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VARIATIONS OF LARYNGEAL FEATURES IN JIANCHUAN BAI

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ABSTRACT

The tonal system in Jianchuan Bai has attracted much attention for its complex combinations of pitch and phonation type. In this paper,[1] based on EGG signals, three parameters, namely F0, Open Quotient (OQ) and Speed Quotient (SQ), are extracted to examine the tonal quality. It is found that there are two non-modal phonation types, Harsh and Pressed, and roughly four groups of pitch pattern (31/31/41; 33/433; 55/54; 35) in the eight tonal categories. One pair of tones can only be distinguished from each other by phonation type since their pitches are the same. As for other pairs, both pitch and phonation type may contribute to the distinction between them. Notably, non-modal phonation types vary across different Bai speakers. For a particular non-modal tone, one speaker may employ harsh voice, while another may use pressed voice. Sometimes, the non-modal phonation type even changed within a syllable. It is then suggested that different strategies may be used to produce non-modal tones in contrast with their modal counterpart. Moreover, based on the Bai data, how to define different phonation types based on the three basic parameters, F0, OQ and SQ, is discussed. Harsh voice is a better term for the type with the laryngeal features [Middle falling F0, -OQ, -SQ] rather than high-pitched voice.

SUBJECT KEYWORDS

Jianchuan Bai **E**GG **P**honation type **T**one

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1. INTRODUCTION

It was a half century ago that non-modal voices in minority languages in China were first discovered (e.g. Ma 1948), the category 'Tense vowels' contrasted with 'Lax vowels' (of modal voice) in the phonology (cf. Hu and Dai 1964; Dai 1979). In the 1980's, experimental studies on acoustic signals revealed that the 'Tense/Lax' contrast is a distinction in phonation types rather than in articulation (Maddieson and Ladefoged 1985). Later experimental studies on different phonation types have been relying on Electroglottography (EGG) signals, since the amount of reliable parameters to describe the movements of vocal folds can be obtained without any intrusion (cf. Kong 2001).

Phonation types in the Bai language are rich. Xu and Zhao (1984:12) stated that "syllables in Bai bear the Lax/Tense distinction, which is associated with not only vowels but also tones". Here is their description of Jianchuan Bai (English translation is added).

Table 1 The description of tonal system of Jianchuan Bai (From Xu and Zhao1984:12)

调名 Tone name	调值 Tone value	调号 Tone mark	元音松紧 Vowel quality	例字 Example	
1	33	˧	松 Lax	pɑ1 泡沫 'foam'	tɕi1 拉 'pull'
2	42	˦˨	紧 Tense	pɑ2 奶 'milk'	tɕi2 追 'chase'
3	31	˧˩	松 Lax	pɑ3 闹 'noisy'	tɕi3 田 'farmland'
4	55	˥	松 Lax	phɑ4 扒 'dig up'	tɕi4 多 'many'
5	35	˧˥	松 Lax	pɑ5 八(哥鸟) 'myna'	tɕi5 急 'hurry'
6	44	˦	紧 Tense	pɑ6 倒 'collapse'	tɕi6 蚂蟥 'leech'
7	21	˨˩	紧 Tense	pɑ̃7 蹄 'hoof'	tɕi7 手镯 'bracelet'
8	55	˥	紧 Tense	pɑ8(水) 坝 'dam'	tɕi8 寄(宿) 'lodge'

Regarding the combination of tone and lax/tense vowels, the table suggests that there are eight phonological categories which can be marked by the eight single numerals. Each category corresponds a unique tone value. For example, the tone value of Tone 1 is 33 following the five-tone scale created by Chao (1930/1980). Notably, the above tone letters are creative. The lax ones are marked on the left as usual, while the tense ones on the right. In fact, such letters suggest that two domains of Lax/Tense should be differentiated at first, and under each domain pitches play distinctive roles. It is generally now known that the Lax/Tense distinction is not due to articulation of vowels, but phonation of vocal folds. From the perspective of phonation, Kong (2001) proposed the theory of tone quality to incorporate Tiaoshi (调时) 'temporal tone' and Tiaosheng (调声) 'phonation tone'. Temporal tone indicates how fast the vocal folds vibrate in the temporal domain, and its acoustic parameter is F0. Phonation tone indicates how the vocal folds vibrate, and open quotient and speed quotient are parameters that are often used (details to follow below). To apply this theory to the Bai data, the question is, how do these parameters in temporal tone and phonation tone interact internally and externally in an integrated tone system.

