# USING ACOUSTICS TO RESOLVE PLACE CONTROVERSIES IN DEG XINAG FRICATIVES

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## 1. INTRODUCTION

Field linguists have disagreed about whether the Deg Xinag reflexes of the Proto-Athabaskan third person plural subject prefix *χ- (Leer 2000) and areal prefix *χʊ - (Leer 2005) contain the uvular fricative [χ] or the glottal fricative [h]. In an earlier acoustic study of differences among the eight voiceless fricatives of Deg Xinag that can occur in stems (Wright, Hargus, and Miller 2005, in prep.) we found that /χ/ and /h/ differ significantly in skew and kurtosis but not center of gravity, lowest spectral peak, or standard deviation. In this study we investigate the identity of the prefixal fricative ("x"): specifically, whether it patterns with stem /χ/ or /h/.

## 2. METHOD

### 2.1 Participants

Participants are 8 adult native speakers (3 male, 5 female) of Deg Xinag, between the ages of approximately 68-76 at the time of recording. English is a second language for all speakers, but proficiency varies.

### 2.2 Recording materials and recording procedure

Words on a word list were recorded in isolation in random order (the same random order for each speaker). The word list illustrated three types of fricatives: stem-initial voiceless uvular [χ], stem-initial voiceless glottal [h], and the prefixal fricative whose place of articulation is at issue ("x"). Four lexical items per fricative category were recorded. In two of the words the following vowel was rounded and in two of the words the following vowel was unrounded. Four repetitions of each word were elicited. Some speakers voluntarily produced more than four repetitions. Some repetitions were later discarded due to background noise. Because no speaker was literate in Deg Xinag, the words were elicited through a combination of translation from English and/or prompting in Deg Xinag by the second author.

The recordings were made using a professional CD recorder or compact flash recorder. Participants wore a head mounted microphone (Shure SM-10) to control for source distance. Recordings were made at 44,100 Hz and downsampled to 22,050 Hz.

### 2.3 Acoustic analysis

Four spectral measures (center of gravity, standard deviation, skew and kurtosis) over a 30 ms. window at the midpoint of the fricative were made using PRAAT (version 4.3.27 and previous). The lowest main spectral peak was identified using FFT spectra (512 points, or approximately 25 ms. window) generated with Multi-Speech (2.5 and previous). The lowest main peak was defined for this study as the frequency above 500 Hz after which there was a sustained drop in frequency. Intensity was also measured over a 25 ms. window at the fricative midpoint using Praat.

### 2.4 Statistical analysis

A series of two-factor repeated measure analyses of variance and Bonferroni-Dunn post-hoc tests were conducted to examine the effects of fricative Place (/χ/, /h/ or "x") and vowel Rounding on each measure.

## 3. RESULTS

### 3.1 Spectral differences

For center of gravity Place had a significant effect ($F[2,14] = 13.484$, $p = .0005$) but Rounding of the following vowel did not. There was no significant Place by Rounding interaction for this measure. Figure 1 illustrates the center of gravity results. Stem /h/ is significantly different from both prefixal "x" and stem /χ/ in center of gravity, but "x" and /χ/ do not differ by this measure.

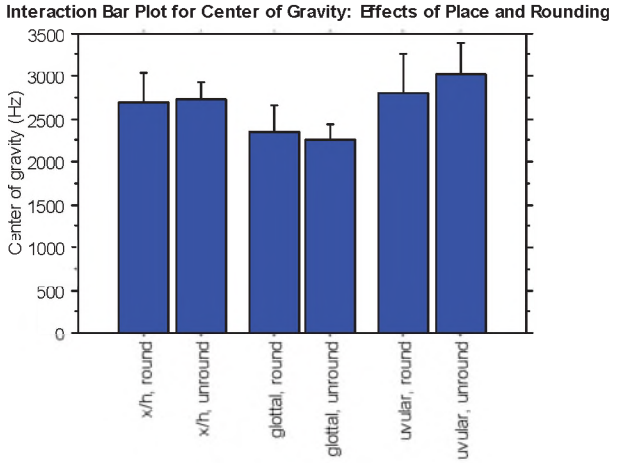


**Figure 1. Effects of Place and Rounding on center of gravity**

Place and Rounding had significant effects on standard deviation (Place, $F[2,14] = 6.149$, $p = .0121$; Rounding, $F[1,14] = 35.492$, $p = .0006$). The glottal and uvular fricatives differed significantly from each other but not from "x". Place and Rounding also had significant effects on kurtosis (Place, $F[2,14] = 26.628$, $p < .0001$; Rounding, $F[1,14] = 36.498$, $p = .0006$). For this measure /h/ differed significantly from both the uvular fricative and prefixal "x", but the latter two did not differ from each other. Place and Rounding also had a significant interact effect for kurtosis ($F[2,14] = 5.189$, $p = .0206$).

