Voice quality of Gitksan ejectives

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Gitksan ejectives: Gitksan, an endangered Tsimshianic language spoken in northwestern British Columbia, has word-initial ejectives that are described as lenis (Rigsby, 1986; Rigsby & Ingram, 1990). Lenis ejectives tend to have creaky voice in the following vowel (Fallon, 2013; Ingram & Rigsby, 1987; Kingston, 1985). Schwan (2013) compared voice quality between glottalized and plain stops in Gitksan using the amplitude difference between the first and second harmonics (H1-H2) at vowel onset. Only the glottalized stops produced by one of the three Gitksan speakers showed significantly more creaky voice than the plain stops. However, there are different types of creaky voice; each type is associated with a distinct set of acoustic measures (Keating et al., 2015; Redi & Shattuck-Hufnagel, 2001). For example, low f0, high noise (irregular f0), and low H1-H2 (glottal constriction) characterize prototypical creaky voice.

Research questions: 1) Which acoustic properties are effective measures of the voice quality of Gitksan ejectives? 2) To what extent can these properties distinguish ejectives from plain stops in Gitksan? Previous studies (Blankenship, 2002; Garellek & Keating, 2011) suggest that the spectral energy difference between H1 and vowel formants can be distinguishing properties for voice quality. Therefore, this study examined the amplitude difference between H1 and the first three formants (H1-A1, H1-A2, and H1-A3) of the post-stop vowel, in addition to H1-H2. Lower amplitude difference indicates more creaky voice.

Methods: Isolated Gitksan words were elicited and recorded (at 48 kHz mono) from two elder, male first-language speakers: HH from Gitsegukla and VG from Gitanyow. From these words, 480 initial prevocalic plain [d ɟ gʷ ɢ] and ejective [t' c' kʷ' q'] stops at the alveolar, palatal, labiovelar, and uvular places of articulation (PoA) were analyzed (2 speakers × 2 stop types × 4 PoA × 10 words × 3 repetitions). The segment boundaries of the initial stops and post-stop vowels were marked in Praat textgrids (Boersma & Weenink, 2019). Using the textgrids, VoiceSauce (Shue, 2010; Shue et al., 201) computed the H1-H2, H1-A1, H1-A2, and H1-A3 values at the onset (first fifth) of the post-stop vowel. The STRAIGHT algorithm (Kawahara et al., 1999) was used to estimate H1 between 40 and 350 Hz for male, creaky voice. The Snack algorithm (Sjölander, 2004) was used to estimate the formant frequencies, with pre-emphasis.

Results: ANOVAs and post-hoc Tukey HSD tests (at $\alpha = .05$) reveal significantly more creaky voice at vowel onset of ejectives than plain stops across all four PoA, based on the H1-A2 results alone for VG and the combined results of H1-H2 and H1-A3 for HH. Within each stop type, alveolar ejectives and uvular plain stops show significantly less creaky voice than stops at the other three PoA, based on the results of H1-A3 and H1-A1, respectively (except for VG's alveolar ejectives which did not differ significantly from the palatal ejectives). Between speakers, the significant test result on H1-A2 suggests that VG produced less creaky voice than HH for plain stops while the significant test result on H1-A3 suggests that VG produced more creaky voice than HH for ejectives.

Discussion: As in Schwan (2013), H1-H2 (alone) could not distinguish ejectives from plain stops or stops by PoA, so it is a weak measure of voice quality of Gitksan stops. Including amplitude differences between H1 and vowel formants (Garellek & Keating, 2011) in the current study yielded more stop pairs with voice quality contrasts. These amplitude-difference measures were fairly effective in distinguishing between stop types but were only slightly effective in discriminating the PoA of each stop type. They appear to be sensitive to interspeaker variation in how creaky voice is produced. Based on the creaky voice described in Keating et al. (2015), the results here suggest that speakers may produce creaky voice in Gitksan stops with glottal constriction and with strong higher-frequency harmonics. Other voice quality measures may also be salient and their acoustic correlates (e.g., jitter and harmonic-to-noise ratio) will be examined.

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