

Phonetic patterns in Arapaho vowels

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Why study vowels in Arapaho?

- While some languages may have short and long vowels, Arapaho also has vowels that are *extra* long. Typologically, this is very rare (Remijsen and Gilley, 2008). How are these vowels produced by speakers? What is the general relationship between vowel quality and vowel quantity?
- There are differing perspectives on the nature of pitch accent in the language. How many possible pitch accents are there and how are they different from each other?
- What can the phonetic patterns reveal about the phonological structure of Arapaho?

Roadmap

- 1 Arapaho phonology
- 2 Vowel quality and quantity
- 3 Pitch accent
- 4 Discussion and future directions

Arapaho vowels (Cowell and Moss Sr., 2008)

Table: Arapaho Vowel Inventory

	Front	Back
High	i	u
Low	ɛ (e)	ɔ (o)

Diphthongs	eɪ (ei)	oʊ (ou)
	ɪʊ (io)	aɪ (oe)

Phonetically, there is a three-way contrast in vowel length in Arapaho. Though, the phonological status of extra long vowels remains unclear. Consonants do not contrast in length.

- Extra long vowels are described alternately as a *triadic sequence* (Salzman, 1956) or as belonging to separate syllables (Cowell and Moss Sr., 2008). Though, only impressionistic evidence for syllable affiliation is given.

Table: Vowel length contrast

Short	Long	Extra long
i	ii	iii
ε	εε	εεε
u	uu	uuu
ɔ	ɔɔ	ɔɔɔ
	ei	eei
	ou	oou
	ai	(aai)
	it	?

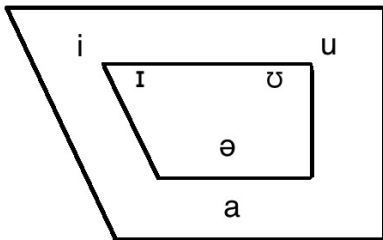
Examples

Length	Word	Gloss	Word	Gloss
short	his	'liver'	hóθɔʔ	'star'
long	níís	'two'	hɔhóót	'tree'
extra long	bɔníít	'work with' <i>porcupine quills</i> '	bɛtóɔt	'dance (noun)'
short	hɛθ	'dog'	θɔɔnoúhut	'He's lazy.'
long	tʃéεθ	'accidentally'	ɔʔúút	'hammer'
extra long	héεé	'yes'	θoʊxɔsuuu	'head-dress'

In addition to length, these vowels seem to be different in quality too.

Vowel quality and quantity

- “As against their short counterparts, the long high vowels are closer and tenser.” (Salzman, 1956, 53).
- “When the vowels occur long, they show changes in quality as well as quantity. In particular, /ii/ and /uu/ have values approaching [i] and [u].” (Cowell and Moss Sr., 2008, 13).
- Neither Salzman nor Cowell & Moss mention any quality difference among low vowels. Impressionistically, low vowels seem to differ in quality too, e.g. [ɛ] vs. [æ:], [ʌ] vs. [ɔ:].
- In languages with contrastive vowel length, shorter vowels are typically more lax (or central) and longer vowels are more tense (or peripheral) (Johnson and Martin, 2001).



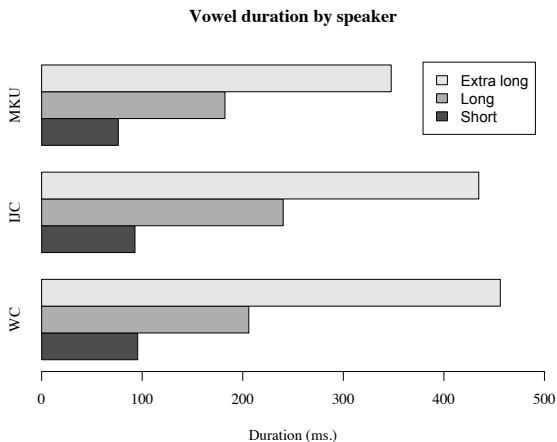
- Typically, the expectation is that when vowels are shorter, speakers lack the duration to reach a vowel target. This is called *vowel undershoot* (Lindblom, 1963). Over time, these patterns become part of the phonology of a language, so vowels of different *quantity* also differ in *quality*.
- However, this pattern *should* affect all the vowels in a language, not just the high vowels. Can we test this in Arapaho?