2. DATA OF JIANCHUAN BAI

The four native Bai speakers in this study are from the Jinxing village of the Jinhua town, Jianchuan county, Yunnan, two males (M) and two females (F). M1, 55-year old; M2, 37-year old; F1, 65-year old; F2, 78-year old.

Cooledit 2.0 is used to record sound on the left channel and EGG signals on the right channel. The sample rate is 22050Hz.

Regarding tones in Jianchuan Bai, though interpretations of the phonetic realities are still controversial, the eight phonological categories are generally agreed upon. For convenience, this paper will use tone names. To highlight the Lax/Tense distinction, the two cover symbols, T for Tense and L for Lax, precede the tone names, e.g. L1, T2, L3, L4, L5, T6, T7, and T8.

3. TEMPORAL TONE

For each tone four examples are given in Table 2 as follows:

Table 2 Recording samples

	Ex.1	Ex.2	Ex.3	Ex.4
L1	拉 tɕi1 'pull'	泡沫 pɑ1 'foam'	斧头 pɯ1 'axe'	贩卖 pe1 'sell'
T2	追 tɕi2 'chase'	奶 pɑ2 'milk'	踩踏 tɑ2 'tread'	插 pe2 'insert'
L3	地 tɕi3 'farmland'	闹 pɑ3 'noisy'	偷 tɑ3 'steal'	倍 pe3 'double'
L4	多 tɕi4 'many'	伯伯 tɑ4 (tɑ4) 'elder uncle'	星星 ɕian4 'star'	糠 tshõ4 'chaff'
L5	急 tɕi5 'hurry'	八(哥) pɑ5 'myna'	那 tɑ5 'that'	来 ɣə5 'come'
T6	蚂蟥 tɕi6 'leech'	倒 pɑ6 'collapse'	北 pɯ6 'north'	走 pe6 'walk'
T7	手镯 tɕi7 'bracelet'	一只 tə7 'Classifier for bird'	桃子 tɑ7 'peach'	皮 pe7 'skin'
T8	寄 tɕi8 'post'	大(哥) tɑ8 (ko33) 'elder brother'	县 ɕian8 'county'	冲(菜) tshõ8 'Chongcai leaf mustard'

Each word was pronounced twice. F0 is extracted by the method of auto-correlation[2]. Thirty points are extracted for each sample, but the three at the beginning and the three at the end will be excluded to ensure stable representation. At first, we deal with F0 data person by person. For the two males, the F0 patterns are almost the same. Taking M2 and F2 as the example, we observe their F0 contours are distributed in Figure 1 and Figure 2.

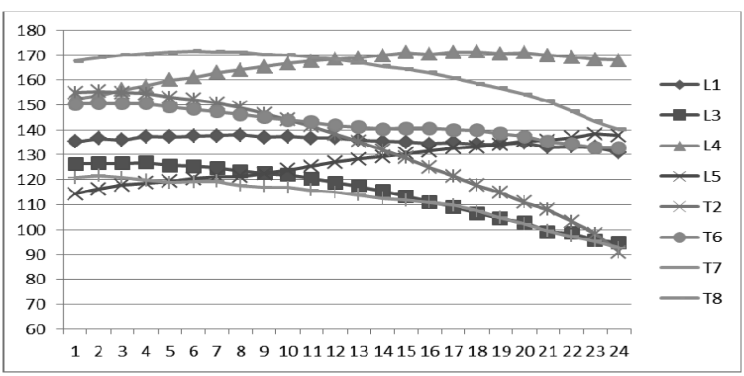

Figure 1 F0 contours of M2 for eight tones

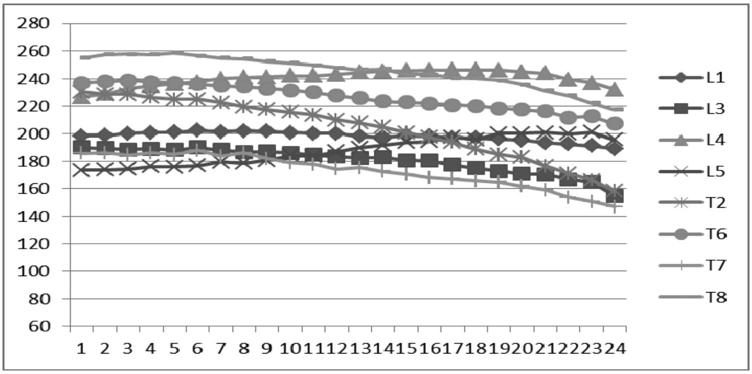

Figure 2 F0 contours of F1 for eight tones

Values of F0 can be converted to relative values (RV) according to Chao (1930/1980) in order to reflect linguistic distinctions. The following fomula can be used:

RV(x)=[(lgx-lgb)/(lga-lgb)*4]+1
(Note: 'a' is the largest F0 value; 'b' is the smallest F0 value.)

