, including the many processes that insert or delete segments which make it rather difficult for the uninitiated to interpret examples without confusion.

Overview of Cheyenne Segmental Phonology

Cheyenne has ten consonant phonemes (p, t, k, m, n, s, š, v, h, ʔ) and three vowels (e, a, o). These will be classified according to the feature system of Clements and Halle [1983], in which the vowels, nasals, h, and ʔ are [+son(orant)], h is distinguished as [+spread (glottis)], and ʔ as [+const(ri^ct^ed glottis)]. Among the vowels, e is distinguished as [-back], and o as [+round].

Assimilation processes found throughout the examples include the following:⁵

- (7a) š becomes [x] when next to a back vowel (i.e., mirror image), with an intervening glottal stop permissible.
- (7b) v becomes [w] next to a rounded vowel.
- (7c) t assimilates to ts before a front vowel.
- (7d) h, when preceded by e, becomes [s] or [š] if followed by t or k respectively.

The consonants and vowels of Cheyenne are further subject to the rules of deletion, insertion, and devoicing given below. In the examples used to illustrate these, plural forms of nouns will often be given. Due to certain historical changes there have arisen two classes of plural suffixes, called 'e-class' and 'o-class'. There is a further division between plural suffixes for animate-gender and

⁵For a more complete discussion of Cheyenne segmental processes, see Davis [1962], Frantz [1972a], and Leman [1979] and [1980].

inanimate-gender nouns. The o-class suffixes are /-o/ (animate) and /-ot/ (inanimate). The e-class suffixes are /-é/ (animate) and /-ét/ (inanimate). The tones given in these examples will be motivated later below.

Deletion of final nasal or h. A sonorant consonant, excluding glottal stop, deletes word finally. This process thus affects nasals and h. The underlying presence of these segments can be seen in the first and third examples below, and their deletion in the second and fourth.

$$(8) \quad \begin{array}{c} C \\ [+son \\ -const] \end{array} \rightarrow \emptyset / _ \# \#$$

Thus: /háhnomah + o/ → [háhnomah0] 'bees'

But: /háhnomah/ → [háhnoMA] 'bee'

Thus: /šéʔšenon + o/ → [šéʔšenoNO] 'rattles'

But: /šéʔšenon/ → [šéʔšeNO] 'rattle'

Final e deletion. A word-final e deletes when preceded by a sonorant consonant other than glottal stop (i.e., nasals and h).

$$(9) \quad \begin{array}{c} V \\ [-back] \end{array} \rightarrow \emptyset / \begin{array}{c} C \\ [+son \\ -const] \end{array} _ \# \#$$

Thus: /hetane/ + [oʔ0] → [hetaneoʔ0] 'men'

But: /hetane/ → [hetaN] 'man'

Thus: /manehe/ + [oʔ0] → [maneheoʔ0] 'pelicans'

But: /manehe/ → [maneh] 'pelican'

Note that rule (8) feeds rule (9):

(10) Thus: /maʔšemen + o/ → [maʔxemeN0] 'apples'

But: /maʔšemen/ →⁽⁸⁾ maʔšeme →⁽⁹⁾ [maʔxeM] 'apple'

Vowel Copying. In a word-final sequence of two vowels, the second vowel is copied to the right with an intervening glottal stop. An obstruent may follow the vowel sequence:

(11)
$$V_i V_j \overset{C}{\left([-\text{son}] \right)} \# \# \rightarrow V_i V_j \overset{C}{? V_j \left([-\text{son}] \right)} \# \#$$

Where V_i may equal V_j

Thus: /méhtanke + o/ → [méstAhkeoʔ0] 'owls'

And: /vého + o/ → [véhooʔ0] 'chiefs'

And: /séot/ → [seoʔ0ts^e] 'ghost'

But: /séot + o/ → [séot0] 'ghosts'

Note that in 'ghost' the following rule of e epenthesis also applies.

e epenthesis. An epenthetic voiceless e is added after a final obstruent or glottal stop. Note that this process together with rule (9) has the effect of ensuring that final nasals and h are never followed by e, and all other final consonants are always followed by e. Leman and Rhodes [1978] have argued convincingly that this e is not present in underlying representation, and that the rule assigning it is fairly late so that it does not affect the tonal and devoicing processes. It does, however, trigger the rule assibilating a preceding t to ts (7c), as can be seen in the second example below. The epenthetic e will be represented by a superscript to avoid confusion with an e present underlyingly.

(12)
$$\emptyset \rightarrow e / \overset{C}{\left[\begin{array}{l} -\text{nasal} \\ -\text{spread} \end{array} \right]} _ \# \#$$

Thus: /hehtétat + o/ → [hestsétat0] 'kidneys'

But: /hehtétat/ → [hestsetAts^e] 'kidney'

Thus: /éhtema? + é/ → [éstsemá?E] 'gophers'

But: /éhtema?/ → [éstesma?^e] 'gopher'

Final devoicing. A sonorant devoices word finally or before a word-final obstruent.⁶ It is this rule that accounts for the devoicing of the vowel of the final syllable. (Examples follow (14).)

(13) [+son] → [-voice] / __ ([-son]) # #

Consonant devoicing. A consonant preceding a voiceless segment devoices. This rule is fed by final devoicing (13), as well as by prepenultimate devoicing (1b).

