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# Voice Quality of Gitksan Ejectives

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## 1. Introduction

- Gitksan is an endangered Tsimshianic language spoken by ~500 speakers in northwestern British Columbia [1].
  - Its ejectives are characterized as “lenis” [2].
- During the stop-vowel transition, “lenis” ejectives typically have creaky voice in the following vowel [3].
- Schwan [4] compared creaky voice between plain and glottalized stops in Gitksan:
  - The amplitude difference between the first two harmonics (H1-H2) at vowel onset showed that glottalized stops were produced with more creaky voice by one of the three speakers only.
- However, there are different types of creaky voice; each one has a distinct set of acoustic measures [5].
  - E.g., a “prototypical” type is characterized by low f0, irregular f0 (correlated with high noise) and glottal constriction (correlated with low H1-H2).

### Research questions

1) Which acoustic properties are effective measures of voice quality of Gitksan ejectives?
2) To what extent can these properties distinguish Gitksan ejectives from plain stops by place of articulation (PoA)?

## 2. Gitksan stops and vowels

**Table 1.** Gitksan initial prevocalic stops [2,6]

| Stops | Bilabial | Alveolar | Palatal | Labiovelar | Uvular |
|---|---|---|---|---|---|
| Plain | b | d | ɟ | gʷ | ɢ |
| Ejective | pʼ | tʼ | cʼ | kʷʼ | qʼ |

### Gitksan vowels [7]

- /a aː/
- /eː/
- /i iː/
- /oː/
- /u uː/
- /ə/
- Their phonetic realization may differ (e.g., /a/ → [e]) [8].

### Examples

(1) a. [bakʷ] ‘arrive’
b. [duːs] ‘cat’
c. [ɟiːs] ‘be mistaken’
d. [gʷenks] ‘spring’
e. [ɢoːtʰ] ‘heart’
f. [tʼaks] ‘dive’
g. [cʼeːç] ‘tallow’
h. [kʷʼoːtxʷ] ‘be lost’
i. [qʼaːç] ’feather’

Note: [pʼ] rarely occurs word-initially so it is omitted in the acoustic analysis along with its [b] counterpart.

## 3. Corpus

### Gitksan language consultants

- Two male adult first-language speakers:
  - HH from Gitsegukla
  - VG from Gitanyow

### Stimuli

- English words from the Gitksan-English dictionary [9] and Gitksan grammar [6]:
  - The words’ translations in Gitksan contain an initial prevocalic stop.

### Elicitation

- Multiple sessions conducted at UBC in Vancouver
- The consultant was prompted with English words.
- He was asked to translate them into Gitksan or to confirm the Gitksan translations presented.

### Recording

- The consultant was asked to say the translated Gitksan words naturally three times.
- The speech was recorded using a Marantz audio recorder at a sampling rate of 48 kHz in 24-bit mono.
- Only words familiar to the speaker were recorded and used in the analysis.

## 4. Acoustic analysis

### Dataset

- Isolated words with initial prevocalic stops
- 480 tokens (2 speakers x 2 stop types x 4 PoA x 10 words x 3 repetitions) minus 5 unanalyzable stops
- Different vowel contexts

### Acoustic measures (*corrected for formant effect)

- Differences in amplitude between
  - H1 and H2 (H1*-H2*)
  - H1 and the first formant (H1*-A1*)
  - H1 and the second formant (H1*-A2*)
  - H1 and the third formant (H1*-A3*)

### Annotation in Praat [10]

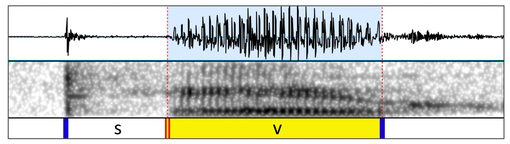


**Figure 1.** Initial stop (s) and vowel (v) of HH’s production of [tʼɛxʷ] ‘sweep’

### Acoustic measurements

- VoiceSauce [11] computed all four acoustic measures at the onset (first 20%) of the vowel.

## 5. Results

- For each speaker, an ANOVA with post-hoc Tukey HSD test (at $\alpha = .05$) was performed on each acoustic measure, with stop type and PoA as independent variables.

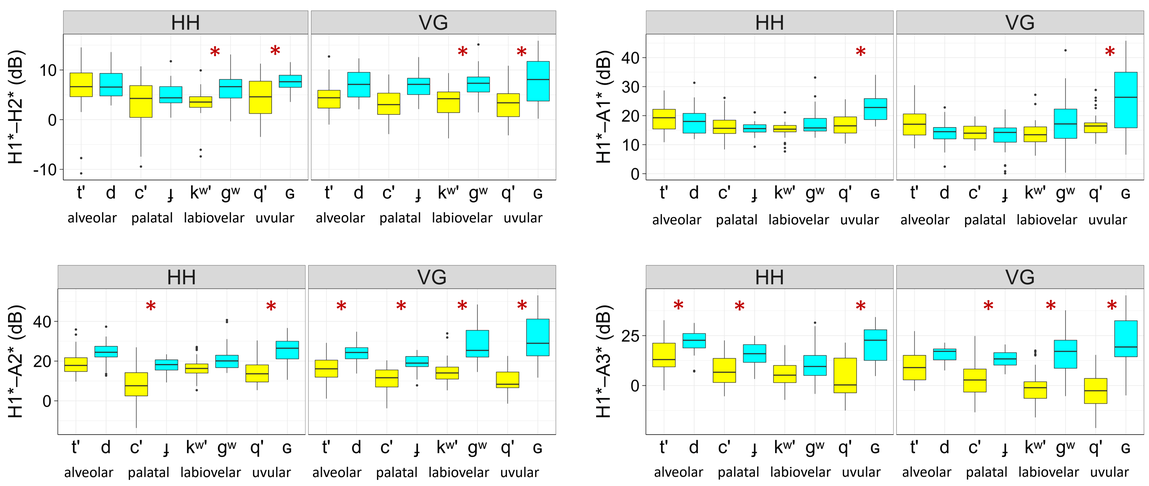


**Figure 2.** Harmonic amplitude differences between stop types across PoA for both speakers (HH and VG): stop pairs (yellow = ejective, cyan = plain) with significant difference at a PoA (see Table 2) are marked with *

