PHONATION CONTRAST IN TWO REGISTER CONTRAST LANGUAGES AND ITS INFLUENCE ON VOWEL QUALITY AND TONE

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ABSTRACT

This study aims to provide a better understanding of the phonetic realization of phonation contrast in register contrast languages and its interaction with vowels and tones by comparing the production of two Yi languages: Southern Yi and Bo. Results show that 1) Electroglottographic contact quotient is the essential mechanism of the phonation contrast in both languages; 2) Phonation mainly influences the vowel space in Yi with tense vowels lower in tongue position; 3) by contrast, the Bo phonation contrast leads to significant F0 differences within each tonal category.

Keywords: phonation, Yi languages, interaction

1. INTRODUCTION

Tibeto-Burman languages, especially Yi family languages, have phonation-based register contrasts (tense vs. lax), which are different from Germanic languages type. For example, all else being equal, [be33] ('mountain') contrasts with [be̠33] ('foot') by phonation. The contrastive phonation types vary across languages and dialects, partially due to their different origins [12]. Despite the fact that Yi languages are typical cases for phonation based register contrast languages, the essential mechanism of their phonation contrast is not clear yet, since very few measures were investigated in earlier production studies [12].

In addition to phonation, the tense vs. lax contrast is usually accompanied with acoustic correlates from multiple dimensions, such as duration, airflow, VOT, vowel quality and F0. Phonation influence on F0 is one of the dimensions that particularly interests us here, because Yi languages are tonal languages, typically with three level tones. Previous studies on other languages have shown that F0 can interact with phonation. On one hand, phonation can affect F0 values. For example, breathy phonation usually has a lower F0 than modal phonation. On the other hand, tone categories can be related to different phonation types. For example, low tones can usually be accompanied by creaky voice, e.g. Mandarin dipping tone, Cantonese. Languages contrasting both phonation and tone may have more complicated interactions, as shown in Mazatec [4]. Yi languages are a good case to investigate interactions between tone and phonation.

Phonation influence on vowel quality is the other question this study will address. Laryngoscopic studies found that a phonation contrast can involve articulators other than glottal settings and that different phonation types can involve different articulators. Edmondson and Esling [3] showed that the phonation contrast in Northern Yi involves tongue root retraction. This is indirectly supported by Kong's acoustic study on Northern Yi showing that tense vowels have lower F1 than their lax counterparts [9]. This is intriguing because the tongue root advancement (ATR) is well known as the main property of African languages' vowel register contrast. Further investigation of Yi languages can shed light on the big picture of interaction between glottal and supraglottal setting in phonation production.

2. PRODUCTION EXPERIMENTS

2.1. Methods

2.1.1. Speakers

All the data in this study were obtained during a trip to Yunnan province of China in the summer of 2009. I visited the Yi villages (Xinping and Jiangcheng,) and Bo villages (Shizong and Xingfucun), and made recordings from six native speakers (three males and three females) per village.

2.1.2. Recording material

Bo and Yi are closely related languages, having similar phonological systems. They both have two contrastive registers (tense vs. lax) and three contrastive tones (Low, Mid and High). For each language, a word list of monosyllable minimal pairs with all possible combinations of tone × phonation × vowels was made for the purpose of this phonation contrast study (Details of Elicitation procedures of the fieldwork is in [11]). To balance the data structure, high tone words were excluded in this study because phonation contrasts do not occur with high tone in either language.

2.1.3. Procedures

For all 24 speakers, both electroglottograph (EGG) and audio recordings were made.

2.2. Measures

Acoustic measures reflecting different phonation properties were made using VoiceSauce [15]: H1*-H2* (corrected version by Iseli, et al. [7]), controversially reflecting open quotient of the vocal folds [6], which has been found to successfully distinguish contrastive phonations across languages [8]; Amplitude of H1 relative to the amplitudes of F1, F2, and F3 (H1*-A1*, H1*-A2*, H1*-A3*), indicating the strength of higher frequencies in the spectrum, which might be related to closing velocity of the vocal folds [16]; Cepstral peak prominence (CPP) [5], reflecting the harmonics-to-noise ratio, which has been found to be an indicator of breathy phonation [2]; H2*-H4*, which might indicate a high pitch voice [10]. Other acoustic measures include formant frequencies (F1, F2), pitch (F0) and energy. The EGG analysis in our study is done by EggWorks [17]. Two measures were extracted from the EGG signals: Contact Quotient (CQ), which is defined as the duration of the vocal fold contact during each single vibratory cycle [14]; Peak Increase in Contact (PIC), defined as the amplitude of the positive peak on the DEGG wave, corresponding to the highest rate of increase of vocal fold contact [8, 13].