(14) C → [-voice] / __ [-voice]

Final devoicing and consonant devoicing apply after the deletion rules (8) and (9) and vowel copying (11), but before e epenthesis (12).

Thus: /ma?šemen + o/ ⁽¹³⁾ → ma?šemen0 ⁽¹⁴⁾ → [ma?xemeNO] 'apples'

And: /séot/ ⁽¹¹⁾ → seo?ot ⁽¹³⁾ → seo?Ot ⁽¹²⁾ → [seo?Ots^e] 'ghost'

And: /hováhn + é/ ⁽⁹⁾ → hováhn ⁽¹⁴⁾ → [howáhN] 'animals'

⁶In very rapid connected speech this sonorant sometimes remains voiced, but I find this quite uncommon, and not easily elicited without considerable arm-twisting.

Summary of Rules

Rules (8) through (14) are listed here for convenient reference. They are given in order of application.

- (8) Deletion of Final Nasal or h:

$$\begin{array}{c} C \\ [+son \\ -const] \end{array} \rightarrow / _ \# \#$$

- (9) Final e Deletion:

$$\begin{array}{c} V \\ [-back] \end{array} \rightarrow \emptyset \quad \begin{array}{c} C \\ [+son \\ -const] \end{array} _ \# \#$$

- (11) Vowel Copying:

$$\begin{array}{c} C \\ V_i V_j \end{array} \begin{array}{c} [-son] \\ \# \# \end{array} \rightarrow V_i V_j \text{ ? } V_j \begin{array}{c} C \\ [-son] \\ \# \# \end{array}$$

Where V_i may equal V_j

- (13) Final Devoicing: $[+son] \rightarrow [-voice] / _ ([-son]) \# \#$

- (14) Consonant Devoicing: $C \rightarrow [-voice] / _ [-voice]$

- (12) e Epenthesis:

$$\emptyset \rightarrow e / \begin{array}{c} C \\ [-nasal \\ -spread] \end{array} _ \# \#$$

1. Leman's Pitch Sandhi Analysis

Leman [1981] asserts that 'five phonetically distinguishable levels of pitch' can occur on a penultimate vowel in a word. These pitches are derived from the two underlying tones HIGH and LOW. The names Leman gives these variant tones are listed below from highest to lowest, along with the symbols and the diacritic vowel-marking he uses (shown here on [a]):

(15)	RAISED HIGH	\hat{H}	[â]
	HIGH	H	[á]
	MID	M	[ā]
	LOWERED HIGH	\check{H}	[ǎ]
	LOW	L	[a]

Leman describes RAISED HIGH as being 'slightly above high' with MID and LOWERED HIGH falling between HIGH and LOW. He analyzes these three tones as sandhi tones conditioned by the adjacent tones in the following ways:

LOW to MID raising [Leman 1981:294]. Penultimate LOW becomes MID if followed but not preceded by HIGH:⁷

(16)	$L \rightarrow M / \left\{ \begin{array}{l} \# \\ L \end{array} \right\} _ H \# \#$	
	/kosán/	→ [kōsA] 'sheep (sg)'
	/ne?e?é/	→ [ne?ē?E] 'bullsnake'

HIGH raising [Leman 1981:296]. Penultimate HIGH becomes RAISED HIGH if followed but not preceded by HIGH:

(17)	$H \rightarrow \hat{H} / \left\{ \begin{array}{l} \# \\ L \end{array} \right\} _ H \# \#$	
	/šé?šé/	→ [šê?šE] 'duck'
	/hotóhké/	→ [hotôhkE] 'star'

⁷The underlying tone patterns are from Leman [1979], and will be discussed later below.

HIGH lowering [Leman 1981:297]. Penultimate HIGH becomes LOWERED HIGH if followed by LOW and not preceded by HIGH:

- (18) $H \rightarrow \check{H} / \left\{ \begin{array}{l} \# \\ L \end{array} \right\} _ L \# \#$
- /honóʔkon/ → [honǒʔkO] 'quilt'
- /péʔe/ → [pěʔE] 'nighthawk'

As can be seen in these examples, the final vowel devoices following the tone sandhi, and so the final tone is not realized.

My reasons for questioning this analysis are, first, that I have never heard all five pitch levels, and second, that the phonetic description of them is implausible. Leman and Rhodes [1978:19] observe the following:

The musical distance between a high tone and a following low tone is approximately that of a major third. But the musical distance between a low tone and a following high is approximately that of a major second, but sometimes is as small as a minor second.

Given the above rules, however, RAISED HIGH, MID, and LOWERED HIGH can only occur on the penultimate vowel if they are preceded by a LOW antepenult, or are word initial. If, therefore, the antepenult is LOW, four different surface pitch sequences are possible over the antepenult and penult: LOW-RAISED HIGH, LOW-MID, and LOW-LOWERED HIGH, as well as LOW-LOW. It would be quite remarkable if consistent distinctions were made among four pitch levels within the range of a major second plus however much 'slightly above' HIGH is.

Testing the Analysis

In order to test Leman's analysis, I measured the difference in F₀ above a preceding LOW tone of each of the five putative pitch levels, and compared the differences. My goal was to determine whether the five pitch levels are phonetically distinct from one another, and if not, how they

should be grouped into a smaller number of levels that are distinct.