Table 3 The eight tones of Jianchuan Bai

	RV(M2)	RV(F1)	Xu & Zhao 1984
L1	33	33	33
T2	41	41	42
L3	31	31	31
L4	55	45	55
L5	24	23	35
T6	433	43	44
T7	31	31	21
T8	54	54	55

From the above table, it is impossible to distinguish L3 from T7 based on the F0 parameters. However, F0 does not equal pitch. It is intriguing to investigate whether and how different phonation types contribute to the pitches in future studies. Anyway, it is expected that the two pairs, L3/T7 and L1/T6, may be differentiated from their phonation types.

Interestingly, if the tone domain splits into two, Lax and Tense, the contrasts in each domain are quite clear, taking M2 as the example as shown below.

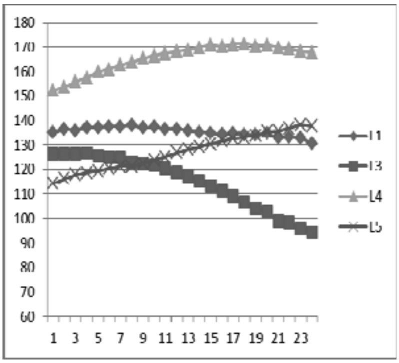

Figure 3 Lax tones of M2

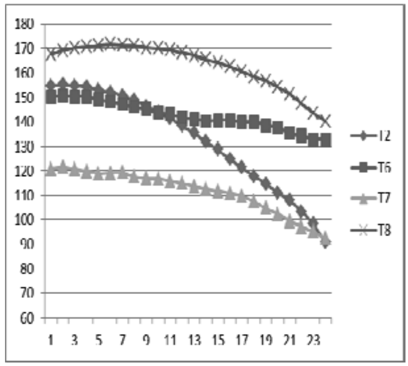

Figure 4 Tense tones of M2

4. PHONATION TONE

4.1 EGG Signals and the Bai Data

A typical EGG signal can be shown as below.

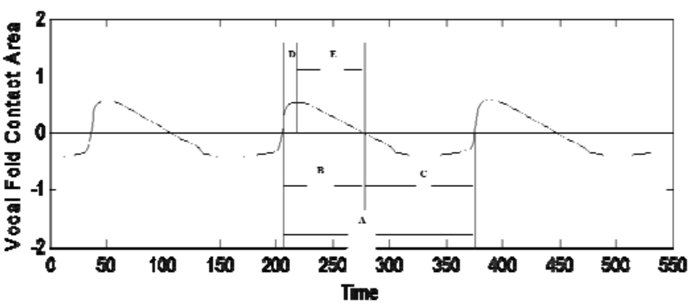

Figure 5 EGG signals

The phase A is a period of the vibrations of vocal folds. B= the closed phase. C= the open phase. D= the closing phase. E= the opening phase. Two parameters, Open quotient (OQ) and Speed Quotient (SQ), are frequently used to describe phonation types.

Open Quotient= Open phase (C) / Period (A)×100%
Speed Quotient= Opening phase (E) / Closing phase (D)×100%

By the parameters of temporal tone (Pitch) and phonation tone (OQ, SQ), several typical phonation types can be defined as in the following Table 4 (see Kong 2001:188). In the following analysis, this table will be the major reference to define the phonation types in Bai.

Table 4 Phonation types and their parameters

	Vocal fry	Breathy	Pressed	Modal	High-pitch
OQ	+	+	-	+ -	-
SQ	+	-	+	+ -	-
Pitch	-	-	-	+ -	+

According to the F0 similarities of the eight tones, three groups can be recognized to investigate their contrasts in phonation types as follows:

(1) T7 (31) / L3 (31) / T2 (41);
(2) L1 (33) / T6 (433);
(3) L4 (55) / T8 (54).

Table 5 below presents minimal pairs for the three groups.