Phonetic study on vowel quality and quantity

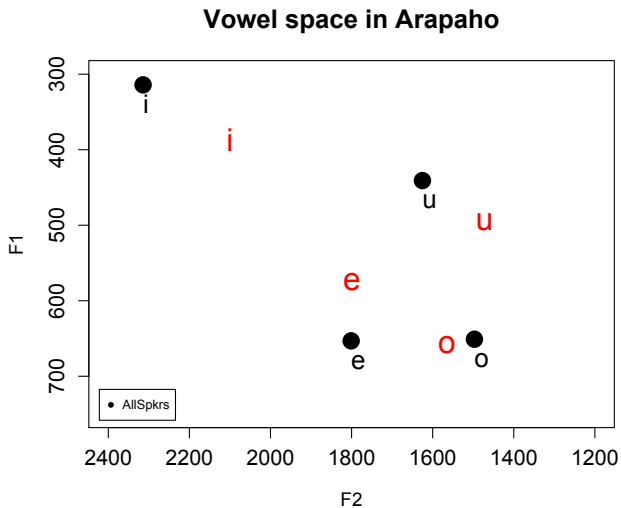
- Recordings made by the first author from 7-8 hours of elicitation sessions with two male speakers (WC and IJC) in October 2012, which were supplemented with an existing recording of a female speaker, MKU (35 minutes) recorded by Lisa Conathan (Conathan, 2004-2007).
- While the words differed across speakers, most words had 2-3 repetitions. For WC, 163 words were analyzed. For IJC, 90 words were analyzed. For MKU, 62 words/sentences were analyzed.
- Number of vowels analyzed: 1290 for WC, 688 for IJC, and 579 for MKU.
- Labeled vowels and analyzed formant values on vowels of different lengths using a script written for Praat (Boersma and Weenink, 2011).

Results: vowel duration

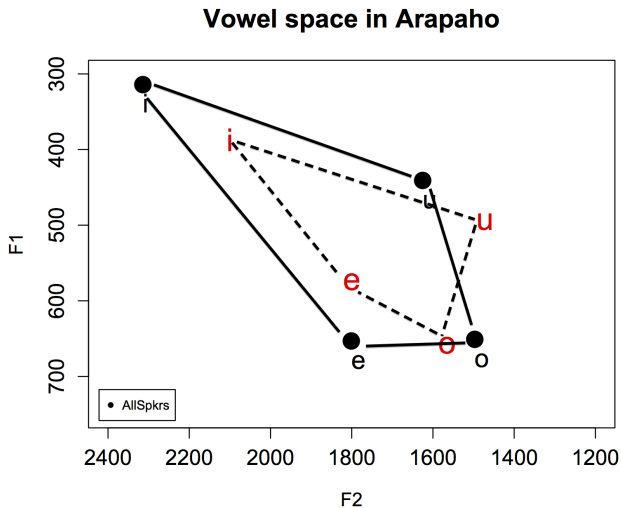
Long vowels are twice as long as short vowels and extra long vowels are almost twice as long as long vowels.