Method. The data used in this study were taken from recordings made of three speakers, two in Oklahoma (L.L. and J.F.) and one in Montana (J.G.). No phonological differences were noticed between the speakers from the two areas. The recordings were made in the course of several different interviews with each of the subjects, and consisted of words elicited in random order with an oral English cue, to which the subject responded with the corresponding Cheyenne word in the frame:

(19) nawóomo (NOUN) 'I see the (NOUN)'

Forms were elicited in this frame rather than in running text because a preliminary study showed that in rapid speech there is a decrease in the already narrow pitch separation between tones. Furthermore, words in contrastive position within a sentence generally exhibit greater pitch separation. The frame 'I see the (NOUN)' tended to elicit a contrastive reading, and so was conducive to maximal pitch separation, at the same time providing a natural context for the word being examined.

In the analysis, the F_0 of a tone was always measured in reference to that of another vowel in the same word. In all cases the reference vowel was a LOW-toned vowel in the immediately preceding syllable. The vowel of the target tone was always the penult for RAISED HIGH, MID, LOWERED HIGH, and LOW, and was the antepenult for HIGH (which does not occur penultimately following LOW, as described by Leman). Only forms that are segmentally identical or nearly identical in the environment of the tones being examined were compared.

Each test utterance was digitized at 8 kHz, and then analyzed using software developed in the Cornell Phonetics Laboratory for a PDP-11/40. The reference vowel was isolated on the wave form using a wave-form editing program, and was then fed to a companion F_0 -extraction program. F_0 readings were taken once every 10 ms. Sharp transitional pitch changes of 30 ms duration or less in the reference vowel were disregarded (average vowel length was about 100 ms total), and the resulting readings for the reference vowel's pitch contour were then averaged to give a mean F_0 value for the vowel.

Next, the target tone was segmented using the wave-form editor and analyzed by the F \emptyset -extraction program. This time, however, measurements were converted to semitone difference above or below the mean F \emptyset value of the reference tone. The result was a 'semitone difference curve' for the target tone contour, with the semitone difference from the mean value of the preceding LOW as a function of time from the onset of the target vowel. The time scale was then normalized to the average duration of the target vowel for a given type, and the mean and standard deviation were calculated for the curves of each type. The standard deviation curves were then graphed for a visual comparison with the corresponding curves of other types.

Results. A representative sample of these curve comparisons is given below in Figures 1 to 6. In each of these figures, the horizontal axis represents 100% normalized time, and the vertical axis indicates semitones above or below the mean F \emptyset value of an immediately preceding LOW tone. The dashed and solid lines represent one standard deviation above and below the mean semitone difference curve for the given type. The reference and target vowels are underlined in the phonetic transcriptions below the graphs. The tones marked are those claimed by Leman.

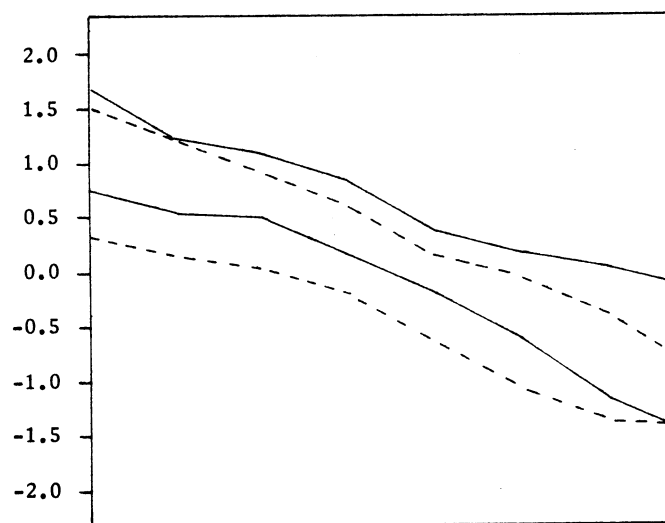


Figure 1. Comparison of HIGH and RAISED HIGH (speaker L.L.)

— HIGH [hetohkeo^o] 'stars' (8 tokens)
 --- RAISED HIGH [hetohke] 'star' (9 tokens)

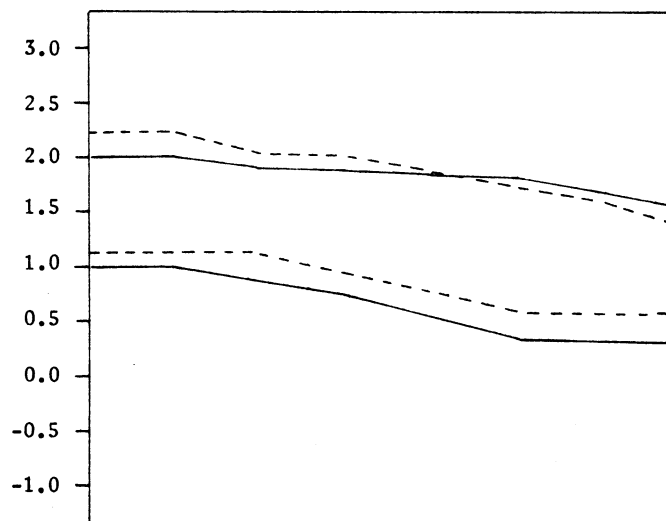


Figure 2. Comparison of HIGH and RAISED HIGH (speaker J.F.)