Table 5 Three groups of minimal pairs of phonation types

Group (1)

T7 (31)	L3 (31)	T2 (41)
手镯 tɕi7 'bracelet'	地 tɕi3 'farmland'	追 tɕi2 'chase'
皮 pe7 'skin'	倍 pe3 'double'	插 pe2 'insert'
一只 tə7 'Classifier for bird'	豆 tə3 'bean'	草乌 tə2 'Radix Aconiti Kusnezoffii'
漂浮 pɯ7 'float'	托带 pɯ3 'help to bring'	敷药 pɯ2 'apply medicine'
荞麦 kv7	柜子 kv3 'cabinet'	坐 kv2 'sit'
桃子 tɑ7 'peach'	偷 tɑ3 'steal'	踩踏 tɑ2 'tread'

Group (2)

L1(33)	T6 (433)
拉 tɕi1 ‘pull’	蚂蟥 tɕi6 ‘leech’
贩卖 pe1 ‘sell’	走 pe6 ‘walk’
等待 tə1 ‘wait’	得到 tə6 ‘obtain’
斧头 pɯ1 ‘axe’	北 pɯ6 ‘north’
鬼 kv1 ‘ghost’	犄角 kv6 ‘horn’
泡沫 pɑ1 ‘foam’	倒 pɑ6 ‘collapse’

Group (3)

L4 (55)	T8 (54)
多 tɕi4 ‘many’	寄 tɕi8 ‘post’
伯伯 tɑ4 (tɑ4) ‘elder uncle’	大(哥) tɑ8(ko1) ‘elder brother’
星星 ɕian4 ‘star’	县 ɕian8 ‘county’
糠 tshõ4 ‘chaff’	冲(菜) tshõ8(tse4) ‘Chongcai leaf mustard’

4.2 OQ/SQ and Phonation Types of the Four Tense Tones

Each sample is pronounced twice by each of the four informants. Thirty points of each sample were extracted to calculate their OQ and SQ values. The first three and the last three points were not counted to keep the stable data. At first, the average OQ and SQ values are expected to display a general picture. The average OQ and SQ of samples of each tone at the stable 24 points will be counted, and then the 24 values will be averaged again. Taking M1 as the example, the final average OQ and SQ of the three groups of tense/lax tones can be shown as follows.

M1

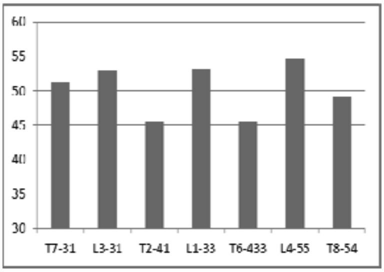

Figure 6 OQ of M1

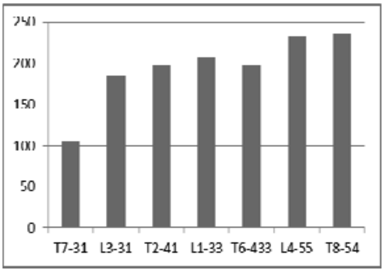

Figure 7 SQ of M1

In each of the three groups, the modal sound will be taken as the baseline to measure the relative value of the non-modal sound. For M1, OQ of L3 is higher than both of the non-modal sounds, T7 and T2. Therefore, the relative values of the two non-modal sounds are T7(-OQ) and T2(-OQ) compared to L3(+-OQ). Similarly, the relative values of group 2 can be marked as T6(-OQ) compared to L1(+-OQ). The relative values of group 3 can be marked as T8(-OQ) compared to L4(+-OQ). The same procedure could be applied to SQ of M1. For group 1, T7 (-SQ) and T2(+OQ) compared to L3(+-SQ) can be obtained. For group 2, T6(-SQ) compared to L1(+-SQ) is marked. For group 3, T8(+SQ) compared to L4(+-SQ) is marked.

The OQ/SQ contrasts of the four speakers can be summarized as follows in Table 6:

Table 6 Summary of OQ/SQ contrasts of the four speakers

		M1		M2		F1		F2	
		OQ	SQ	OQ	SQ	OQ	SQ	OQ	SQ
Group 1	T7-31	-	-	-	+	-	-	-	+
	L3-31	+-	+-	+-	+-	+-	+-	+-	+-
	T2-41	-	+	-	+	-	+	-	+
Group 2	*L1-33*	+-	+-	+-	+-	+-	+-	+-	+-
	T6-433	-	-	-	+	-	-	-	+
Group 3	*L4-55*	+-	+-	+-	+-	+-	+-	+-	+-
	T8-54	-	+	-	+	-	+	-	-