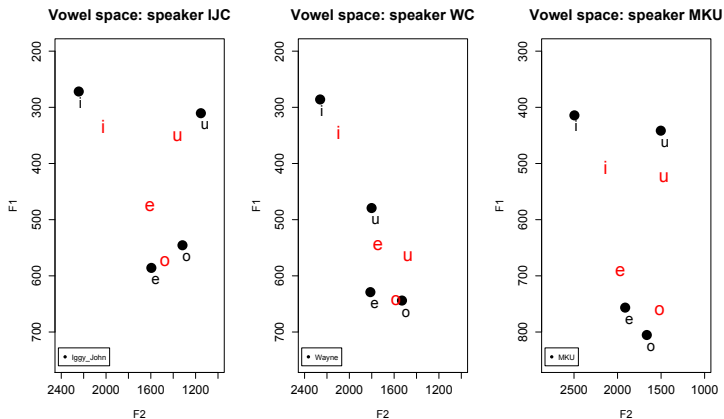
Results: Length and quality



Results: Length and quality



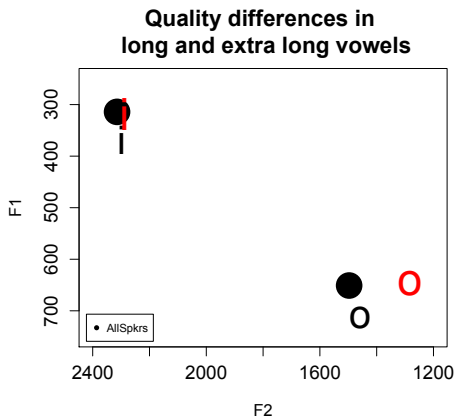
Results: Speaker differences



For all speakers, long high vowels are *higher* than short high vowels and long /ε/ is lower than short /ε/.

Extra long vowels

Vowel quality for the extra long vowels was similar to that of the long vowels for /i/, but more retracted (back) for /ɔ/. Though, too few tokens of other vowels to allow us to determine a general tendency.



Summary & Interim discussion

- Differences across speakers in how back vowels are realized, but similarity among front vowels.
- Clear difference in vowel quality which corresponds with a change in quantity. The low vowel /ɛ/ is higher when short, but lower when long ([æ]), a previously unreported phenomenon.
- Findings fit with the more general notion that short vowels are *centralized*, or undershot, while long vowels are more peripheral in the vowel space, as opposed to idea that only the high vowels lower.
- Speaker variability in whether /ɔ/ changes quality when short or long. However, the extra long vowel is more retracted than the long vowel.

Pitch accent

- Previous work describes pitch accents associated with individual vowels in Arapaho, e.g. úu, uú, úú, (Cowell and Moss Sr., 2008).

Accent	Short vowels	Accent	Long vowels	Accent	Extra long vowels
H	ó	HH	óó	HHH	*
L	ɔ	HL	óɔ	HHL	*
		LH	ɔó	HLH	óó
		LL	ɔɔ	HLL	óɔ
				LHH	*
				LHL	*
				LLH	ɔó
				LLL	*

Examples

Word	Gloss	Word	Gloss
wɔ́nɔʔ	'ankle'	héβes	'beaver'
neétʃεε	'chief'	hóʔtʃɔɔ	'devil'
nehéi	'aunt'	tɔʔúút	'hammer'
tʃεʔεεʔ	'potato'	béteε	'heart'
hoóú	'porcupine'	hóou	'crow'
wóúú	'copulate!'		

Questions

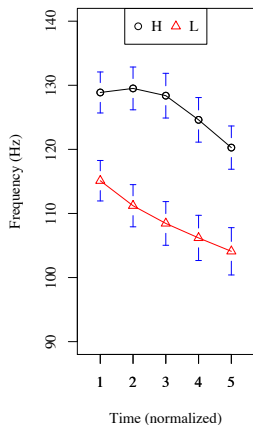
- Pitch accent has been a particularly difficult aspect of Arapaho grammar to describe. Many of the morphological alternations which influence it have no clear explanation (Cowell and Moss Sr., 2008).
- Cowell and Moss note that both elicitation session types and significant speaker variation can distort pitch accents. To what extent are the pitch accents stable across speakers uttering different words in different elicitation sessions?
- How are pitch accents produced? How does vowel length influence pitch accent?

