Deg Xinag lateral affricates: Phonetic and historical perspectives*

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Background

- Deg Xinag, an Athabaskan language spoken in western Alaska
    - 7 speakers remaining

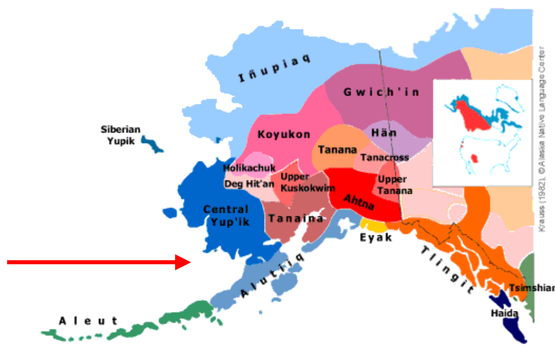

Figure 1. **Native peoples and languages of Alaska** (Krauss 1982). Deg Xinag is called Deg Hit’an on this map (arrow).

- Deg Xinag lateral affricate phonology
    - Stem-initial and –medial: 3-way contrast
        - /tɬ/ [tɬl:]: e.g. /tɬen/ ‘mouse’
        - /tɬ^{h}/ [tɬ:l]~[tɬ:]: e.g. /tɬ^{h}aG/ ‘bum, no good’
        - /tɬ’/ [tɬ’l]~[tɬ’]: e.g. /tɬ’eɬ/ ‘rope’
    - Stem-final: 2-way contrast
        - /tɬ/: e.g. /χʊtɬ/ ‘sled’
        - /dl/: e.g. /vʊʁʊdl/ ‘his/her sled’
    - Verb prefixes
        - single lateral affricate < *hə-s-ɬə- (grammatical functions) (Leer 2000)

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- Richard Wright, for comments on an earlier version of this poster

    - prefixes unstressed relative to stems
- Reflexes of Proto-Athabaskan *hə-s-ɬə-
    - [l]: Tanacross, Upper Tanana, Ahtna, Dena’ina
    - [ɬ]: Witsuwit’en, Dakelh, Dëne Sųɬiné, Tsek’ene (>[h]), Hupa (some contexts)
    - [s]: Navajo, Hupa (other contexts)
    - Lateral affricate
        - [tɬ]: Koyukon, Lower Tanana
        - [tɬ], [tɬ’], [dl]: Deg Xinag (and Holikachuk?) only languages with ejective reflex
- Disagreement about laryngeal state of Deg Xinag prefixal lateral affricate
    - consistently ejective: <yith nitl’idugg> ‘hail’ (lit. ‘snow is made into a ball’) (Kari 1978)
    - consistently voiceless unaspirate: <Deg Xinag Dindlidik> ‘Deg Xinag is written’ (Jerue et al. 1993)
    - sometimes voiced: <yith ndlduq> ‘hail’ (MacAlpine et al. 2007)

Research questions

- Overarching question: What is the laryngeal state of the Deg Xinag prefixal lateral affricate?
    - Hypotheses (< subjective listening, visual inspection of waveforms and spectrograms)

	__cor stop	__[j], [ð], [ʐ]	__[n]	__non-cor
#__	1. tɬ’ə	2. [no exx.]	3. tɬ’ə	4. tɬ’ə
n__	5. dl	6. tɬ’ə~tɬə	7. tɬ’ə~tɬə	8. tɬ’ə~tɬə
V__	9. dl	10. tɬ’ə~tɬə	11. tɬ’ə~tɬə	12. tɬ’ə~tɬə

Table 1. Hypothesized contextual realizations of prefixal lateral affricate. Shading indicates groupings of cells by experiment.

- Research questions subject to experimental verification
    1. Questions about lateral ejective affricates:

1A. Do the measures used in previous studies of ejectives (Wright, Hargus, and Davis 2002, Gordon and Applebaum 2006) distinguish the Deg Xinag stem-initial lateral affricates from each other?

- Hypothesis: /tɬ/, /tɬ^h/, /tɬ’/ in stems will differ in one or more of VOT, jitter, f0, rise time, and relative intensity of fricative noise.