— HIGH [hesémoN0ts^e] 'his boats' (7 tokens)
 --- RAISED HIGH [hesêMO] 'his boat' (7 tokens)

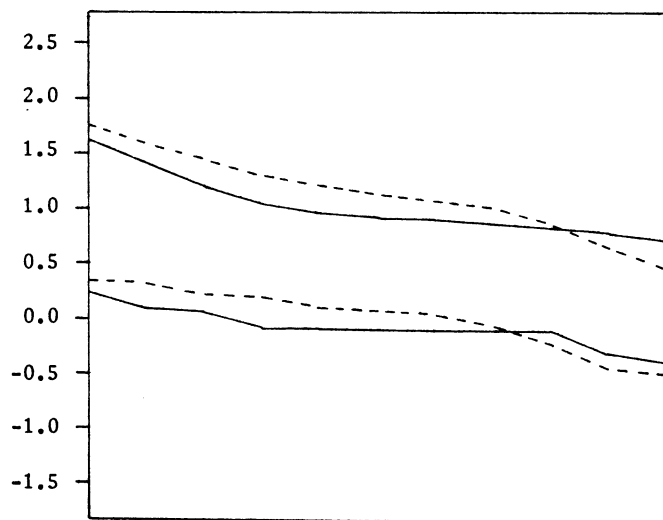


Figure 3. Comparison of HIGH and MID (speaker J.F.)

— HIGH [heškówet0] 'porcupines' (7 tokens)
 --- MID [hexōW0] 'clam' (5 tokens)

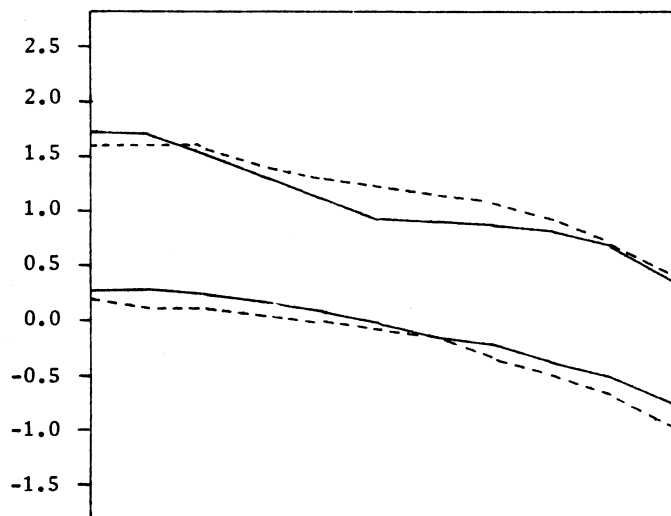


Figure 4. Comparison of RAISED HIGH and MID (speaker J.G.)

— RAISED HIGH [mo'e'hâN] 'magpies' (6 tokens)
 --- MID [ne'hâN] 'lake' (7 tokens)

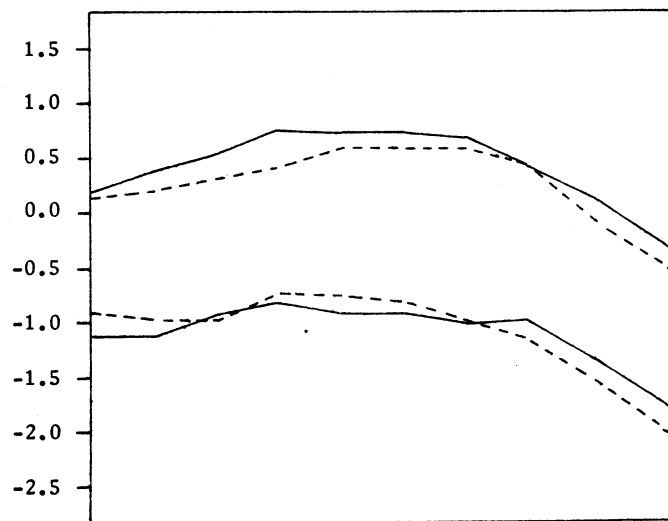


Figure 5. Comparison of LOW and LOWERED HIGH (speaker L.L.)

— LOW [maneh] 'pelican' (10 tokens)
 --- LOWERED HIGH [ho'emaněh] 'judge' (9 tokens)

