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A preliminary acoustic study of tone in Dzongkha

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1. Introduction

Dzongkha, the national language of Bhutan, is a language with a two-way tonal contrast: high (H) and low (L). This study reports a preliminary acoustic analysis of Dzongkha tones, whose nature has not been studied instrumentally. The current data comes from a single native speaker of Dzongkha; hence, our data should be taken to be preliminary. However, since there have not been any instrumental analyses on the phonetics of this language, aside from an impresionistic description by van Driem (2015), we would like to situate the current study as a first stepstone toward more systematic phonetic analyses of this language, which are on-going.

2. Method

Dzongkha has eight vowels, transcribed by van Driem (2015) as /a/, /ä/, /e/, /i/, /o/, /ö/, /u/, and /ü/. Each of these vowels were read by a native speaker of Dzongkha with H-tone and L-tone. Both f0 and spectral natures of these vowels were analyzed using Praat (Boersma 2001). In addition to these vowels read in isolation, 34 H-tone tokens and 33 L-tone tokens, varying in vowel quality and onset consonants, were also read by the same speaker. The f0 patterns of these syllables were analyzed. Finally, we addressed one consonant-tone interaction in Dzongkha by examining 18 syllables with a voiced onset and 16 syllables with what has been referred to as "devoiced" consonants (van Driem 2015).

3. Results

3.1. Vowel quality

We first started by exploring the acoustic nature of each vowels that exist in Dzongkha (/a/, /ä/, /e/, /i/, /o/, /u/, /ö/, /ü/). Figure 1 plots the standard F1 and F2 chart of these eight vowels, which shows that for those vowels without umlaut signs (/a/, /e/, /i/, /o/, /u/), their F1 and F2 distribute in expected F1-F2 regions. We also observe that umlauted versions have lower F1, but, more clearly, higher F2 compared to non-umlaut versions, which suggests that they are fronted versions of the corresponding non-umlaut vowels (i.e. umlaut represents frontness, as in German). In Figure 1, four types of vowels are clustered in the left-top region (/i/, /e/, /ö/, /ü/). In order to explore how these sounds are distinguished acoustically, we examined their F3, which is known to distinguish front unrounded vowels from front rounded vowels (Reetz & Jongman 2009). The results appear in Figure 2. As expected, F3 distinguishes unrounded front vowels (/e/, /i/) and rounded front vowels (/ö/, /ü/), in that the latter group has much lower F3.

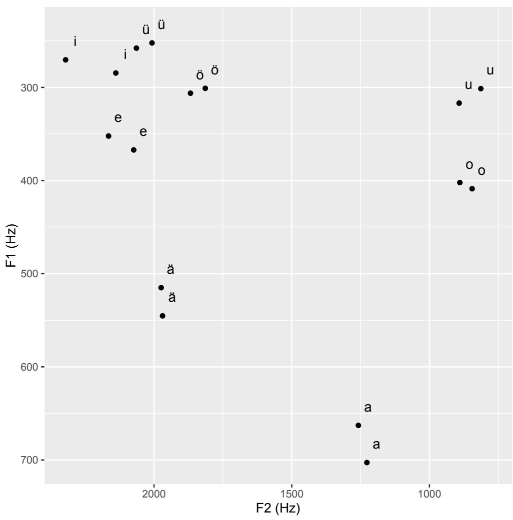

Figure 1: F1-F2 plot

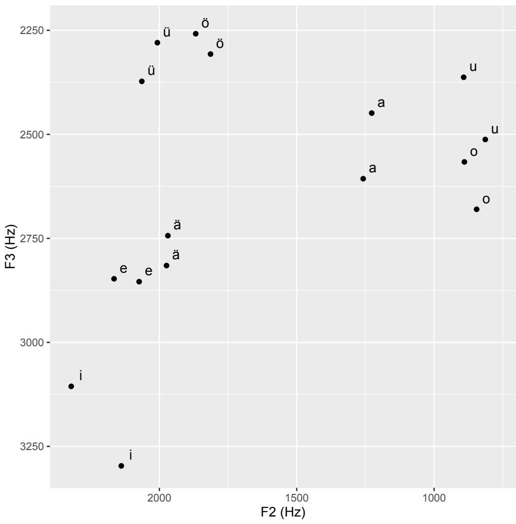

Figure 2: F2-F3 plot

3.2. Basic tonal patterns

Figure 3 shows raw f0 data of each vowel read in isolation. In this figure, all pitch points detected by Praat are plotted for the two tone types, presented by separate vowels. We generally observe separation between H-toned syllables and L-toned syllables in the first halves of the vowels. Some L-toned syllables (/ä/, /e/, /i/, /ö/, /ü/) show some bumps at their onset, to the degree that sometimes L-toned syllables have f0 as high as H-toned syllables. We are not confident whether these are simply measurement errors, or reflect something real (there is a generalization to be made here that only and all front vowels show this bump.) Besides these bumps, however, it is clear that H-toned syllables and L-toned syllables are separated in terms of their f0, especially at the beginning of syllables.

