Using acoustics to resolve place controversies in Deg Xinag fricatives

Richard Wright, Sharon Hargus, Julia Colleen Miller
rawright@u.washington.edu sharon@u.washington.edu jcm@u.washington.edu

Dept. of Linguistics (Linguistic Phonetics Lab), University of Washington, Seattle

CAA Vancouver 2008 / ACA Vancouver 2008
Deg Xinag language

- Athabaskan family
- Spoken in western Alaska
- Moribund; 7 speakers left

Deg Xinag, a.k.a. Deg Hit’an

<table>
<thead>
<tr>
<th>Consonant inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consonant inventory</strong></td>
</tr>
<tr>
<td><strong>stops</strong></td>
</tr>
<tr>
<td><strong>affricates</strong></td>
</tr>
<tr>
<td><strong>lateral</strong></td>
</tr>
<tr>
<td><strong>release</strong></td>
</tr>
<tr>
<td><strong>other</strong></td>
</tr>
<tr>
<td><strong>release</strong></td>
</tr>
<tr>
<td><strong>fricatives</strong></td>
</tr>
<tr>
<td><strong>sonorants</strong></td>
</tr>
<tr>
<td><strong>others</strong></td>
</tr>
<tr>
<td>v(~w)</td>
</tr>
</tbody>
</table>

- Note 7 voiceless fricatives (also [ɕ] = /j/)
- Unusual (for Ath.) 4-way phonation contrast among stops (but common in Alaska). Voiced (innovative) mainly restricted to word-final position; e.g. [ts’əd] “blanket” (cf. [tʃət] “smoke”).
- Voiceless and laryngealized sonorants mainly restricted to word-final position.
/χ/ vs. /h/

- Contrast in stem-initial position
  - [genoχa] ‘you (pl.) will pick (berries)’
  - [genohha] ‘he/she will pick (berries)’

  - [enoxɛʃ] ‘you (pl.) will camp’
  - [enohɛʃ] ‘he/she will camp’

Speaker ED
Verb prefixes

• Limited contrast between /χ/ and /h/
• Linguists have variously transcribed /χ/ < x > or /h/ < h > in verb prefixes, even in names for the language!
  – Deg Hit’an (Krauss 1974) (lit. “people of this area”)
    • *χʊ- areal (Leer 2000)
  – Deg Xinag (Kari 1978) (lit. “this language”)
    • *χəŋəgi “language” (Story 1984), < *qə-nə-(h)e:xj, -(h)aʔ (Krauss and Leer 1981)

Acoustic differences between DX /χ/, /h/

- /χ/ and /h/ in stems (Wright, Hargus, and Miller 2005)
  - Significantly different in skew and kurtosis
  - Not significantly different in center of gravity, lowest spectral peak, or standard deviation
- /χ/ and /h/ differ in relatively few spectral measures
- Given limited contrast possibilities in prefixes, /χ/ and /h/ might be confusible

Wright, Hargus and Miller (2005) An acoustic study of Deg Xinag fricatives. JASA 117: 2491
Research question

• What is the identity of the prefixal fricative (“x”)?
  – Does “x” pattern with /χ/ or with /h/?
Method
Participants

- 8 adult native speakers (3 male, 5 female)
- Ages
  - apx. 68-76 at time of recording
  - 3 speakers now deceased
- All bilingual in English
  - varying oral proficiency
  - minimal written proficiency for all but 3 speakers
Word list recordings

• $[\chi]$, $[\text{h}]$, “x” lexical sets
  – $[\chi\text{ot}]$ ‘slowly’
  – $[\text{ho}^\text{h}]$ ‘he/she is walking’
  – $[“x”\text{ot}^\text{h}]$ ‘they’re walking’

• Two vocalic contexts (___ rounded vs. unrounded V)

• Two lexical sets per context

• Four repetitions elicited; sets of repetitions recorded in random order

• Recording equipment
  – professional CD recorder or compact flash recorder
  – Shure SM-10 head-mounted microphone

• Sampling rate
  – recorded at 44,100 Hz
  – downsampled to 22,050 for analysis
Acoustic analysis

- **Praat** (version 4.3.27 and previous)
  - Spectral moments (center of gravity, standard deviation, skew and kurtosis) (30 ms. window at midpoint)
  - Intensity (dB) (25 ms. window at midpoint)

- **Multi-Speech** (2.5 and previous)
  - lowest main spectral peak (512-point FFT spectra, 25 ms. window at midpoint)
Lowest main peak

- Graph of averaged FFT output
- $[\chi_a]$ ‘grease, gasoline’
  - lowest main peak (1206 Hz)
Statistical analysis

• Repeated measures ANOVA
  – Independent variables
    • fricative Place
    • vowel Rounding
  – Dependent variable
    • each speaker’s mean center of gravity, standard deviation, skew, kurtosis, lowest main peak, intensity
  – Post hoc analysis: Bonferroni/Dunn
  – Alpha level = .05
Results
Results overview

- Repeated measures ANOVA: significant Place effects for 3 of 6 measures
  - Center of gravity
  - Kurtosis
  - Intensity

- Bonferroni/Dunn
  - “x” patterns with $[\chi]$ (center of gravity and kurtosis)
  - “x” patterns with $[h]$ (intensity)
Significant spectral differences

- Center of gravity

- "x" = [χ]

- Place: F[2,14] = 13.484, p = .0005
- Rounding: n.s.
- No significant interaction effect
Significant spectral differences

- Kurtosis

- “x” = [χ]

- Place: F[2,14] = 26.628, p < .0001
- Rounding: F[1,14] = 36.498, p = .0006
- No significant interaction effect
Significant intensity differences

- Intensity

- “x” = /h/ (and /h/ = /χ/)

  - Place, $F[2, 14] = 4.797$, $p = .0259$
  - Rounding: $F[1, 14] = 23.488$, $p = .0019$
  - No significant interaction effect
Discussion
What is “x”?