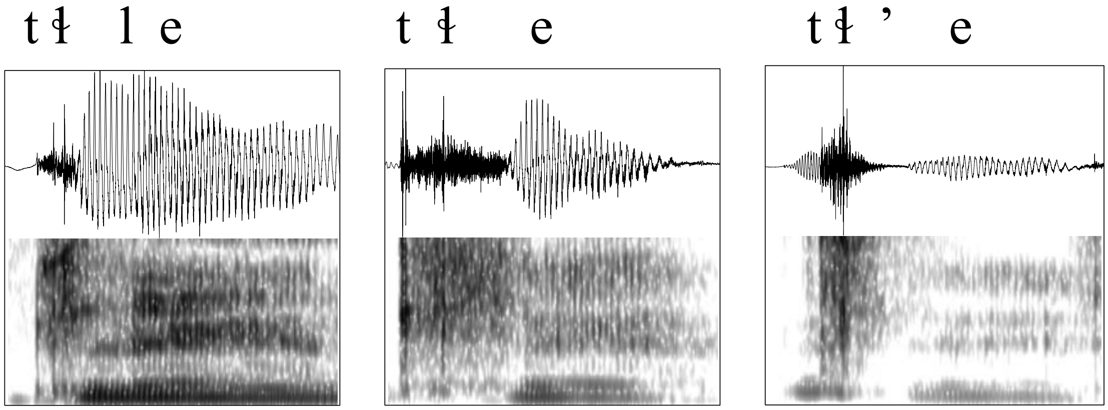

Figure 2. Waveforms and spectrograms of [tɬ] (left), [tɬʰ] (center), and [tɬ’] (right) (speaker JD) from the words [tɬen] ‘mouse’, [q’an’ətɬʰe] ‘I’m praying’, and [tɬ’eɬ] ‘rope’. Notice the differences in peak intensity of the fricative relative to peak intensity of the vowel.

1B. How does the prefixal lateral affricate differ from stem-initial ejective and voiceless unaspirated lateral affricates when

- word-initial (contexts 1, 3 and 4 in Table 1)?
- post-vocalic and not before a coronal stop/affricate (contexts 10-12 in Table 1) ?
- post-nasal and not before a coronal stop/affricate (contexts 6-8 in Table 1) ?
- ➢ Hypotheses:
    - The word-initial prefixal lateral affricate will exhibit some of the characteristics of a stem-initial ejective.
    - The post-vocalic and post-nasal prefixal lateral affricates may exhibit some ejective characteristics but fewer than the word-initial prefix.

2. Question about voiced lateral affricates:
How does the prefixal lateral affricate differ from stem-final lateral affricates when pre-coronal (contexts 5, 9 in Table 1)?

- ➢ Hypotheses:
    - The stem-final lateral affricates differ in voicing.
    - The prefixal lateral affricate in this context will have more of the characteristics of voiced stem-final lateral affricates than voiceless.

Methods

- Word list recordings
    - Three Deg Xinag native speakers: 1 female, 2 male
    - Professional CD or compact flash field recorder; table top microphone (AT 4041)
    - Recorded at sampling rate of 44,100 Hz; downsampled to 22,050 Hz
    - Words in isolation, 2-3 lexical items per category, random order, 4 repetitions each

- Measures
  - Multi-Speech 2.5.1 (voicing analysis module (vx.dll) restored)
  - Measures for research questions 1A-B
    - VOT
    - normalized f0 = f0 averaged over 30 ms. window at voiced onset – f0 averaged over 30 ms. window at vowel peak energy
    - normalized jitter = jitter averaged over 30 ms. window at voiced onset – jitter averaged over 30 ms. window at vowel peak energy
    - energy measures
      - intensity of fricative noise: energy measured at peak of voiceless fricative (subset of tokens, controlled for vowel quality)
        - normalized as peak energy of vowel – energy at 30 ms. after voice onset
      - rise time: energy measured at voice onset, 30 ms. after voice onset, and at peak energy of vowel
        - normalized as peak energy of vowel – energy at 30 ms. after voice onset