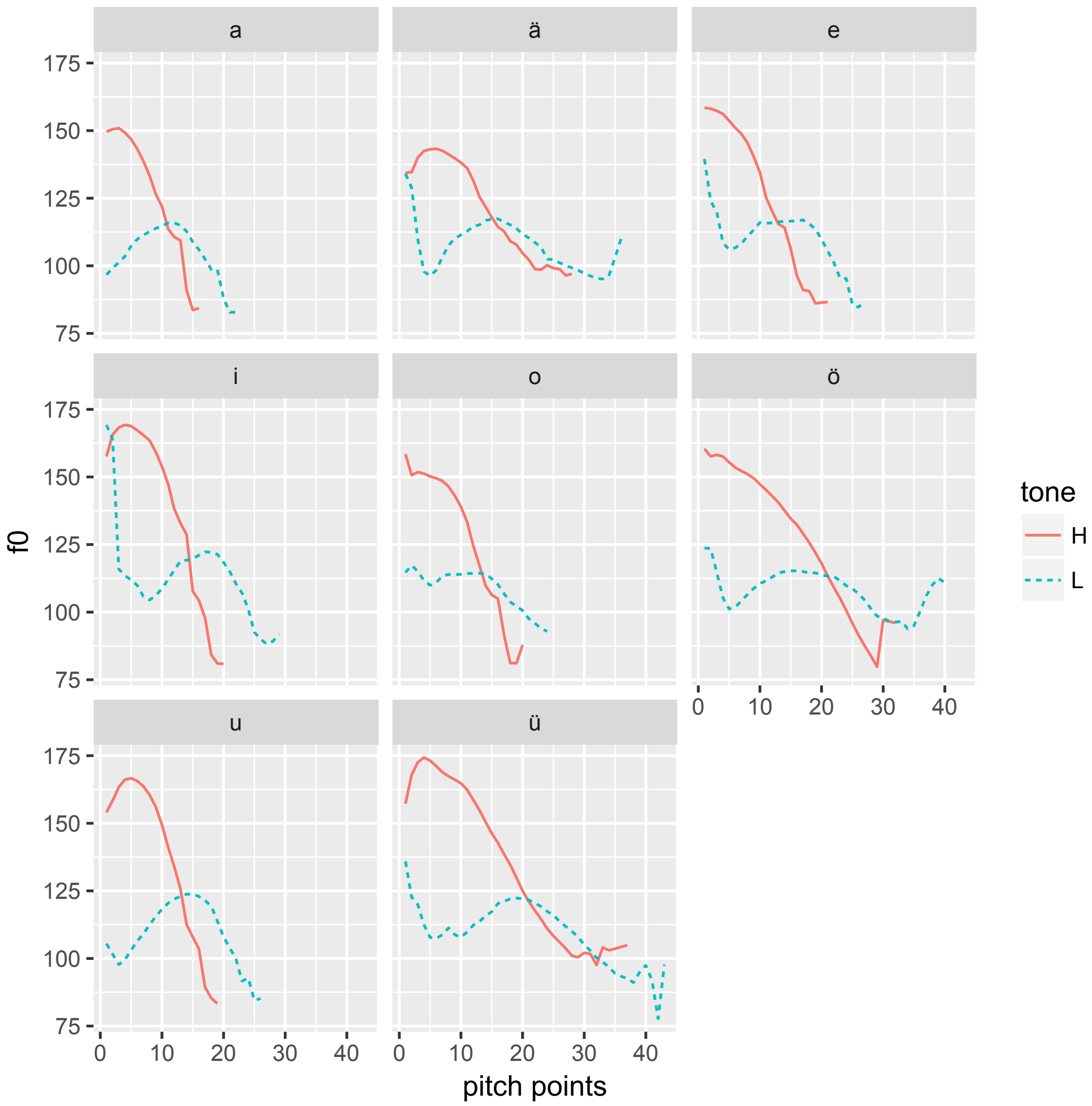

Figure 3: F0 movement of two types of tones by vowel (raw measurement values).

Figure 4 shows smoothed f0 curves which were obtained by deviding the vocalic intervals into five equally-timed windows, and taking the average f0 values within each window. It shows that H-toned and L-toned syllables are separated clearly at the onset of syllables, and the differences are neutralized toward the end for some vowels. The tonal difference seems to persist throughout the syllables for /a/, /i/, and /u/.