There were no significant effects of Place or Rounding on skew.

Rounding had a significant effect on lowest peak ($F[1,14] = 59.141$, $p = .0001$), but Place did not.

### 3.2 Intensity differences[a]

For intensity Place and Rounding both had significant effects (Place, F[2,12] = 5.201, p = .0236; Rounding, F[1,12] = .0042, p = 20.106). For this measure, the uvular and prefixal "x" fricatives are significantly different, but "x" and /h/ do not differ from each other in intensity, nor do the uvular and glottal fricatives. Figure 2 illustrates the intensity results. There was no significant interaction effect of Place and Rounding.

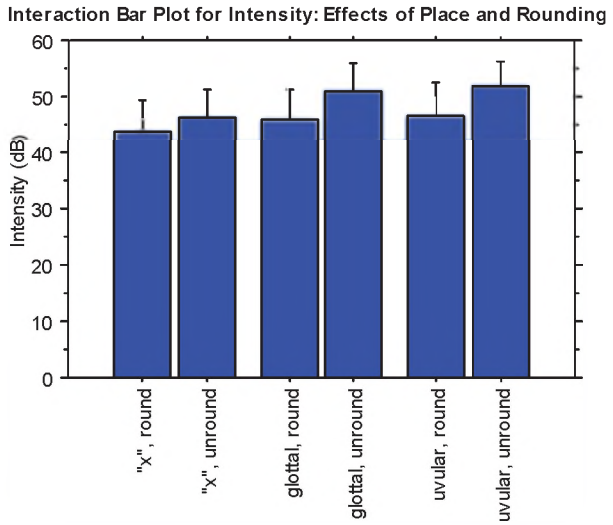


**Figure 1. Effects of Place and Rounding on intensity**

### 3.3 Summary

The significant differences between prefixal "x" and the glottal and uvular fricatives in stems for the measures presented in 3.1 and 3.2 are summarized in Table 1:

| | "x" |
|---|---|
| center of gravity | = χ, ≠ h |
| standard deviation | -- |
| kurtosis | = χ, ≠ /h/ |
| skew | -- |
| lowest peak | -- |
| intensity | ≠ χ, = h |

**Table 1. Significant differences between prefixal "x" and stem /χ h/ (Bonferroni-Dunn test)**

## 4. DISCUSSION

Prefixal "x" patterns with the uvular and not the glottal fricative for two of the spectral measures but with the glottal fricative and not the uvular fricative for the intensity measure. We suggest that the conflict between the two types of results may be a result of the fact that prefixal "x" occurs in unstressed syllables on our word list, as opposed to /χ/ and /h/, which occur in stems, which are stressed. Although stress in Deg Xinag has not been instrumentally studied, there are well known differences in stress between prefixes and stems in Athabaskan languages, with stems consistently reported as receiving stress in a variety of languages (Rice and Hargus 2005). We are therefore inclined to give greater weight to the spectral measures, and identify "x" as the uvular fricative.

The Deg Xinag third person plural subject prefix "x"- (now equated with χ- on the basis of our results) has been reconstructed for Proto-Athabaskan as *χ- (Leer 2000). Assuming that this reconstruction is correct, and valid also for the other instances of Deg Xinag prefixal /χ/-, Deg Xinag can be seen as conservative, but perhaps headed to a stage in which prefixal /χ/- is being replaced with the glottal fricative, as it has been in e.g. Witsuwit'en (Hargus 2007), a related Athabaskan language. Although Witsuwit'en has a contrast between uvular and glottal fricatives in stems, like Deg Xinag, the third person plural prefix is /h/- and the areal prefix is /ho/-~/w/-. The change in Witsuwit'en (and incipient change in Deg Xinag) may be essentially prefixal lenition of stricture, perhaps due to lack of consistent stress on prefix syllables. We also note that since there is no contrast between prefixal /χ/ and /h/, there may be a decreased functional load on "x"-, thereby increasing its variability and reduction (Lindblom 1990).

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[a]Intensity results are currently available only for 7 of 8 speakers.