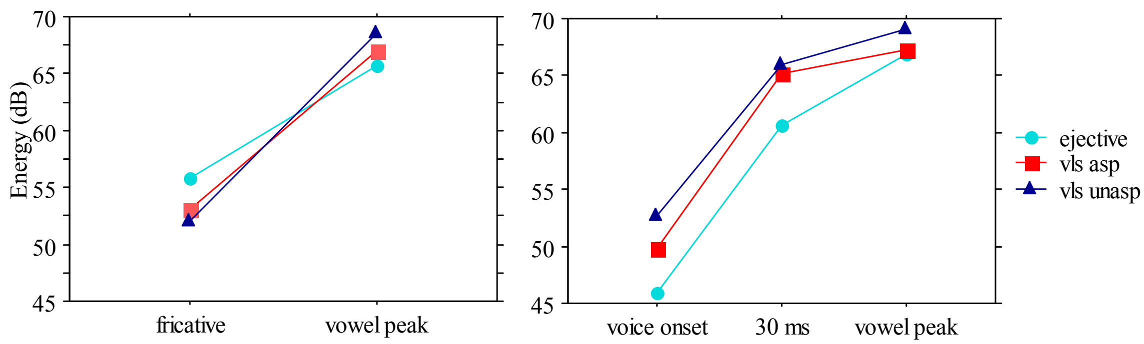

Figure 3. Line graphs of fricative intensity relative to vowel peak (left) and intensity at three points in the vowel (right) (across speakers)

  - Measure for research question 2: duration of voicing within lateral affricate / total duration of lateral affricate = percent voiced
- Inferential statistics
  - Across speakers: Repeated measures ANOVA using each speaker's mean as dependent variable
  - Each individual: Factorial ANOVA
  - Post hoc test : Fisher's PLSD

Results

1A. How do the stem-initial lateral affricates differ from each other?

	across speakers	ED	JD	PA
VOT	va > ej > vu	va > ej > vu	va > ej > vu	va > ej > vu
norm f0	*n.s.*	va > vu > ej	ej > va, vu	*n.s.*
norm jitter	*n.s.*	ej > va, vu	*n.s.*	ej > va, vu
norm fric intens	ej < va, vu	ej, va < vu	ej, va < vu	*n.s.*
rise time	ej > va, vu	ej, vu > va	ej > va, vu	ej > va, vu

Table 2. Significant differences between stem-initial ejectives (ej), voiceless unaspirates (vu) and voiceless aspirates (va) as determined by Fisher's PLSD. Darker shading of cells indicates factors which distinguish stem-initial ejectives from voiceless unaspirates.

- VOT: significantly different across speakers ($F[2,4] = 24.838$, $p = .0056$) and for each individual

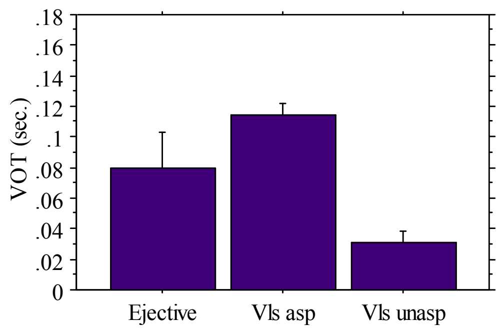

Figure 4. Bar graph showing effect of laryngeal category on VOT: averaged across speakers. Notice the intermediate VOT of the ejectives.

- Normalized f0 (f0 at voice onset – f0 at peak energy of vowel): not significantly different across speakers. Significant for two of three speakers: ED, $F[2,55] = 19.814$, $p < .0001$; JD, $F[2,54] = 43.697$, $p < .0001$.