According to Kong (2001:188, as shown above in Table 4), the phonation types of the seven tones can be defined as below in Table 7:

Table 7 Classification of phonation types of Jianchuan Bai

		M1	M2	F1	F2
Group 1	T7-31	High-pitch	Pressed	High-pitch	Pressed
	L3-31	*Modal*	*Modal*	*Modal*	*Modal*
	T2-41	Pressed	Pressed	Pressed	Pressed
Group 2	*L1-33*	*Modal*	*Modal*	*Modal*	*Modal*
	T6-433	High-pitch	Pressed	High-pitch	Pressed
Group 3	*L4-55*	*Modal*	*Modal*	*Modal*	*Modal*
	T8-54	Pressed	Pressed	Pressed	High-pitched

However, these definitions are based on OQ/SQ. If the parameter of pitch is considered as in Table 4, some problems may be raised. For instance, the phonation type of T7-31 in M1 and F1 should not be called 'High-Pitch' since its 31 pitch is rather middle-falling, and is almost the same as its lax counterpart, L3-31. According to some observations, it is realized as Harsh (Li 1992; Edmondson and Li 1994; Edmondson 艾杰瑞 et al 2000[3]), or 'Glottal squeezing and friction' (Li 1992). Based on our hearing, our data would support the term Harsh. Therefore, we revised the definitions as follows in Table 8:

Table 8 Revised Classification of phonation types of Jianchuan Bai

			M1	M2	F1	F2
Group 1		T7-31	Harsh	Pressed	Harsh	Pressed
		L3-31	*Modal*	*Modal*	*Modal*	*Modal*
		T2-41	Pressed	Pressed	Pressed	Pressed
Group 2		*L1-33*	*Modal*	*Modal*	*Modal*	*Modal*
		T6-433	Harsh	Pressed	Harsh	Pressed
Group 3		*L4-55*	*Modal*	*Modal*	*Modal*	*Modal*
		T8-54	Pressed	Pressed	Pressed	Harsh

From the above table, two observations can be made. Firstly, the same tone category does not imply the same phonation type. For instance, T3-31 is associated with Harsh voice in M2 and F1, but with Pressed voice in M2 and F2. Secondly, the tonal distinction may be afforded by F0 or phonation type or both. For instance, T7-31 and T2-41 in M1 can be distinguished by F0 (31 vs 41) or phonation type (Harsh vs Pressed). T7-31 and L3-31 in M1 can be distinguished only by phonation type (Hash vs Modal). T7-31 and T2-41 in M2 can be distinguished only by F0 (31 vs 41).

4.3 Variations of OQ/SQ within Syllables and Across Speakers

In fact, more variations of OQ and SQ across speakers can be obtained if the whole 24 points of each tone will be shown based on the average value of OQ contours and that of SQ contours. The details are listed speaker by speaker according to the three groups.

Group 1: **M1**

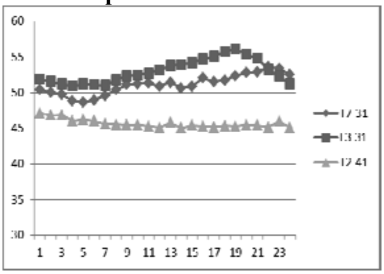

Figure 8 OQ of M1

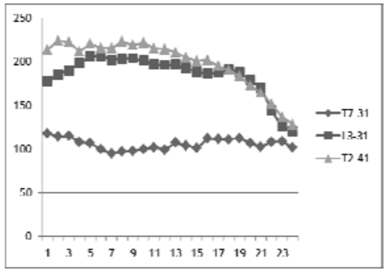

Figure 9 SQ of M1

Regarding OQ, T7-31 is not higher than L3-31 any more at the final three points. Regarding SQ, T2-41 becomes the same with L3-31. Such variations cause the distinctive function of the lower OQ of T2-41 and the lower SQ of T7-31 in contrast with their lax counterpart, L3-31, to become salient. In other words, SQ of T2-41 and OQ of T7-31 in contrast with this group may not be functional at the end of the syllables.

