Spectral moments analysis of stop release bursts of Shina

Qandeel Hussain
University of Toronto, Canada

Shina is an endangered Indo-Aryan (Dardic) language spoken in Gligit, Northern Pakistan. There have been a wide range of studies on the sociolinguistic and grammatical aspects of Shina (Schmidt & Kohistānī, 2008). However, there are no detailed phonetic descriptions. Shina has a three-way laryngeal contrast in stops (e.g., /p p^h b/) at five places of articulation (bilabial, dental, retroflex, palatal, and velar). The current study presents the first detailed acoustic-phonetic description of the rich laryngeal and place contrasts of Shina using spectral moments analysis of stop release bursts. The first four spectral moments (spectral center of gravity (CoG), spectral standard deviation (SD), spectral skewness, and spectral kurtosis) are widely used to characterize consonants produced at different places of articulation (Hussain et al., 2017) but are not generally reported in the literature on laryngeal contrasts. The first spectral moment (spectral CoG) shows the mean distribution of acoustic energy in the burst spectrum and generally correlates with the length of the front cavity (Forrest et al., 1988). The second spectral moment (spectral SD) is a measure of dispersion on both sides of the mean acoustic energy (spectral CoG) and is generally used to differentiate between the tongue postures of consonants (e.g., apical vs. laminal in coronals). The third spectral moment (spectral skewness) shows whether the acoustic energy is skewed toward higher (negative skewness) or lower (positive skewness) frequencies and correlates with the length of the front cavity. The fourth spectral moment (spectral kurtosis) indicates the degree to which the spectral envelope is focused in a particular region, whether it is compact or diffuse, which is an indicator of the tongue postures of consonants produced at different places of articulation. In general, retroflexes, due to their larger sub-lingual cavity, have lower spectral CoG, spectral SD, and higher spectral skewness, and spectral kurtosis, compared to bilabials, dentals, and velars (Hussain & Mielke, 2020).

Five Shina speakers (range: 18–32 years; mean age: 24.6 years) were recruited from Gilgit, Northern Pakistan. Word lists of nonsense CV words were created where word-initial C represented a stop consonant, followed by vowel /a/ (e.g., /pa/, p^ha/, /ba/). As quality of vowels can affect on spectral moments, nonsense words were created to better control for the phonological environment. The first four spectral moments (spectral CoG, spectral SD, spectral skewness, and spectral kurtosis) of stop release bursts were measured in Praat from fast Fourier transform (FFT) spectra generated over a single 5 ms Hamming analysis window centered at the beginning of the stop release burst. Statistical analyses were performed using LMER models (R Core Team, 2013). Only general patterns of the LMER estimates are reported here.

Boxplots of the first four spectral moments (spectral CoG, spectral SD, spectral skewness, and spectral kurtosis) of stop release bursts are shown in Figure 1. The voiceless unaspirated and aspirated series of stops appeared to have higher spectral CoG, spectral SD, but lower spectral skewness and spectral kurtosis, compared to the voiced unaspirated series. In terms of places of articulation, palatal stops showed higher mean spectral CoG compared to bilabial, dental, retroflex, and velar stops. There were no clear patterns in spectral skewness and spectral kurtosis across laryngeal and place contrasts. Spectral moments correlate with the articulatory configurations of the vocal tract (Sundara, 2005). For instance, a large front cavity, either created by raising or by lowering the tongue tip, can result in higher spectral CoG and spectral SD. In Shina, velar stops were characterized by lower spectral CoG than retroflex stops. A similar type of pattern was observed in Arrernte (Tabain et al., 2016) and Kalasha (Hussain & Mielke, 2020) where retroflex stops showed slightly higher spectral CoG, compared to velar stops. The findings of this study will contribute to the phonetic and phonological typology of endangered Indo-Aryan languages.