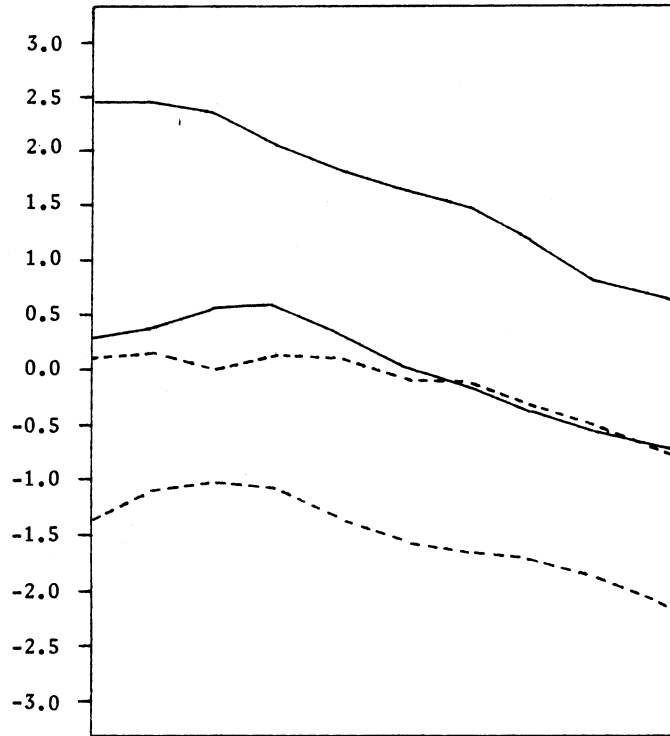
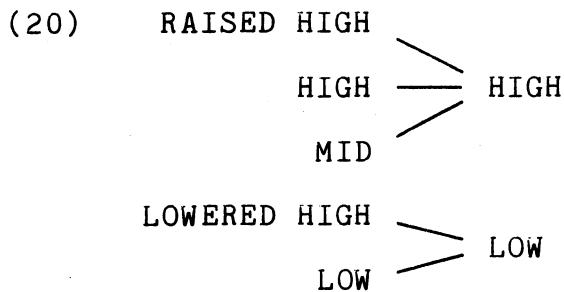


Figure 6. Comparison of RAISED HIGH and LOW (speaker J.F.)

— RAISED HIGH [ma'êxA] 'eye' (8 tokens)
 --- LOW [mo'eško] 'finger' (9 tokens)

Discussion. The nearly complete overlap of area within the curves in Figures 1 and 2 indicates that HIGH and RAISED HIGH are not distinguishable. Figure 3 shows HIGH and MID likewise to be indistinguishable. Figure 4 shows MID to be as far above a preceding LOW tone as RAISED HIGH is. Thus MID, HIGH, and RAISED HIGH do not represent distinct ranges of F₀ difference from a preceding LOW tone, and so cannot be different tone variants. In Figure 5 LOW and LOWERED HIGH are shown to be in an identical relationship to a preceding LOW. They also, then, should be considered to be the same tone. Finally, Figure 6 compares the distance of LOW and RAISED HIGH from a preceding LOW. It is evident from this figure that there is no room for three additional distinct pitch levels HIGH, MID, and LOWERED HIGH between these two.

These results indicate that RAISED HIGH, HIGH, and MID are not phonetically distinct, and that LOW and LOWERED HIGH are not phonetically distinct. We may therefore collapse the five spurious pitch levels as follows:



Since Leman's pitch sandhi account is thus not in accord with the phonetic facts as determined above, we are still left with the question of whether the tone of the devoiced vowel of the final syllable is phonologically recoverable, and if so, by what means.

2. An Alternative Analysis

In this section I will argue for an alternative analysis of tonal phenomena involving the final vowel. This analysis is most conveniently stated using the principles and

formalisms of autosegmental phonology.⁸

Tonal Patterns in LOW-LOW and HIGH-LOW Sequences

The clearest evidence for the underlying and corresponding surface tone patterns on the final and penultimate syllables is provided by nouns undergoing various types of suffixation. Consider first the following o-class words, in which all of the tones are LOW, both in the singular and when the plural suffix is added:

- | | | | | |
|------|-----------|---------|-----------------------------|-----------------------------|
| (21) | [maʔxeM] | 'apple' | [maʔxemeNO] | 'apples' (NCh) ⁹ |
| | | | [maʔxemeNOts ^e] | 'apples' (SCh) |
| | [heʔkO] | 'bone' | [heʔkoNOts ^e] | 'bones' |
| | [hoxeoʔO] | 'sock' | [hexeoNO] | 'socks' |

As Leman [1981] demonstrates, underlying tonal representations of noun stems can be determined from equative forms. These are denominal verbs formed by affixing the third person prefix /é-/ and the equative formative /-éve-/. When the equative formative is added, all of the noun stem falls to the left of the penultimate syllable, where tonal processes such as those discussed above are not claimed to occur. In the 'equative' forms corresponding to the nouns in (21), the stem remains LOW (stems are underlined here for easier reference):

- | | | |
|------|-------------------------|------------------|
| (22) | [<u>émaʔxemenefE</u>] | 'It is an apple' |
| | [<u>éheʔkonefE</u>] | 'It is a bone' |
| | [<u>éhoxeonefE</u>] | 'It is a sock' |

Thus the stems and o-class plural suffixes in (21) are

⁸For an overview of autosegmental theory, see Goldsmith [1976], Van der Hulst and Smith [1982], and McCarthy [1982].

⁹The word 'apple' is animate for speakers in Montana and inanimate for those in Oklahoma.

evidently LOW in tone on all syllables.

