

Gitksan fricatives: auditory-acoustic trajectories differentiate [s]-[ʃ]-[χ]-[h]

Una Chow¹ and Molly Babel¹

¹University of British Columbia

Gitksan is an endangered First Nations language of the Tsimshianic language family, spoken in northwestern British Columbia, Canada. Its fricative inventory consists of /s ʃ ç x^w χ h/ [1]. Currently, there is a lack of documentation on the acoustic properties of Gitksan fricatives and of lateral fricatives in the world's languages. The need for Gitksan language documentation is urgent as most of the fluent Gitksan speakers are aged 65+ [2]. Also, the acoustic characteristics of lateral fricatives are of typological interest [3]. This study is the first to provide an acoustic-phonetic description of Gitksan word-initial prevocalic fricatives, including the less-studied lateral fricative /ʃ/.

According to [4], [ç x^w] do not occur before vowels in Gitksan; therefore, this study focused on [s χ h ʃ]. Isolated words with initial prevocalic fricatives (e.g., *saak* [sa:c^h] ‘oolachen’; *xatxw* [χatx^w] ‘be cold (of a person)’; *haat* [ha:t^h] ‘intestines’; *hlalp* [ʃalp^h] ‘plane (wood)’) were recorded in-person with three fluent Gitksan first-language speakers in 2023. The Gitksan speakers (HH, VG: male; JH: female) were from different Gitksan communities (HH: Gitsegukla; VG: Gitanyow; JH: Anspayaxw). The elicited and recorded words varied slightly among the speakers due to speaker variations in the pronunciation and familiarity of the words. Each speaker was recorded in a quiet room while wearing a head-mounted microphone. Five repetitions of the elicited words were recorded at a sampling rate of 44.1 kHz mono using Audacity on a computer connected to a USBPre 2 audio device. Three repetitions of the recorded words – a total of 921 fricative tokens – were used in the acoustic analysis (HH: [s]=87, [ʃ]=66, [χ]=15, [h]=126; JH: [s]=78, [ʃ]=81, [χ]=12, [h]=126; VG: [s]=93, [ʃ]=78, [χ]=15, [h]=144). These fricative tokens appeared in different vowel contexts: /a e i o u a: e: i: o: u:/. To account for context-specific vowel coarticulation and to better describe language-specific differences in fricative articulations, a dynamic measure was used: spectral measurements of peak frequency in equivalent rectangular bandwidths (peak ERB; [5]) were estimated from 17 20-*ms* windows centered at equidistant points between the onset and offset of the fricative. Praat textgrids [6] were used to mark (i) the fricative onset where the amplitude increases in the waveform and the spectral energy increases in the spectrogram and (ii) the fricative offset where frication of the fricative ends and periodicity of the following vowel begins. The full duration of the fricative was considered, including any voicing near the offset mainly observed in JH's [ʃ] (Fig. 1). Even though JH's [ʃ] tends to be voiced towards the offset, its mean duration is close to HH's [ʃ] duration, as with the durations of their [s χ h] (Table 1).

Fig. 2 shows the peak ERB of each fricative averaged across speakers. Overall, the peak ERB decreases as the place of articulation/phonation shifts further back and lower in the vocal tract (alveolar [s ʃ]~20-31, 88% of the fricative; uvular [χ]~18-19; glottal [h]~16-17). The lateral alveolar [ʃ] also shows a lower peak ERB than the central alveolar [s]. This descriptive analysis suggests that word-initial prevocalic fricatives in Gitksan can be differentiated by the range, shape, and/or peak location of their peak ERB trajectories. These robust descriptive patterns will be confirmed with quantitative analyses.

Compared with a Salish language spoken in British Columbia, the [s] produced by the three Gitksan speakers has a similar peak ERB trajectory range and shape to the [s] produced by the five ʔayʔaʃuθəm speakers in [7]. However, the ʔayʔaʃuθəm speakers produced the [ʃ] with a lower peak ERB range (~15-20) and at a different peak location (middle third) than the male Gitksan speakers. This supports Gordon, Barthmaier, and Sands' analysis that [ʃ] tends to vary in acoustic properties across languages [8].

This study's documentation of the dynamic spectral characteristics of Gitksan fricatives contributes importantly to the preservation of the Gitksan language. The observed voicing and spectral patterns of its [ʃ] also contribute to the typological research on lateral fricatives.