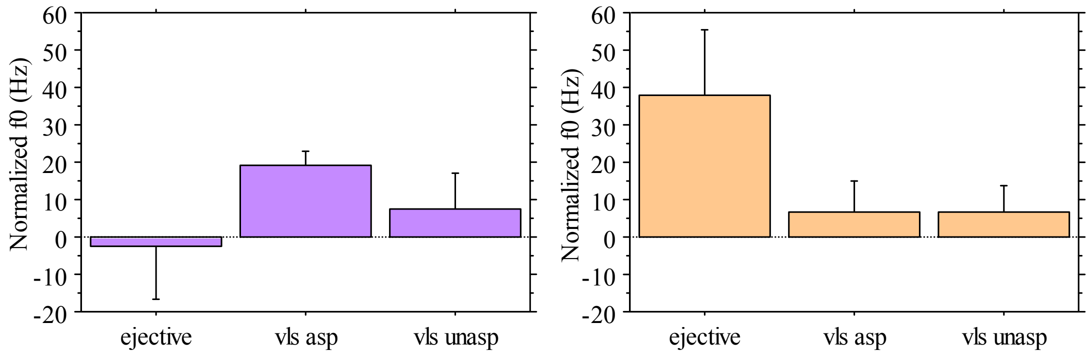

Figure 5. Bar graphs showing effect of laryngeal category on normalized f0, ED (left) and JD (right). Notice that ED's ejectives are pitch-depressors whereas JD's ejectives are pitch-raisers.

- Normalized jitter (jitter at voice onset – jitter at peak energy of vowel): not significantly different across speakers. Significant for two of three speakers: ED, $F[2,55] = 8.476$, $p = .0006$, PA,: $F[2,58] = 6.517$, $p = .0028$.

- Relative intensity of fricative noise (vowel peak energy – fricative peak energy): significantly different across speakers ($F[2,6] = 24.562$, $p = .0013$) and for two of three individuals

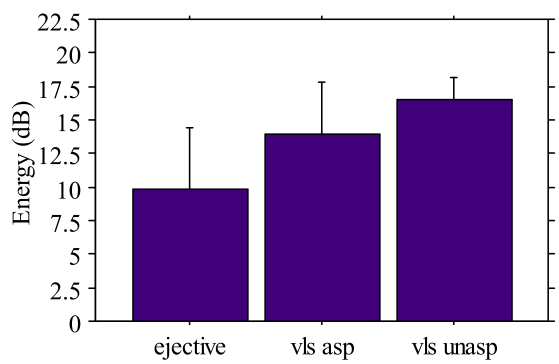

Figure 6. Bar graph showing effect of laryngeal category on relative intensity of fricative noise: averaged across speakers.

- Rise time (vowel peak energy – energy at 30 ms. after voice onset): not significantly different across speakers; significantly different for each individual: ED, $F[2,55] = 10.536$, $p = .0001$; JD, $F[2,54] = 35.904$, $p < .0001$; PA, $F[2,58] = 31.423$, $p < .0001$

1B. How does the prefixal lateral affricate (word-initial, post-vocalic, post-nasal) differ from stem-initial ejectives and voiceless unaspirates?

	across speakers	ED	JD	PA
VOT	ej > vu, Vpf	ej > #pf > Vpf, Npf, vu	#pf, Npf > ej, Vpf, vu	ej > Npf > Vpf, vu #pf > Vpf, vu
norm f0	*n.s.*	#pf, ej < vu < Vpf	ej > #pfx > Vpfx, vu ej > Npf > vu	ej, vu < #pf, Npf, Vpf
norm jitter	#pf > vu	#pf > Npf, Vpf, vu	*n.s.*	#pf, ej > Npf, Vpf, vu
norm fric intensity	ej, #pf < vu	ej < #pf, Npf < Vpf ej < vu	ej, #pf, Npf, Vpf < vu	ej, #pf, Vpf < vu
rise time	ej > #pf, vu, Vpf	Npf > #pf, Vpf	ej > #pf, Npf, Vpf, vu	ej > #pf, Npf, Vpf, vu Npf > Vpf

Table 3. Significant differences between stem ejective (ej), word-initial prefix (#pf), post-vocalic prefix (Vpf), post-nasal prefix (Npf), and stem voiceless unaspirate (vu) as determined by Fisher's PLSD.