2.3. Results

2.3.1. Main effects of phonation and tone

For each language, a random coefficients model was employed to evaluate the main effects of phonation and tone. In this random coefficients model, both tone and phonation have been specified as fixed effects, and speaker has a random effect on both intercept and slope. The main effects of tone (low, mid) and phonation (tense, lax) in the two languages are summarized in Table 1 and Table 2. (Only significant effects are reported in the tables with $p < .05$, direction is included)

Table 1: Main effects of phonation in Yi and Bo.

	Yi	Bo
H1*-H2*	Tense lower	Tense lower
H2*-H4*		
H1*-A1*	Tense lower	Tense lower
H1*-A2*	Tense lower	Tense lower
H1*-A3*	Tense lower	Tense lower
CPP	Tense higher	Tense higher
Energy	Tense higher	Tense higher
F0		Tense higher
CQ	Tense higher	Tense higher
PIC	Tense lower	Tense lower

Table 2: Main effects of tone in Yi and Bo.

	Yi	Bo
H1*-H2*	Mid tone higher	Mid tone lower
H2*-H4*	Mid tone lower	Mid tone higher
H1*-A1*		Mid tone lower
H1*-A2*	Mid tone lower	Mid tone higher
H1*-A3*	Mid tone lower	Mid tone higher
CPP	Mid tone higher	Mid tone higher
Energy		
F0	Mid tone higher	Mid tone higher
CQ		
PIC		

As indicated in Table1, phonation has a significant main effect on CQ, PIC and spectral tilt measures in both languages, which confirms that tense vs. lax contrast in both languages involves phonation contrast; And tense phonation has higher CQ, higher CPP, lower H1*-H2* and lower spectral tilts (H1*-An*) values, indicating that tense phonation is creakier than the lax phonation. H2*-H4* shows no phonation effect in both languages. Although phonations in these two languages show a similar pattern in general, only Bo has a significant phonation effect on F0.

In general, tone shows a different pattern from phonation in both languages (Table 2). CQ and PIC are not involved in tonal contrast, but most spectral measures have significant tonal effects. This suggests that tone and phonation are physiologically distinctive but acoustically related.

Despite the overall agreement in the significance of tone effects, the directions of these tonal effects are opposite in the two languages. This suggests that the mechanism of phonation production in these two languages is different in some aspects.

2.3.2. Phonation effect on formant frequencies

For each language, a series of linear mixed effect models were run to look at the main effects of phonation on F1 and F2 for each vowel, with speaker as the random effect, summarized in Table 3 and Table 4.

Table 3: Summary of effect of phonation on formant frequencies of Yi vowel pairs, only significant effects are reported here (p<.05), L= Lax, T=Tense.

	ɛ	ə	i	u	a	ʅ	o
F1	L<T	L<T	L<T	L<T	L<T	L<T	L<T
F2	L>T	L>T		L>T	L<T		L>T

Table 4: Summary of effect of phonation on formant frequencies of Bo vowel pairs, only significant effects are reported here (p<.05), L= Lax, T=Tense.

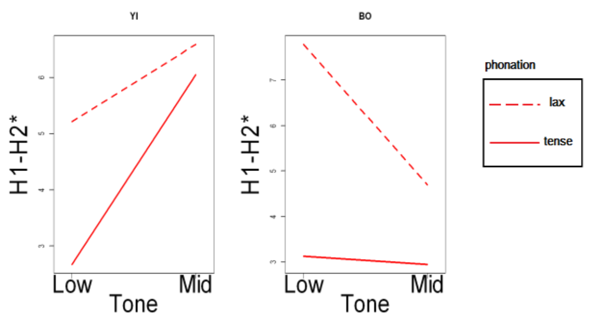
	ɛ	ə	i	u	ɯ	a	ʅ	o
F1		L<T						L<T
F2			L<T		L>T	L>T		L>T

Table 3 shows that F1 values for tense vowels of Yi are consistently higher than their lax counterparts, indicating a lower tongue position in vowel space; but such strong phonation effect is not found in Bo. F2 does not have consistent phonation effect in either language.