M2[4]

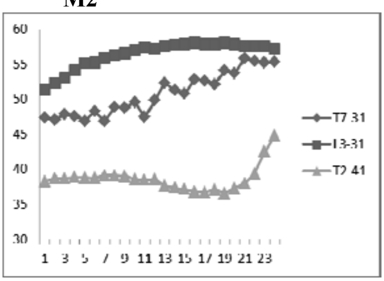

Figure 10 OQ of M2

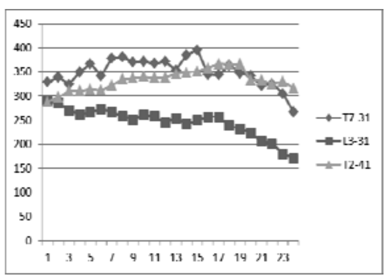

Figure 11 SQ of M2

In contrast with L3-31, the relative value of T7-31 and T2-41 remains stable, except that SQ of T2-41is not higher than L3-31 at the first two points. Though it does not have any impact on the contrast of this group, the relative positions of T7-31 and T2-41 vary a bit.

F1[5]

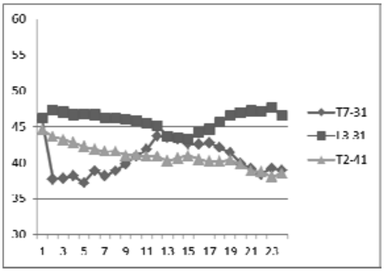

Figure 12 OQ of F1

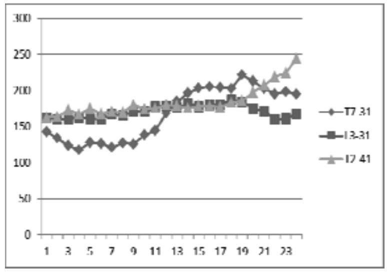

Figure 13 SQ of F1

Variations of F1 are quite salient. In the middle three points, OQ of T7-31 becomes the same with L3-31. Only in the last five points, SQ of T2-41 begins to be larger than L3-31. More interestingly, SQ of T7-31 is smaller than L3-31 in the first half of the syllable, while it becomes larger in the last half. That means the phonation type of T7-31 changes from Harsh to Pressed within a syllable.

F2

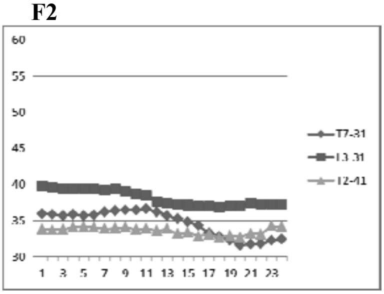

Figure 14 OQ of F2

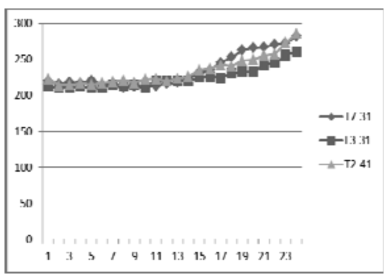

Figure 15 SQ of F2

SQ of the three tones becomes distinguishable a little bit only at the last one-third of the syllable. This would result in the salience of OQ distinction in this group.

Group 2: M1

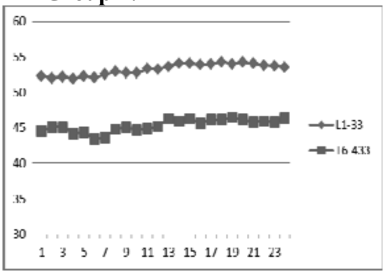

Figure 16 OQ of M1

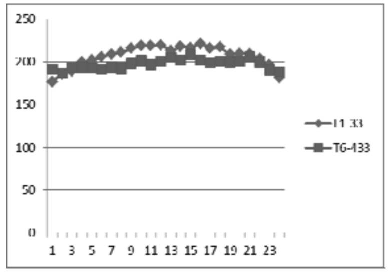

Figure 17 SQ of M1

T6-433 cannot be distinguished from its lax counterpart L1-33 by SQ at the very beginning and the very end, while its OQ is obviously lower.