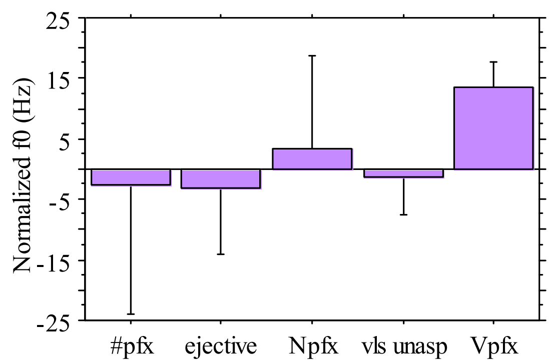

Figure 7. Bar graph of normalized f0 (speaker ED), showing patterning of word-initial prefix (#pfx) with stem ejective.

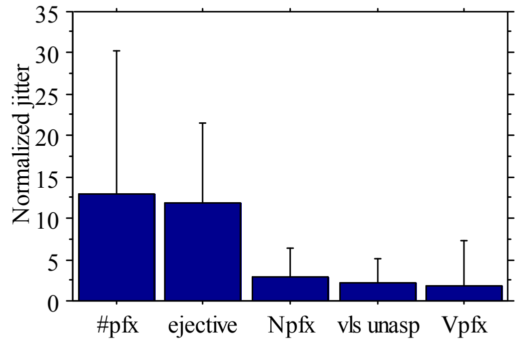

Figure 8. Bar graph of normalized jitter (speaker PA), showing patterning of word-initial prefix (#pfx) with stem ejective.

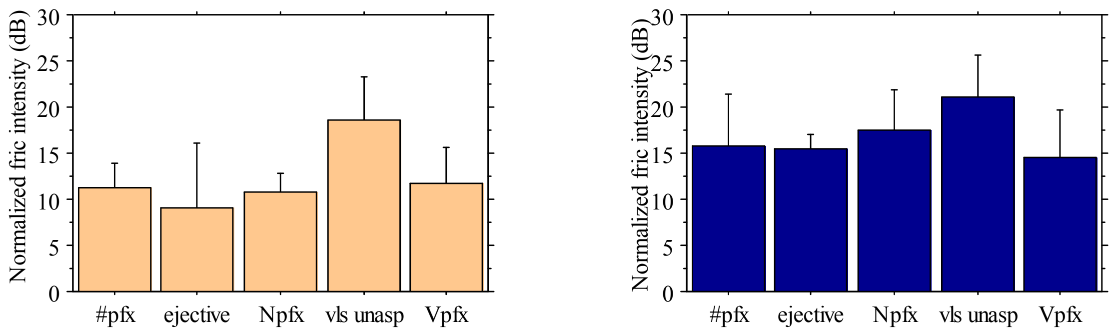

Figure 9. Bar graphs of normalized fricative intensity (JD, left; PA, right), showing patterning of word-initial prefix (#pfx) with stem ejective (JD) and patterning of word-initial and post-vocalic prefixes with stem ejective (PA).

	across speakers	ED	JD	PA
#pf	fric intensity	f0, *VOT, jitter*	fric intensity, *VOT, f0*	jitter, fric intensity, *VOT*
Vpf			fric intensity	fric intensity
Npf			fric intensity, *VOT*	*VOT*

Table 4. Strong and weak ejective characteristics of each kind of prefix. Strong ejective characteristics (plain) are measures by which prefix is not significantly different from ejective but is significantly different from voiceless unaspirate. Weak ejective characteristics (italics) are measures by which prefix is intermediate between ejective and voiceless unaspirate.

2. How do the stem-final lateral affricates and the non-word-initial, pre-coronal stop prefixal lateral affricate differ from each other?

	across speakers	ED	JD	PA
% voiced	N-pfx, V-pfx > vd > vls	N-pfx > V-pfx > vd > vls	V-pfx, vd > vls N-pfx > vls	N-pfx > vd > vls V-pfx > vls

Table 5. Significant differences in percentage of voicing of stem-final voiceless lateral affricate (vls), stem-final voiced lateral affricate (vd), post-vocalic prefixal lateral

affricate (V-pfx), and post-nasal prefixal lateral affricate (N-pfx), as determined by Fisher's PLSD. Shading of cells indicates cases in which the prefixal lateral affricate can be considered voiced. Notice that the percentage of voicing of the prefixal lateral affricate in both contexts generally exceeds even that of the stem-final voiced lateral affricate.