2.3.3. Interaction between phonation and tone

Significant interaction between phonation and tone is not found for either EGG measure, but it is found for H1*-H2* in both languages. This measure is particularly important, since it has been found to be significantly correlated to both tone and phonation [11]. Figure 1 shows the interaction between phonation and tone for H1*-H2*.

Figure 1: Two-way Interaction between tone and phonation of H1*-H2* in Yi (left) and Bo (right). Line type shows phonation.

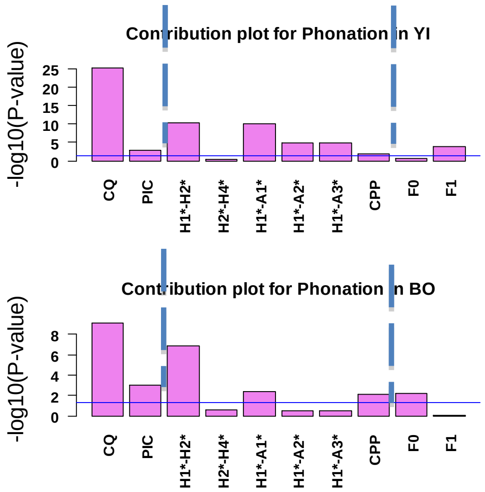


In general, in both languages, low tone has a similar and more distinctive phonation contrast than the mid tone, although CQ and PIC show no significant interaction between phonation and tone. This one more time suggests that phonation and tone can interact with each other in the acoustic space. Nonetheless, as suggested in 2.3.1, the direction of the tonal effect is different in these two languages.

2.3.4. Contributions of all the measures

A forward stepwise mixed-effect logistic regression model was utilized to evaluate the independent contributions of different measurements to tense vs. lax phonation, “gender”, “vowel quality”, “tone”, with “speaker” put into random effects to normalize the different scales in these factors. The quantity – log10 (p-value) was used as an indicator of this contribution. The contributions are plotted in Figure 2, with the horizontal lines marking the significance threshold, p<0.05.

Figure 2: Contributions of measures to phonation contrast production in Yi (Top) and Bo (Bottom) (EGG on the left, phonation related acoustics in the middle, F0 and F1 on the right). Horizontal lines show significance threshold.



In general, measures reflecting phonation distinctions contribute most to the contrast in both languages. Compared to PIC, CQ is the primary physiological difference in the phonation contrast in both languages. H1*-H2*, the measure best correlated with CQ (r=-0.51, p<0.01), contributes the most among the acoustic measures.

Although phonation is the essential property of tense vs. lax contrast in both languages, the measure reflecting vowel quality (F1) also has significant contribution in Yi. This indirectly supports Edmondson & Esling’s [3] proposal that supraglottal settings (e.g. tongue root retraction) are involved in the production of tense vs. lax contrast in Yi. However, the contribution of vowel quality is not significant in Bo. Instead, F0 has a significant contribution to the tense vs. lax contrast in Bo.

3. GENERAL DISCUSSION

The two languages investigated here exhibit interestingly similar but different patterns. With extensive phonation-related measures (both EGG and acoustic), we confirmed that a phonation contrast is the main property of the tense vs. lax contrast in both languages. But the phonation contrast has different interaction with vowel space and tonal categories. In Yi, the influence of phonation is mostly on the vowel space. Tense vowels are significantly lower than their lax counterparts. A perception experiment shows that F1 is a salient cue in native speakers' minds [11]. This might involve the mechanism of retraction of tongue root ([RTR]) in this language. This pattern can be lined up with the widely known [ATR] contrast in African languages (e.g. Akan, Maa). Smaller pharyngeal size ([-ATR] or [+RTR]) leads to creakier voice quality while larger pharyngeal size ([+ATR] or [-RTR]) may contribute to a breathier voice quality [11].

On the other hand, in Bo, phonation tends to split the tonal categories. Tense tones in this language have significantly higher F0 than their lax counterparts. Thus multiple level tones are forming in this language. This can shed light on other languages with multiple level tones. They might have experienced a similar stage like Bo, during which tonal categories were split by phonations.

We also observe different interactions between tone and phonation in these two languages. Although the mechanism is not yet clear, it should be related to the different phonation effect on F0.

In conclusion, phonation contrasts interact with other phonological dimensions (e.g. tone and vowels), and may lead to different consequences in sound change: vowel splitting and tone splitting.

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