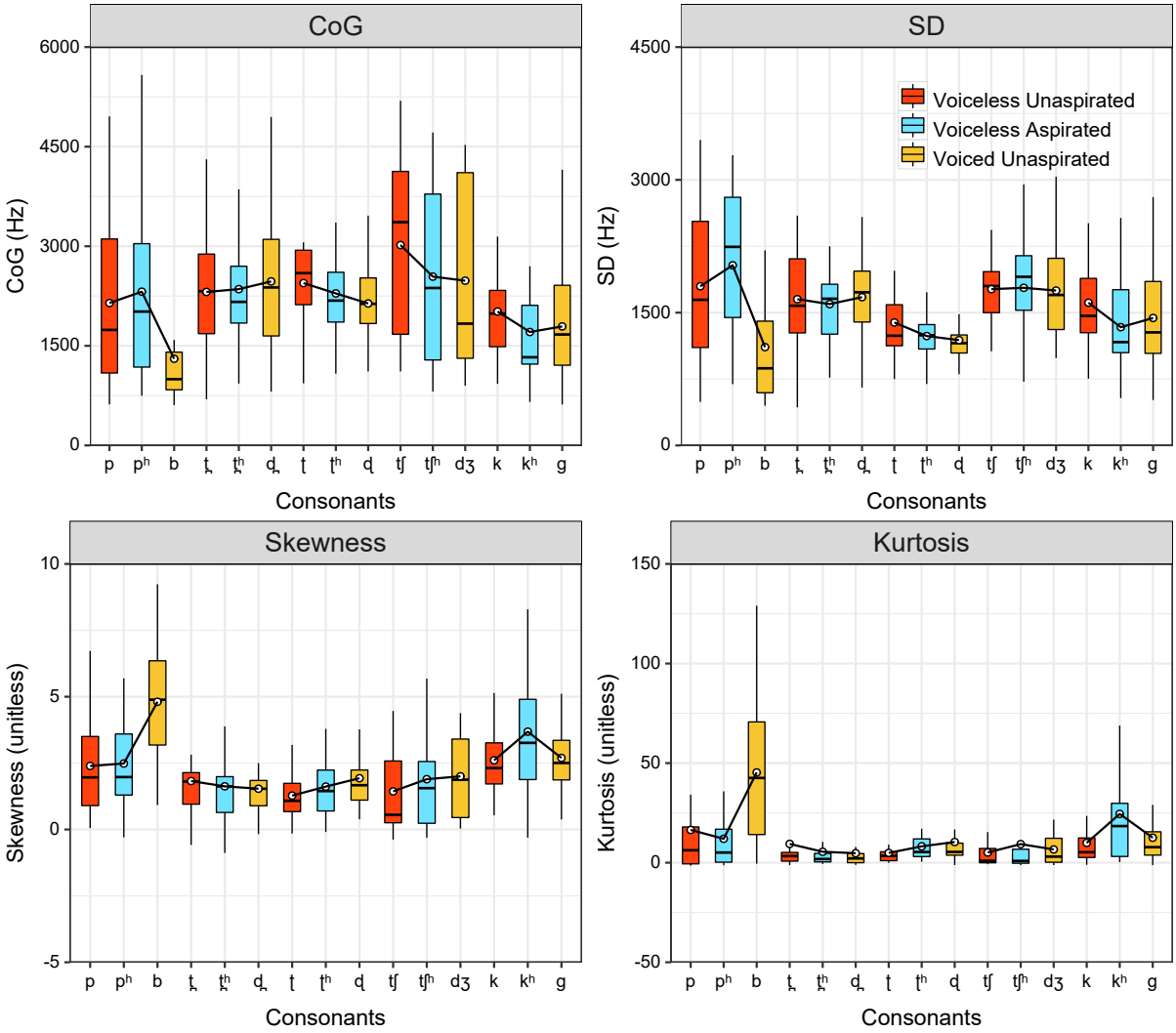

Figure 1: Boxplots of first four spectral moments (spectral CoG, spectral SD, spectral skewness, and spectral kurtosis) of stop release bursts of Shina. White circles indicate the means. Black lines connect the means of three laryngeal series (voiceless unaspirated, voiceless aspirated, and voiced unaspirated) at each place of articulation (bilabial, dental, retroflex, palatal, and velar).

References

Forrest, K., Weismer, G., Milenkovic, P., & Dougall, R. N. (1988). Statistical analysis of word-initial voiceless obstruents: Preliminary data. *Journal of the Acoustical Society of America*, *84*(1), 115–123.

Hussain, Q., & Mielke, J. (2020). An acoustic and articulatory study of laryngeal and place contrasts of Kalasha (Indo-Aryan, Dardic). *Journal of the Acoustical Society of America*, *147*(4), 2873–2890.

Hussain, Q., Proctor, M., Harvey, M., & Demuth, K. (2017). Acoustic characteristics of Punjabi retroflex and dental stops. *Journal of the Acoustical Society of America*, *141*(6), 4522–4542.

R Core Team. (2013). *R: A language and environment for statistical computing*. Vienna, Austria. ([Computer program])

Schmidt, R. L., & Kohistānī, R. (2008). *A grammar of the Shina language of Indus Kohistan*. Wiesbaden: Otto Harrassowitz Verlag.

Sundara, M. (2005). Acoustic-phonetics of coronal stops: A cross-language study of Canadian English and Canadian French. *Journal of the Acoustical Society of America*, *118*(2), 1026–1037.

Tabain, M., Breen, G., Butcher, A., Jukes, A., & Beare, R. (2016). Stress effects on stop bursts in five languages. *Laboratory Phonology: Journal of the Association for Laboratory Phonology*, *7*(1), 1–23.