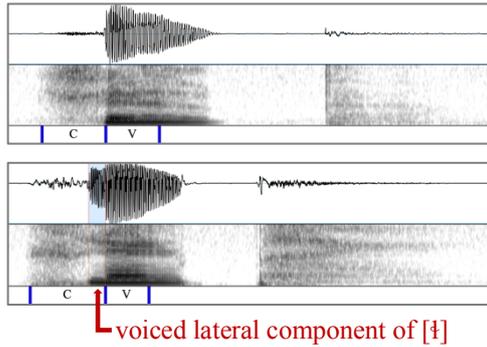


Fig. 1. *hlelp* [ɬelpʰ] produced by HH (top);
hlalp [ɬalpʰ] produced by JH (bottom).
 C = target consonant [ɬ]; V = adjacent vowel.

Table 1. Duration of [s ɬ χ h] produced by each speaker: mean (sd) in *ms*.

Fricative	HH	JH	VG
s	186 (34)	180 (24)	221 (50)
ɬ	141 (29)	148 (30)	214 (88)
χ	155 (35)	147 (13)	248 (41)
h	86 (21)	82 (20)	119 (52)

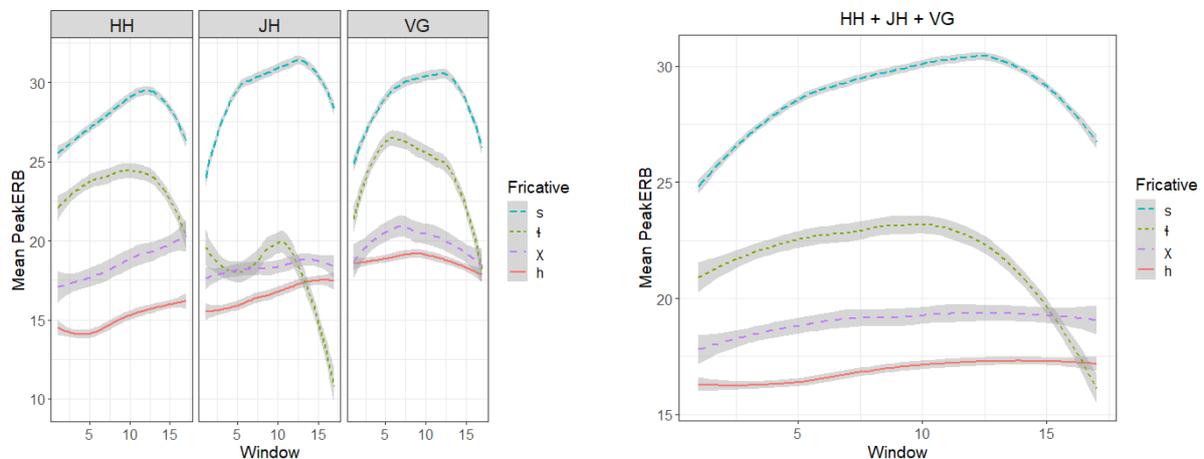


Fig. 2. Mean peak ERB of [s ɬ χ h] across 17 20-*ms* windows of the fricative of each speaker (left) and of all 3 speakers (right).

References

- [1] Rigsby, B. (1986). *Gitksan grammar* (Manuscript, University of Queensland, Australia).
- [2] Gessner, S., Herbert, T., & Parker, A. (2022). Report on the status of B.C. First Nations languages (4th ed.). First Peoples' Cultural Council. <https://fpcc.ca/wp-content/uploads/2023/02/FPCC-LanguageReport-23.02.14-FINAL.pdf>
- [3] Tabain, M. (2019). The phonetic properties of consonants. In W. F. Katz & P. F. Assmann (Eds.), *The Routledge Handbook of Phonetics* (pp. 264–288). New York: Routledge.
- [4] Brown, J., Davis, H., Schwan, M., & Sennott, B. (2016). Gitksan. *Journal of the International Phonetic Association*, 46(3), 367–378.
- [5] Reidy, P. F. (2016). Spectral dynamics of sibilant fricatives are contrastive and language specific. *The Journal of the Acoustical Society of America*, 140(4), 2518–2529.
- [6] Boersma, P., & Weenink, D. (2023). Praat: Doing phonetics by computer (Version 6.3.17) [Computer application]. Retrieved October 29, 2023, from <http://www.praat.org>
- [7] Mellesmoen, G., & Babel, M. (2020). Acoustically distinct and perceptually ambiguous: ʔayʔajuθəm (Salish) fricatives. *The Journal of the Acoustical Society of America*, 147(4), 2959–2973.
- [8] Gordon, M., Barthmaier, P., & Sands, K. (2002). A cross-linguistic acoustic study of voiceless fricatives. *Journal of the International Phonetic Association*, 32(2), 141–174.