Phonetic study on pitch accent

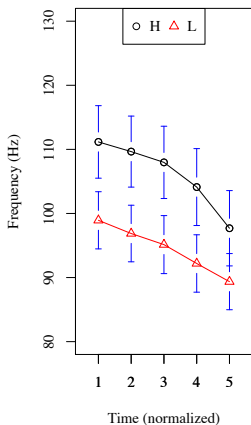
- Same recordings and words as before.
- Labeled vowels and analyzed F_0 (pitch) values on vowels of different lengths using a script written for Praat (Boersma and Weenink, 2011).
- Examined similar accentual patterns across vowel lengths, e.g. HLL vs. HL, LLH vs. LH.

Results: Pitch accents on short vowels

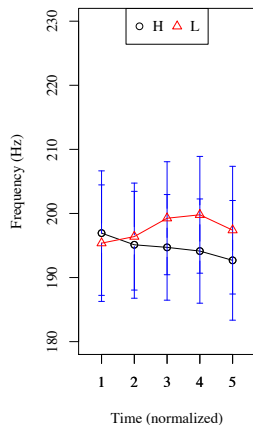
Pitch accents on short vowels
Speaker WC



Pitch accents on short vowels
Speaker LJC

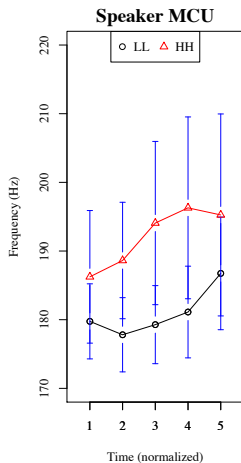
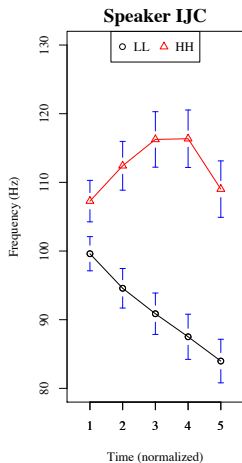
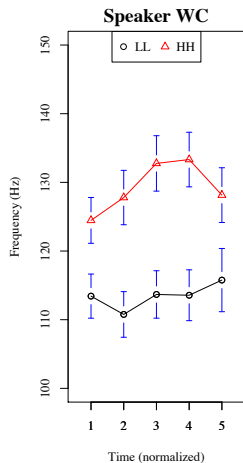


Pitch accents on short vowels
Speaker MKU



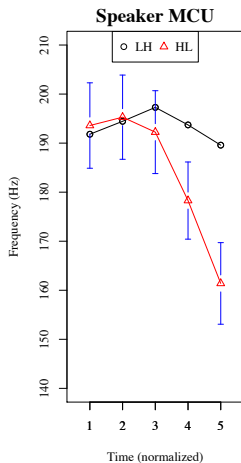
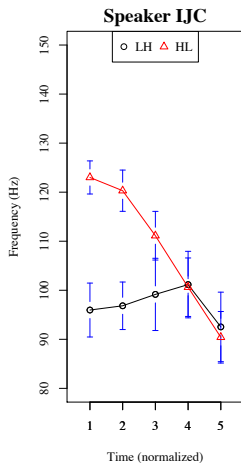
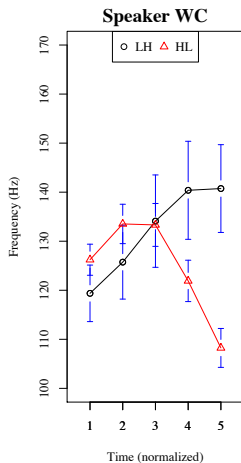
Results: HH and LL pitch accents

HH and LL accents on long vowels



Results: HL and LH pitch accents

HL and LH accents on long vowels

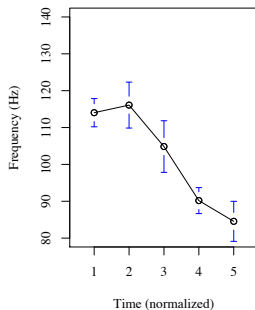


Observations

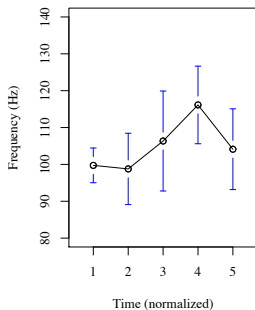
- Clear difference between H (accented) and L (unaccented) in short vowels, mainly in terms of pitch height. A different trajectory in pitch was observed for MKU. On long vowels, speakers produce both HH and HL patterns similarly.
- There is substantial between-speaker variation in the pitch shape of L, LL, and LH patterns.