M2

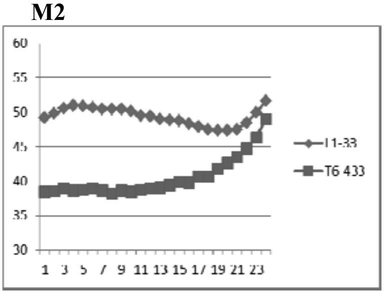

Figure 18 OQ of M2

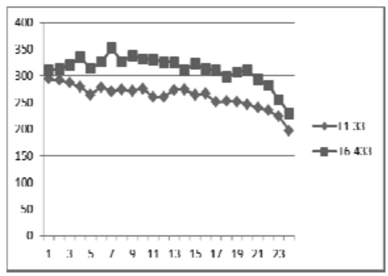

Figure 19 SQ of M2

F1

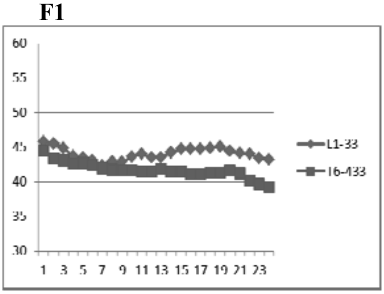

Figure 20 OQ of F1

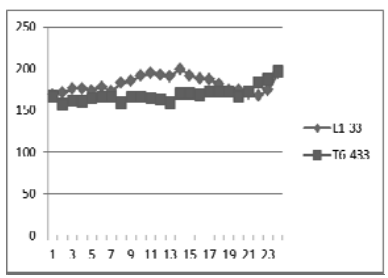

Figure 21 SQ of F1

At the beginning one-third, OQ of T6-433 is almost the same with L1-33. Meanwhile, T6-433 can be hardly distinguished from its lax counterpart L1-33 by SQ at the beginning and the end.

F2

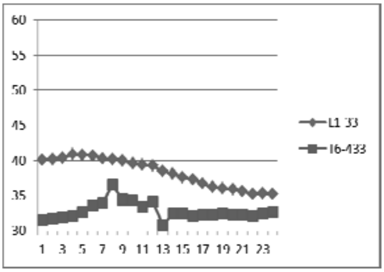

Figure 22 OQ of F2

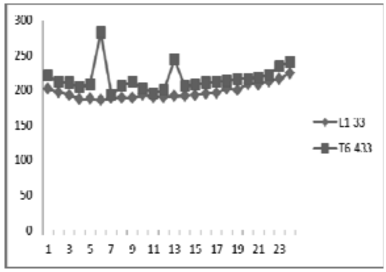

Figure 23 SQ of F2

Group 3:M1

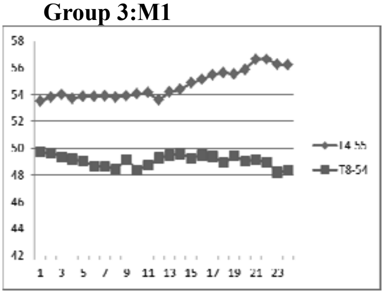

Figure 24 OQ of M1

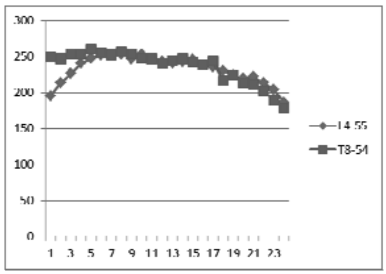

Figure 25 SQ of M1

T8-54 and L4-55 are almost the same in SQ, while T8 is much lower than L4 in OQ.

M2

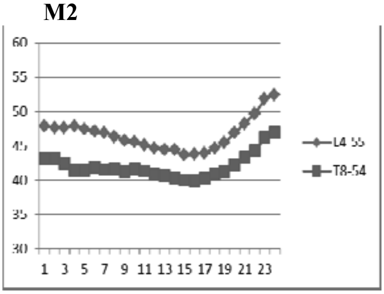

Figure 26 OQ of M2

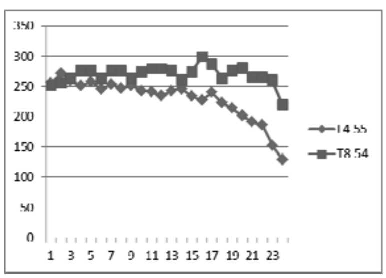

Figure 27 SQ of M2

T8-54 and L4-55 are almost the same in SQ at the first three points.

F1

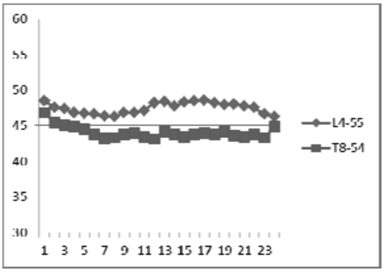

Figure 28 SQ of F1

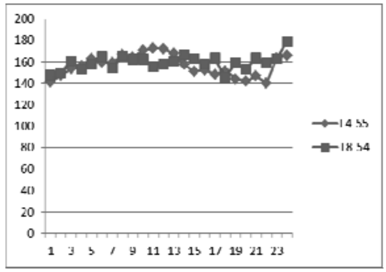

Figure 29 OQ of F1

The contours of T8-54 and L4-55 are almost mixing together.