• In terms of spectral properties, more like /χ/ than /h/  
  – center of gravity  
    • /χ/, “x” higher  
    • /h/ lower  
  – kurtosis  
    • /χ/, “x” more diffuse  
    • /h/ more peaked
• In terms of intensity, “x” more like /h/ than /χ/
  – “x” < /h/ < /χ/

• But intensity does not neatly divide the 3 fricatives into 2 classes in DX.
  Bonferroni/Dunn patterns of significance
  – “x” = /h/
  – /h/ = /χ/
  – “x” ≠ /χ/
Why does “x” pattern with /h/, not /χ/, for intensity?

- DX “x” occurs only in prefixes
- Prefixes are widely reported unstressed in Ath languages (Rice and Hargus 2005)
- Unstressed vowels in Witsuwit’en and Tsek’ene have less intensity than stressed vowels (Hargus 2005)
- Stem-initial stops and nasals in San Carlos Apache are longer than prefix nasals (Tuttle 2005)

### Distributional restrictions on /χ h “x”/

<table>
<thead>
<tr>
<th>prefixes</th>
<th>stems</th>
</tr>
</thead>
<tbody>
<tr>
<td>V__</td>
<td>V__</td>
</tr>
<tr>
<td>/χ/</td>
<td>X</td>
</tr>
<tr>
<td>/h/</td>
<td>X</td>
</tr>
<tr>
<td>“x”</td>
<td>X</td>
</tr>
</tbody>
</table>

〇= Contexts represented on our word list

- [genoχa] /g-e-n-o-ʊχ-ha/ ‘you (pl.) will pick (berries)’
  unspO-fut-‘pick’-fut-2pS-‘pick’
- [genoha] /g-e-n-o-ha/ ‘he/she will pick (berries)’
  unspO-fut-‘pick’-fut-‘pick’
Consequences of lack of contrast

• Lack of contrast between prefixal “x” and /h χ/
  – In fact, prefixal “x” conjunct prefixes only; prefixal /h/ disjunct prefixes only
  ➢ Decreased functional load on “x”
  ➢ Increased variability and reduction (Lindblom 1990)

An analogous situation

• DX lateral affricate phonation contrasts (Hargus 2008)
  • Stem-initial /tɬ tɬʰ tɬ’/
  • Stem-final /tɬ dl/
• Verb prefixes
  • Single lateral affricate [tɬ]~[tɬ’]~[dl]
  • < Proto-Athabaskan *s-ɬ
  • Fortition in word-initial position [tɬ’] (all 3 speakers)
  • Elsewhere, prevocally [tɬ’] (2 speakers), [tɬ] (1 speaker)
• Given lack of contrast, prosody and/or position can shape articulation

Other cases of lenition of prefixal \( *\chi \)

<table>
<thead>
<tr>
<th>PA</th>
<th>3pS ( \chi^- ) (Leer 2000)</th>
<th>areal ( \chi^\text{U}- ) (Leer 2005)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koyukon</td>
<td>( \chi^\text{U}- )</td>
<td>( \chi^\text{U}- )</td>
</tr>
<tr>
<td>Deg Xinag</td>
<td>( \chi^- )</td>
<td>( \chi^- )</td>
</tr>
<tr>
<td>Ahtna</td>
<td>( \text{syll}[\text{q}^\text{h}-, \text{h}-]\text{syll} )</td>
<td>( \chi^\text{u}- )</td>
</tr>
<tr>
<td>Witsuwit’en</td>
<td>( \text{h}- )</td>
<td>( \text{ho/w}- )</td>
</tr>
<tr>
<td>Tsek’ene</td>
<td>( \text{y}- )</td>
<td>( \text{w}- )</td>
</tr>
<tr>
<td>Slave</td>
<td>( \text{k}^\text{h}\sim\text{k}- )</td>
<td>( \text{ko}- )</td>
</tr>
<tr>
<td>Navajo</td>
<td>( \text{h}- \text{ seriative} )</td>
<td>( \text{ho}- )</td>
</tr>
</tbody>
</table>

Acknowledgements

• Deg Xinag speakers Phillip Arrow, Edna Deacon, James Dementi, Raymond Dutchman, Lucy Hamilton, the late Katherine Hamilton, Alta Jerue, and Hannah Maillelle

• Funding provided by the U.S. National Science Foundation (OPP-0137483 and DEL-0651853) (to Sharon Hargus)

• Comments from members of the UW Linguistic Phonetics Lab (Richard Wright, director)

These slides will be posted at http://faculty.washington.edu/sharon/