Results: Pitch accents on extra long vowels

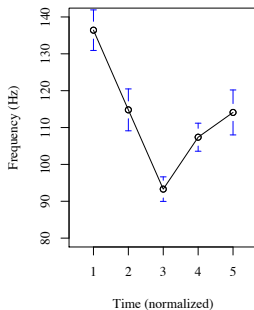
HLL on extra long vowels



LLH on extra long vowels

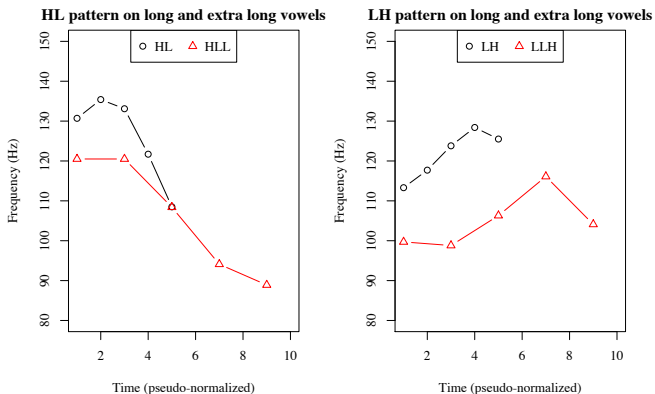


HLH on extra long vowels



How do the HLL and LLH patterns on extra long vowels compare with similar falling and rising patterns on long vowels?

Comparison of falling and rising patterns

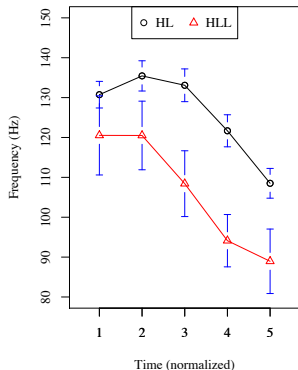


The pitch accent on the long vowel looks like a compressed version of the one on the extra long vowel, but at a different height.

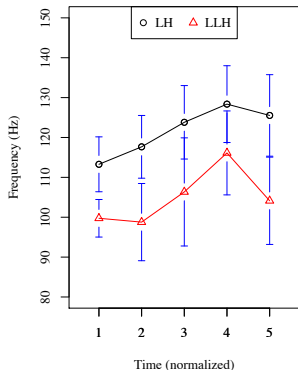
Results: comparison

One way to compare the pitch accent patterns on extra long vowels with those on long vowels is to stretch out the pitch accents on long vowels to see how they match the ones on extra long vowels.

HL pattern on long and extra long vowels

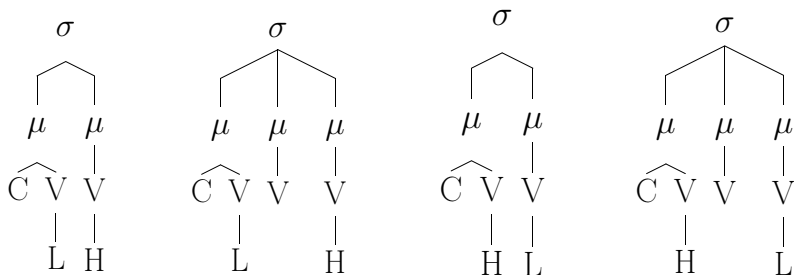


HL and LH accents on long vowels



Summary/Discussion

- Similarities in HL and HLL; and LH and LLH patterns in terms of pitch trajectory, but different in terms of height. The accent on the long vowels is higher than on the extra long vowels.
- Similarity in trajectory favors a phonological representation where the middle mora is tonally unspecified, an account which jibes well with the observed patterns: HLH, HLL, LLH.