Contrast these o-class forms with the e-class words in (23) and (24). In the e-class words the final syllable of the stem has HIGH tone when in penultimate position in the plural form:

- (23) [éstsemaʔ^e] 'gopher' [éstsemáʔ^E] 'gophers'
 [véʔhoʔ^e] 'white man' [véʔhóʔ^E] 'white men'
 [onéhawoʔk^e] 'bead' [onéhawóʔkEsts^e] 'beads'

In the corresponding equatives, however, the stem final vowel is LOW:

- (24) [eéstsemaʔef^E] 'It is a gopher'
 [evéhoʔef^E] 'He is a white man'
 [éonéhawoʔkef^E] 'It is a bead'

The evidence of the equatives indicates that the underlying form of the stem of 'gopher', for example, is /H L L/, that the animate e-class plural suffix is in some way contributing a HIGH tone in the surface plural form.

Compare also the tones on the equative formative (underlined) in the following o-class animate and e-class inanimate plural equative forms below. (The inanimate equatives always take the e-class inanimate plural suffix.)

- (25) [émaʔxemenéveoʔ⁰] 'They are apples' (NCh)
 [éneʔhanévéNEsts^e] 'They are lakes'

In the first example in (25), the equative formative is [-éve-] when followed by the o-class plural suffix. This plural suffix was shown to be LOW in (21) above. When followed by the e-class plural suffix in the second form in (25), however, the equative formative is [-évé-]. This tone change is the same as that seen in (23).

Since the LOW-toned o-class suffixes do not induce this

tone is not realized by phonetic correlates other than F \emptyset in Cheyenne, there is no useful sense in which a vowel can be understood as bearing a tone. It is probably best to maintain, therefore, that in Cheyenne only voiced vowels are specified as possible tone-bearing units. As an automatic consequence of this specification, the tone of the devoiced vowel will disassociate by the following convention:

(28) Disassociation Convention: T
 ‡
 V
 [-voice]

'Gophers' [éstsemá?E] and 'apples' (NCh) [ma?xemeNO] thus derive as in (29). At this point no claim is intended as to the order of devoicing (13) and disassociation (28) relative to the tone rules (26) and (27). Tone spreading as tentatively formulated in (26), with the HIGH associated in the structural description of the rule would, however, have to apply before devoicing and disassociation.

(29)		H	L	L	H		L	L	L	L
	Underlying:									
		ehtema? + e					ma?šemen + o			
	Rule (26):	H	L	L	H		----			
					/					
		ehtema?e								
	Rule (27):	H	L	L	H		----			
				‡/						
		ehtema?e								
	Rules (13) and (14):	H	L	H			L	L	L	L
				/						
		ehtema?E					ma?šemeNO			
	Conv. (28):	H	L	H			L	L	L	L
				/‡						‡
		ehtema?E					ma?šemeNO			
	Other:	[éstsemá?E]					[ma?xemeNO]			

Rules (26) and (27) thus account for the behavior of forms with underlying LOW-LOW and LOW-HIGH sequences in the penultimate and final syllables.

Generalization of Rules to Other Tone Sequences

The following singular/plural examples illustrate forms with another underlying tone pattern. Here the penultimate stem-vowel in the singular is HIGH, but the same stem-vowel is LOW when the plural o-class suffix is added.

- (30) [hexóW0] 'clam' [hexowoN0] 'clams'
 [matšškóM] 'raccoon' [matšškomeh0] 'raccoons'
 [ma?pá?0] 'back (N)' [ma?pa?oNOts^e] 'backs'

The equatives show that the penultimate stem vowel is underlyingly LOW, and that the stem final vowel is HIGH:

- (31) [éhexowóneveo?0] 'They are clams'
 [ématšškoméheveo?0] 'They are raccoons'
 [éma?pa?ónévÉNEsts^e] 'They are backs'

The singulars in (30) thus can be seen as behaving exactly like the plural forms in (23). The plurals in (30), however, take the LOW toned o-class suffixes, and so give evidence of the LOW tone of the devoiced suffix displacing the stem final HIGH. This also follows from our analysis if rules (26) and (27) respectively are generalized as follows:

- (32) Tone Spreading (revised):
- $$\begin{array}{c} T \quad \quad T \\ | \quad \quad | \\ V \quad C_0 \quad V \quad C_0 \quad \# \quad \# \end{array}$$

- (33) Contour Simplification
 (final form):
- $$\begin{array}{c} T \quad T \\ \quad \quad / \\ \quad \quad V \end{array}$$

where 'T' represents any tone. Thus the singular and plural

of 'clam' derive as in (34):

(34)	Underlying:	L L H hešovon	L L H L hešovon + o
	Rule (32):	L L H / hešovon	L L H L / hešovono
	Rule (33):	L L H ‡ / hešovon	L L H L ‡ / hešovono
	Other:	[hexóW0] 'clam'	[hexowoNO] 'clams'

The behavior of underlying penultimate-final tone patterns LOW-HIGH (seen in the plurals of (23)) and HIGH-LOW (seen in the plurals of (30)) are thus accounted for by the analysis presented so far. The pattern LOW-LOW shown in (21) was not problematic, and the forms there may be understood as undergoing rules (32) and (33) with the final LOW displacing the penultimate LOW with no apparent change resulting in the surface LOW-LOW sequence. The plurals in the following sets of forms illustrate the last remaining pattern, HIGH-HIGH:

(35)	[eʔéʔtA]	'thrush'	[eʔeʔtáhN]	'thrushes'
	[maʔéNO]	'turtle'	[maʔenón]	'turtles'
	[maʔtáNO]	'bow string'	[maʔtanóNEsts ^e]	'bow strings'
	[neʔhán]	'lake'	[neʔhanéNEsts ^e]	'lakes'

Here there is an apparent rightward shift of the stem's HIGH tone when the e-class plural suffix is added. The shift must actually be leftward, however, and occur in the singular forms, since the equative forms indicate that the second stem vowel is underlyingly LOW, and the third stem vowel is

underlyingly HIGH:

- (36) [éé?e?táhneveo?0] 'They are thrushes'
 [éma?enóévéNEsts^e] 'They are turtles'
 [éma?tanónévéNEsts^e] 'They are bow strings'
 [éne?hanévéNEsts^e] 'They are lakes'¹⁰

The singular forms of 'thrush', 'turtle' and 'bow string' in (35) can be accounted for in exactly the same way the plurals in (23) were. The plurals 'bow strings' and 'lakes' in (35) also are accounted for by rules (32) and (33), with the final HIGH displacing the penultimate HIGH. Here the effect of the spreading is vacuous, just as it was when a final LOW displaced a penultimate LOW in (21). Words with penultimate-final LOW-HIGH and HIGH-HIGH sequences derive as follows:

- (37)
- | | | |
|-------------|----------|------------------------------|
| Underlying: | L L H | L L H H |
| | | |
| | e?e?tahn | ma?tanon + et |
| Rule (32): | L L H | L L H H |
| | / | / |
| | e?e?tahn | ma?tanonet |
| Rule (33): | L L H | L L H H |
| | ‡ / | ‡ / |
| | e?e?tahn | ma?tanonet |
| Other: | [e?étA] | [ma?tanóNEsts ^e] |
| | 'thrush' | 'bow strings' |

Thus a process of tone spreading along with contour

¹⁰The stem-final é of 'lake' coalesces with the initial é of the equative formative by a process that will be discussed briefly later below.

simplification accounts for the surface realization of all possible underlying sequences over the penultimate and final vowels.

The Cause of Tone Spreading

While the posited tone spreading rule can account for all of the patterns observed above, it would be even better motivated if we knew why the tone spreading occurs. A reasonable first guess is to suppose that the devoicing of the final vowel itself causes the leftward spreading of its tone by creating a floating tone that must (by a grammar-particular constraint) reassociate. This supposition cannot be easily maintained, however, because the tone of a devoiced prepenultimate vowel does not spread. Furthermore, in forms where vowel copying (11) has applied, the vowel that is copied (the last vowel) does not itself devoice, yet its tone nevertheless spreads, as illustrated in the following forms. (The corresponding equatives are given to demonstrate underlying tones.)¹¹

- (38) /maʔheón/ → [maʔhéóʔ0] 'god'
 /oomahóon/ → [ooMAhooʔ0] 'lumber'

Compare with:

- [émaʔheónefE] 'He is God'
 [éooMAhóonefE] 'It is lumber'

There is, however, evidence for a different sort of phonological property accounting for tone spreading. That property is accent.

¹¹ It is likely that the 'copy' of this vowel should rather be considered an epenthetic e added by rule (13) after insertion of the glottal stop. It then assimilates to the quality of the preceding vowel by the application of an independently required rule (not discussed above). The final 'copy' would thus have no more effect on the preceding tones than the usual case of epenthetic e. Space does not permit a fuller discussion of the nature of vowel copying here.

Evidence for Accent

Three types of phonological and comparative evidence suggest that the penultimate vowel is accented.

First, the penultimate vowel never devoices. This fact would not be unexpected if an accent were present on this syllable, since accents by nature mark a syllable as prosodically significant. The presence of this accent would also simplify the form of a rule for prepenultimate vowel devoicing (not formalized here), since it would obviate the need for a lengthy string of segmental variables to ensure that the rule applies prepenultimately. Instead, the rule could simply specify an unaccented vowel in its structural description.

Second, there is a process of vowel coalescence in Cheyenne which can be seen operating in the equative form below.

(39) Thus: /é # nete + éve + o/ → [énetséveoʔ0]

'They are eagles'

Compare: /nete + o/ → [netseoʔ0]

'eagles'

The final e of the stem coalesces with the initial e of the equative formative /-éve-/. The plural nominal form demonstrates the underlying presence of the stem final e. The rule involved deletes an e following another vowel across a formative boundary (+).

This process does not apply, however, when the preceding vowel is penultimate, but instead an epenthetic n appears following the penultimate vowel, blocking coalescence:

(40) Thus: /é # voʔ + éve + ét/ → [évoʔéveNEsts^e]

'They are clouds'

This resistance to coalescence of the penultimate vowel is also a likely effect of an accent. Without the accent, it would be an unexplained accident that vowel devoicing and

vowel coalescence both cannot apply to the vowel of the penultimate.

Third, there is evidence for penultimate stress in other Algonquian languages. See, for example, Goddard [1974] on Arapaho and Atsina, Bloomfield [1962:19] on Menominee, Teeter [1971:194] on Malecite-Passamaquoddy, and Voegelin [1935:26] on Shawnee.