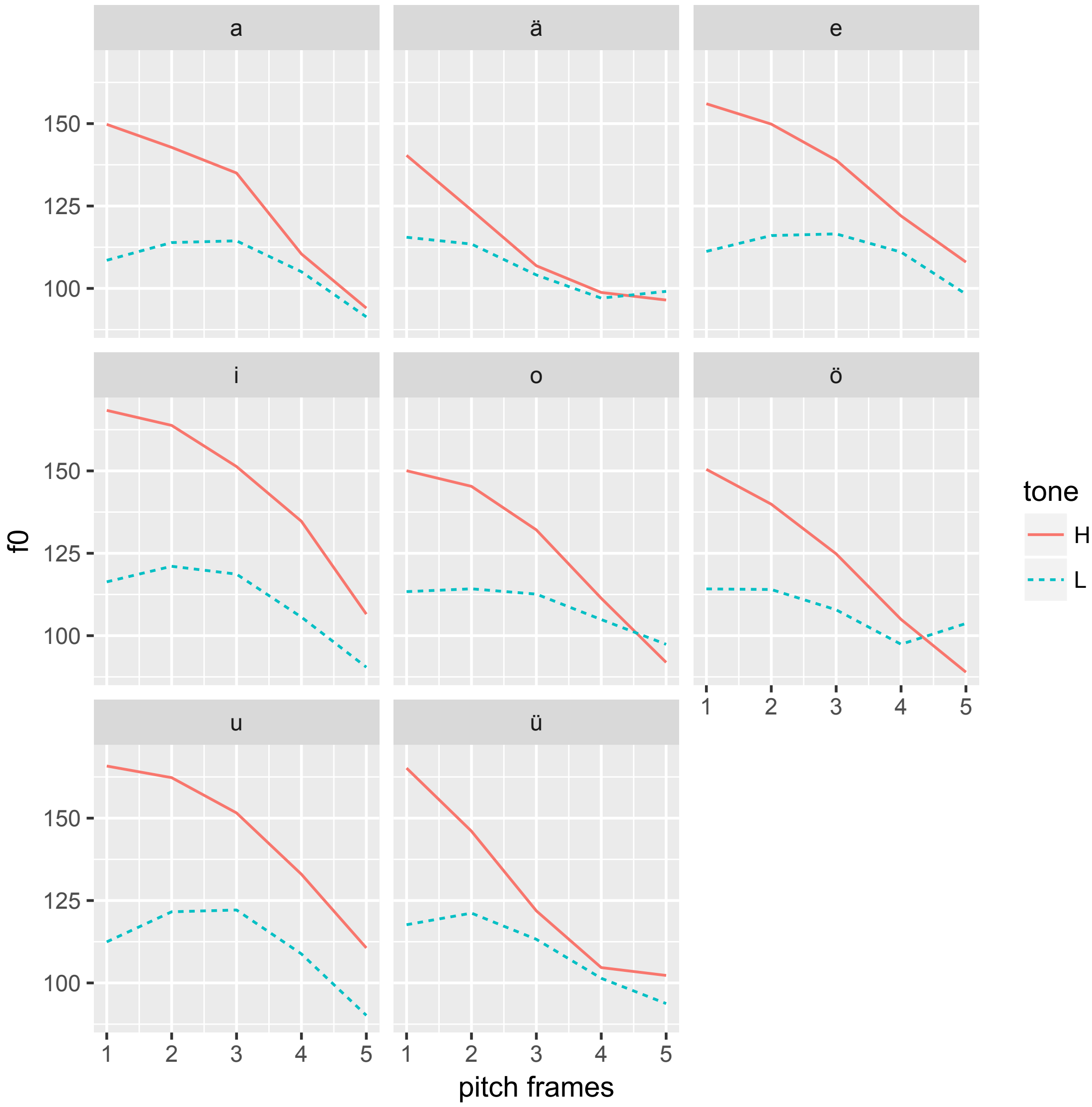

Figure 4: F0 movement of two types of tones by vowel (smoothed).

Figure 5 shows the average F0 plots of H-toned and L-toned syllables, based on tokens with onset consonants. Figure 5 is based on the smoothing analysis that is same as that of Figure 4; however, it targets only vocalic intervals. On average, at the onset of the syllables, H-toned and L-toned syllables differ by 30-40 Hz; the differences in F0 get smaller toward the end of the syllables, and are not observed in the final, fifth frame. What is emerging through our analysis is that tonal differences in Dzongkha manifest themselves at the onset of vowels.

In addition to the analysis of these f0 differences due to lexical H-tone vs. L-tone contrast, we also analyzed one type of tone-consonant interaction. Specifically, we examined 18 syllables with a voiced onset consonant and 16 syllables with what van Driem (2015) referred to as a "devoiced" onset consonant. The lexical tone of these syllables were L-tones. The result, which appears in

Figure 6, shows that the f0 is higher after voiced consonants than after “devoiced” consonants, the pattern that is opposite from what is expected it “devoiced” consonants were voiceless (e.g. Kingston & Diehl; Lee 2008).