General discussion

- Vowel quality changes with quantity. Long vowels are more peripheral and short vowels are more centralized. Extra long /ɔ:/ is even more peripheral.
- Revised system: short /ɪ, ε, ɔ, ʊ/ but long /i:, æ:, ɔ:, u:/.
- Clear differences between different patterns of pitch accent on vowels of varying lengths. The greater variation in the realization of L and LL patterns (as opposed to H, HH) suggests that there is no specific target of a “L.” Rather, these vowels are tonally unspecified.
- Similar trajectory for HL-HLL and LH-LLH patterns suggests pitch is simply interpolated across the syllable between a H and L target; the medial mora is unspecified.

Conclusions and future directions

- Despite the ostensible differences of the elicitation sessions and speakers, stable phonetic patterns were found for vowel length, vowel quality, and, to a certain extent, for pitch accent.
- The nature of using elicited corpora is that there will be gaps in patterns. There were few examples of LH pitch accent and of extra long vowels in the data considered. Given the variation among speakers, more data may be revealing.
- Plan to include additional vowel data from a Conathan's (2004-2007) corpus, with a particular focus on running speech. The goal will be a more complete phonetic description of the Arapaho sound system.

Acknowledgements

Thank you!

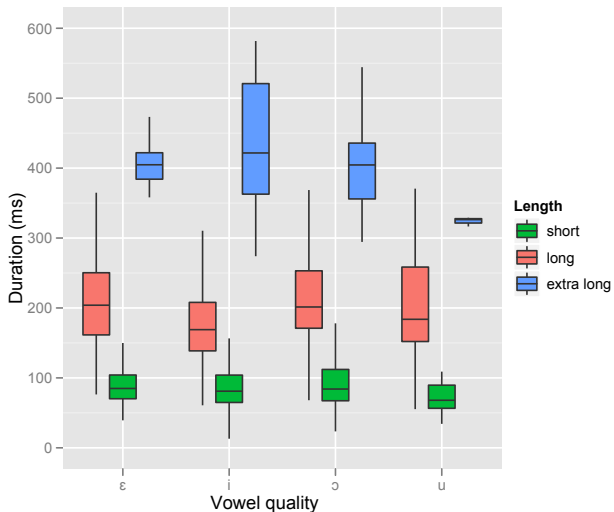
This work was supported by NSF Grant No. 0966411 to Haskins Laboratories: “From endangered language documentation to phonetic documentation.”



National Science Foundation
WHERE DISCOVERIES BEGIN

We would also like to thank the Arapaho community and Lisa Conathan.

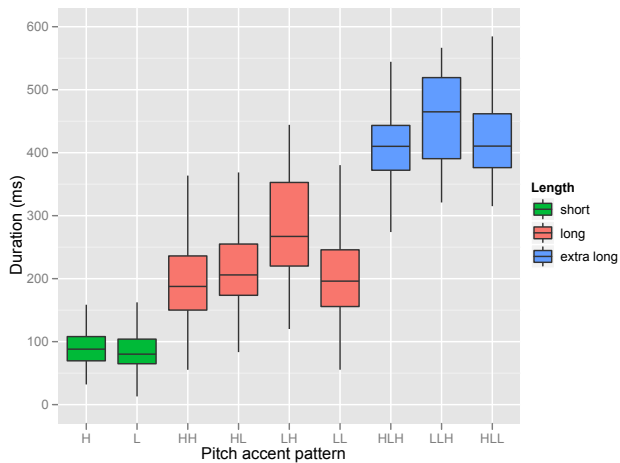
Appendix 1: Vowel quality and duration



Appendix 2: stress or pitch accent?

In languages with stress, it is impossible to have polysyllabic word lacking stress (Hyman, 2006). However, there are words lacking accent in Arapaho. Moreover, adjacent sequences of accented syllables are possible, which never occurs in a stress language. Both observations argue that Arapaho possesses a pitch accent (or simple tonal) system.

Appendix 3: Pitch accent and duration



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