Thus, although there has been as yet no controlled investigation yielding phonetic evidence for penultimate stress in Cheyenne, the phonological restrictions against vowel devoicing and coalescence in the penult suggest an abstract accent assigned to the penultimate syllable, and the comparative evidence is in accord with this hypothesis.

Tentative Reformulation of Tone Spreading

This hypothesized accent motivates the differential treatment of tones in final versus non-final syllables discussed above, because the tone spreading from the final syllable can be reformulated as a natural process of attraction to accent. Segmental variables are thus unnecessary, and the rule is considerably simplified:

(41) Attraction to Accent:
$$\begin{array}{c} T \quad T \\ | \quad \text{---} \\ V \quad \quad \quad \\ * \end{array}$$

where '*' represents the accent, and the tone to the right may or may not be associated with another vowel.

This formulation has the advantage of rendering the ordering relationship between the tone rules on the one hand, and the devoicing and deletion rules on the other hand, irrelevant. Consider the singular 'lake' [neʔháN] and the plurals 'thrushes' [eʔeʔtáhN] and 'turtles' [maʔenÓN] shown in (35) above. Note that in these forms the final vowel has not devoiced, but has deleted by rule (9). (This deletion occurred in the singular of 'raccoon' in (30) as well.) These forms nevertheless behave exactly as the other forms in (35).

This behavior of tones on deleted vowels might be taken as indicating that tone spreading must apply prior to the deletion rule. However, given the representation of tones as

autosegments on an independent tier, there is no need to assume that the deletion of a vowel implies the deletion of its tone. Thus the tone may spread prior to vowel deletion, or the vowel may delete first, leaving the tone floating (unassociated), whereupon the tone reassociates. In either case, the spreading or reassociation can be accounted for simply as attraction to accent by (41). 'Lake' could therefore derive in either of the following ways:

(42)		L L H		L L H
	Underlying		Underlying	
	(with *):	neʔhane	(with *):	neʔhane
		*		*
		L L H		L L H
	Rules (9)		Rules (41)	†/
	and (13):	neʔhaN	and (33):	neʔhane
		*		*
		L L H		L L H
	Rule (41):	/'	Rules (9)	/'
		neʔhaN	and (13):	neʔhaN
		*		*
	Surface:	[neʔháhN]	Surface:	[neʔháhN]
		'lake'		'lake'

Recoverability

What, then, about the recoverability of the tone of the final vowel? Because of contour simplification (33), the tone on any given vowel can have only one of two values: HIGH or LOW. Since tone is not realized on voiceless vowels in Cheyenne, there is a possibility for only a two-way surface tonal distinction (HIGH or LOW on the penultimate) for the four possible underlying tone patterns on the last two syllables (LOW-LOW, LOW-HIGH, HIGH-LOW, HIGH-HIGH). The recoverability of these underlying tone patterns must therefore be limited.

As we have seen, recoverability is limited in the following way. Attraction to accent (41) provides for the complete recoverability of the tone of the final vowel, and

constitutes a case of 'option (4d)' proposed at the beginning of this paper. Contour simplification (33), however, results in the complete loss of the tone of the penultimate. The system thus does not function to render the underlying tonal configuration of the last two syllables of a word maximally recoverable, as is implied in Leman's analysis. Instead, it keeps the tone of the final syllable at the expense of the penult's tone, as shown in the following comparison of derivations claimed by the two analyses for all possible underlying final sequences of tones:

(43)	<u>Leman</u>		<u>Milliken</u>
	L L	→	L -
	H L	→	Ĥ -
	L H	→	M -
	H H	→	Ĥ -
			L L → L -
			H L → L -
			L H → H -
			H H → H -

Conclusions

My purpose in presenting the above phonetic facts and phonological analysis has been to illustrate something of the fundamental nature of tone and tonal processes (in Cheyenne), and to show how tone interacts with devoicing, especially with regard to recoverability.

First, the instrumental analysis showed that a penultimate tone does not vary in pitch under the influence of the underlying tone of the following vowel. When low-level phonetic effects such as the interaction of vowel or consonant type and pitch are experimentally controlled, we find only two distinct surface F₀ ranges. This phonetic evidence does not accord with the complex assimilation processes and sandhi tones posited by Leman for the penultimate and final syllables. While the tone changes that are actually attested could be interpreted in terms of a process of complete assimilation, a simple and straightforward analysis of the system is readily available if the tones are understood as autonomous units formally independent from the vowels with which they are associated. Vowels can provide a tone for reassociation only if the tone is not an intrinsic part of the vowel itself, as it would be if it were

merely a set of specifications within the vowel's feature matrix. The tone changes observed on the penultimate vowel then follow from principles and rule types well established in autosegmental theory.

Second, the complete recoverability of the tone of the final syllable is provided for by a redistribution of the tone on the word. The tone of the final vowel spreads to the penultimate vowel, which does not devoice. This spreading creates a tonal contour on the penultimate vowel, however, which is eliminated by a rule of contour simplification, resulting in the complete loss of the tone of that vowel.

Finally, by recognizing the independently motivated abstract accent assigned to the penultimate syllable, the asymmetry between the behavior of the tone of the final syllable (which spreads or reassociates) and that of the prepenultimate and penultimate tones (which do not) is explained. The resulting difference in recoverability between the tone of the final syllable and tones earlier in the word is thus accounted for in a principled way.

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