**Table 2.** Significant test results ($p < .05$) of all four acoustic measures: “<” means “less amplitude difference (or more creaky voice)”

| | Between stop types | Among PoA of ejectives | Among PoA of plain stops |
|---|---|---|---|
| H1*-H2* | Ejective < Plain (labiovelar, uvular) | | |
| H1*-A1* | Ejective < Plain (uvular) | HH: labiovelar < alveolar | other 3 PoA < uvular |
| H1*-A2* | Ejective < Plain (HH: palatal, uvular; VG: all four PoA) | HH: palatal < other 3 PoA | HH: palatal < alveolar, uvular<br>VG: palatal < labiovelar, uvular |
| H1*-A3* | Ejective < Plain (HH: all but labiovelar; VG: all but alveolar) | other 3 PoA < alveolar (except for VG’s palatal: $p > .05$) | HH: labiovelar < uvular<br>VG: palatal < uvular |

- Similar tests were performed comparing the speakers.
- Significant test results: (i) on H1*-A2*: HH < VG for plain stops; (ii) on H1*-A3*: VG < HH for ejectives.

## 6. Discussion

Comparing effectiveness of their measure of creakiness:

- H1*-A2* is likely the most effective of the four:
  - It revealed that VG produced ejectives, versus plain stops, with more creaky voice at all four PoA.
  - It also revealed that VG produced less creaky voice than HH did for plain stops.
- H1*-A3* is fairly effective:
  - Together with H1*-H2*, they showed that HH produced ejectives, versus plain stops, with more creaky voice at all four PoA.
  - It revealed that both speakers produced less creaky voice for alveolar ejectives than for the other ejectives.
  - It also revealed that VG produced more creaky voice than HH did for ejectives.
- H1*-H2* is less effective:
  - It revealed that both speakers produced ejectives, versus plain stops, with more creaky voice at only two PoA. (H1*-A2* revealed more PoA.)
- H1*-A1* is probably the least effective:
  - It revealed that both speakers produced ejectives, versus plain stops, with more creaky voice at uvular PoA only.
  - However, it also revealed that both speakers produced less creaky voice for uvular plain stops than for the other plain stops.
- The different degrees of effectiveness of these acoustic measures suggest that creaky voice related to Gitksan ejectives has multiple acoustic correlates.
- E.g., lower H1*-H2* values associated with labiovelar and uvular ejectives indicate that they were produced with greater glottal constriction [5].
- Lower H1*-A2* and H1*-A3* values indicate strong higher-frequency harmonics [12].

## 7. Conclusion

- H1*-A2* and H1*-A3* are likely more effective voice quality measures of Gitksan ejectives than H1*-H2* and H1*-A1* are.
- H1*-H2*, H1*-A2*, and H1*-A3* together were able to distinguish ejectives from plain stops at all four PoA for both speakers.
- These harmonic amplitude differences are more robust, acoustic cues to stop types than to PoA in Gitksan.

### Future directions

- Include other voice quality measures (e.g., jitter and harmonic-to-noise ratio): in progress
- Investigate interspeaker variation in how creaky voice is produced in Gitksan
  - Add more speakers

## References

[1] Dunlop, B., Gessner, S., Herbert, T., & Parker, A. (2018). *Report on the status of B.C. First Nations languages* (3rd ed.). First Peoples' Cultural Council.
[2] Rigsby, B., & Ingram, J. (1990). Obstruent voicing and glottalic obstruents in Gitksan. *International Journal of American Linguistics*, *56*(2), 251–263.
[3] Fallon, P. D. (2013). *The synchronic and diachronic phonology of ejectives*. New York: Routledge.
[4] Schwan, M. D. (2013). *An acoustic description of glottalized obstruents in Gitksan* (Honours Essay, University of British Columbia, Vancouver, Canada).
[5] Keating, P. A., Garellek, M., & Kreiman, J. (2015). Acoustic properties of different kinds of creaky voice. *Proceedings of the 18th ICPhS*, Glasgow, UK.
[6] Rigsby, B. (1986). *Gitksan grammar* (Ms., University of Queensland, Brisbane, Australia).
[7] Brown, J., Davis, H., Schwan, M., & Sennott, B. (2016). Gitksan. *Journal of the International Phonetic Association*, *46*(3), 367–378.
[8] Borland-Walker, K. A. (2019). *An acoustic investigation of vowel variation in Gitksan* (Doctoral dissertation, University of Victoria, Victoria, Canada).
[9] Hindle, L., & Rigsby, B. J. (1973). *A short practical dictionary of the Gitksan language* (Vol. 7, No. 1). Department of Sociology/Anthropology, University of Idaho.
[10] Boersma, P., & Weenink, D. (2019). *Praat: Doing phonetics by computer* (Version 6.1.05) [Computer application]. Retrieved from http://www.praat.org
[11] Shue, Y. L., Keating, P., Vicenik, C., & Yu, K. (2011). VoiceSauce: A program for voice analysis. *Proceedings of the 17th ICPhS*, Hong Kong, China, 1846–1849.
[12] Keating, P., & Garellek, M. (2015). Acoustic analysis of creaky voice. Poster presented at the Annual Meeting of the Linguistic Society of America, Portland, USA.

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