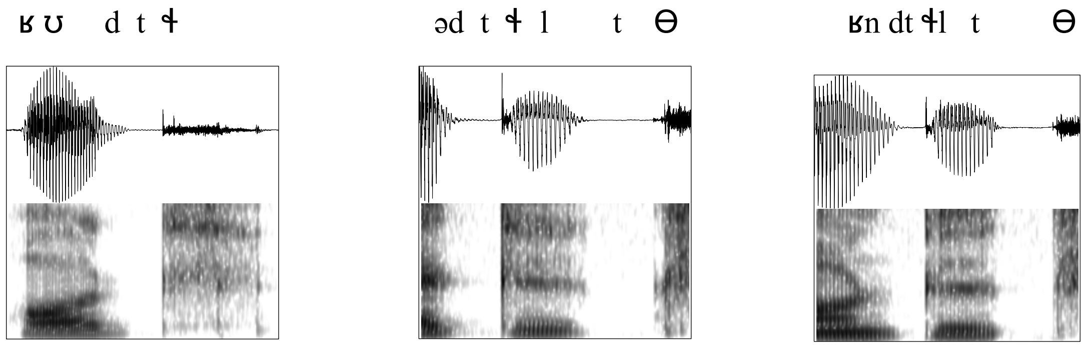

Figure 10. Waveforms and spectrograms of voiced lateral affricates, (from left to right) stem-final /vʊʁʊdl/ 'his/her sled', prefixal /χədltϴ'ət/ 'he/she fell down', and prefixal /naʁndltϴ'ən/ 'bread', all produced by speaker ED. Notice the nearly completely voiced lateral in the prefixal lateral affricates in /χədltϴ'ət/ and /naʁndltϴ'ən/, differing from the partial voicing of the stem-final lateral affricate in /vʊʁʊdl/.

Discussion

- Deg Xinag lateral ejective affricates in stems are most reliably distinguished from voiceless unaspirates by their longer VOT, greater fricative intensity relative to vowel peak, and greater jitter and f0 perturbation at voice onset
  - Similarities with Witsuwit'en ejectives (t', q') (Hargus 2007)
    - VOT, f0 and jitter distinguish ejectives from voiceless unaspirates
    - Speakers are either pitch raisers or lowerers, depending on the pitch perturbing effect of the ejective, with pitch lowerers outnumbering pitch raisers
  - Differences from Witsuwit'en ejectives: Witsuwit'en ejectives have short VOT, DX ejectives have intermediate VOT
- Deg Xinag prefixal lateral affricate
  - Word-initial: ejective for all speakers (VOT, fricative intensity measures)
    - Fewer ejective characteristics than the stem-initial ejective.
  - Post-vocalic or post-nasal: ejective (2 speakers), voiceless unaspirate (1 speaker)
- Ejective characteristics in Deg Xinag
  - stems > word-initial prefixes > post-vocalic and post-nasal prefixes
  - Given historical origins of prefixal lateral affricate from *hə-s-ɬə-, the word-initial ejective lateral affricate in Deg Xinag appears to represent a case of word-initial strengthening (Keating et al. 1999, Fougeron 2001), a type (strengthening to ejective) which is so far unreported in other languages

- Prefixal lateral affricate is voiced when post-vocalic or post-nasal and before a coronal stop, exhibiting greater amounts of voicing than voiced stem-final lateral affricates
    - The following coronal stop environment seems mysterious, but figures elsewhere in Deg Xinag morphophonology, e.g. requiring that reflexes of *s- (one component of *hə-s-ɬə-) and stem-initial coronal stop be adjacent (Hargus 2003)

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