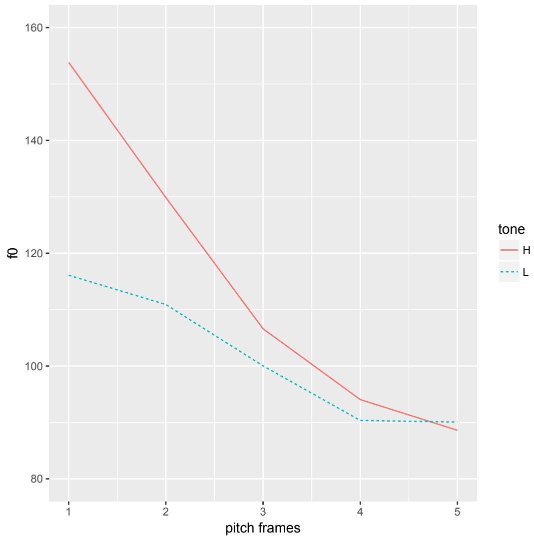

Figure 5: F0 differences of all syllables.

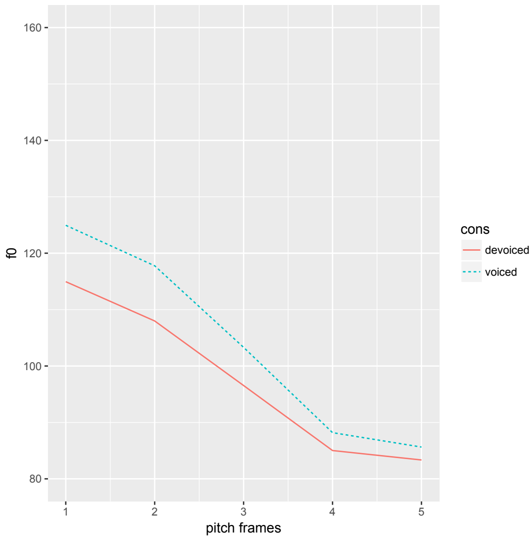

Fig. 6: Effects of “devoiced” consonants.

We thus entertain the possibility that the “devoiced” consonants are in fact breathy. In Bantu languages, breathy-voiced consonants lower the f0 of the following vowel (Baumbach 1987; Lee 2008). If these “devoiced” consonants were breathy, they follow the cross-linguistic pattern of pitch realization following breathy consonants. Although a more extended quantitative analysis is necessary, Figure 7 shows a spectrogram of “devoiced” [ba]. It shows that the consonant has long aspiration, which is compatible with the idea that “devoiced” consonants are in fact breathy.

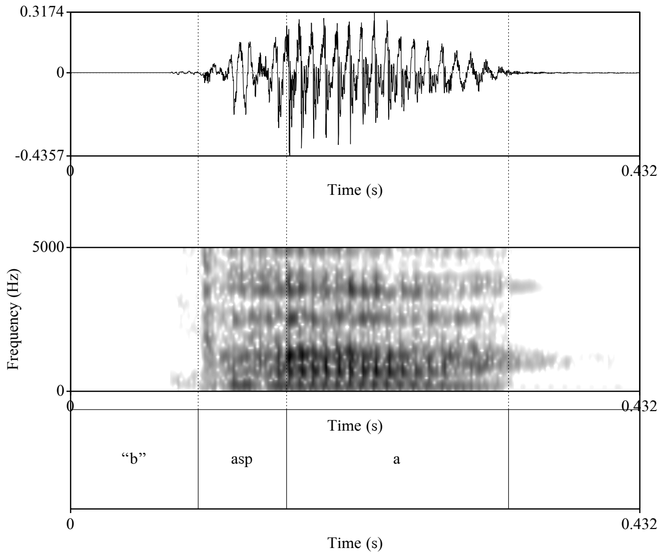

Figure 7: A waveform and spectrogram of "devoiced [ba]".

4. Conclusion

This paper has first examined the acoustic properties of eight vowels in Dzongkha. In addition to the "standard" /a/, /i/, /u/, /e/, /o/, the language has three vowels with umlaut which shows frontness. Those vowels with umlaut show higher F2 compared to the corresponding non-umlaut vowels. Rounding differences in front vowels manifest themselves in F3 in such a way that unrounded vowels have higher F3. Our f0 analysis shows that H-tones and L-tones in Dzongkha are distinguished at the beginning of vowels; i.e. the tonal targets are at the beginning. In some syllables, we observed cases in which f0 differences persist throughout the vowels. Finally, we showed that what has been referred to as "devoiced" vowels by van Driem (2015) raise f0 of the following vowels. We hypothesized that these "devoiced" vowels are in fact breathy. With this all said, our data is based on reading of a single native speaker; the analysis of more speakers of Dzongkha, and other related languages, is a topic of an on-going project.

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