F2

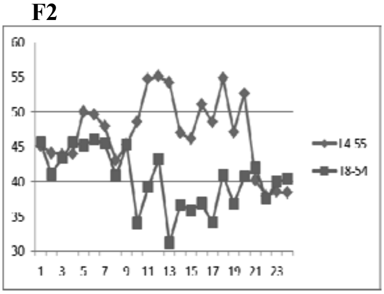

Figure 30 OQ of F2

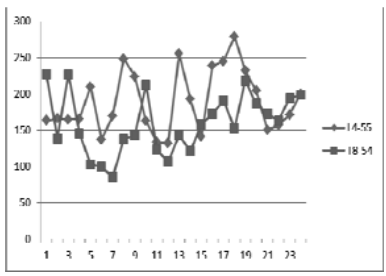

Figure 31 SQ of F2

The fulucation of OQ and SQ in F2 is notably different from other speakers. However, the major trend is still clear. The values of the lax tone are higher than those of the tense tone.

5. CONCLUSION AND REMARKS

The eight tone categories of Jianchuan Bai have attracted much attention. The most intriguing feature of this tonal system is the complex interaction of the two dimensions of tone, namely, temporal tone (pitch) and phonation tone (phonation type). This study based on the calculations of F0, OQ and SQ has found that there are two non-modal phonation types, Harsh and Pressed, roughly four groups of pitch patterns (31/31/41; 33/433;55/54;35) to make the eight tonal categories as shown below in Table 9:

Table 9 The eight tone categories in Jianchuan Bai

Tone name	Pitch	Phonation type
T7	31	Harsh/Pressed
L3	*31*	*Modal*
T2	41	Pressed
L1	*33*	*Modal*
T6	433	Harsh/Pressed
L4	*55*	*Modal*
T8	54	Pressed
L5	35	*Modal*

T7 and L3 must be distinguished by phonation type, since their pitches are the same. As for the other pairs, both pitch and phonation type may contribute to the distinction between them. Notably, non-modal phonation types vary across individuals (see section 4.3). Sometimes phonation types can even change within a syllable, e.g. T7-31 of informant F1 from Harsh to Pressed. Thus, it is suggested that different persons in a society may use different strategies to produce non-modal phonation types in contrast with their counterparts. As for whether and how different strategies are associated with different social factors, more data are needed. For now it is also difficult to detect the distinctive features of phonation types. In future studies, perception experiments may be helpful to figure out the distinctive features.

The Bai language may be the closest sister language of Chinese (Wang 2006b; 2012; 2013). The nature of the Bai tonal system will shed light on understanding the origin and development of the Chinese tonal system. The complex variation of laryngeal features in Jianchuan Bai hints that phonation types may be one source of the Chinese tonal system, in addition to initials or endings (Wang 2006a).

NOTES

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2. The Matlab programs used in this paper are edited by Li Yonghong and Ye Zehua.

3. A duplicate English version of the same/identical article contents has also been published in *The Mon-Khmer Studies Journal* vol. 31 (2001) (p. 83-100) by the same group of authors. It has a tile, “The aryepiglottic folds and voice quality in the Yi and Bai languages: Laryngoscopic case studies.”

4. Lack of the sample pe42 ‘insert’.

5. The sample tə7 ‘classifier (e.g. for rabbit)’ has not been recorded well. It is replaced by ɣə7 ‘to mill’.

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劍川白語的嗓音變異

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提要
劍川白語的聲調系統中音高與發聲類型的配合關係複雜，很引人注目。本文基於電聲門信號，提取基頻、開商和速度商三個參數來探討聲調的性質。在八個調類中，有兩種特殊發聲類型-刺耳音和緊喉音。按音高可以大致分為 4 組，即 31/31/41; 33/433; 55/54;35。其中有一對音高完全相同，只能根據發聲類型的不同來區分調類。至於其他對，音高和發聲類型都可能對區分有貢獻。值得注意的是，特殊發聲類型在不同發音人中有變異。某種特殊發聲類型，一個白語發音人可能用刺耳音，而另一個可能發緊喉音。有時，特殊發聲類型可能在一個音節內發生轉換。這說明不同的發音人可能運用不同的發聲策略來與相對的普通發聲調類構成區別。論文根據白語進一步探討了如何根據基頻、開商和速度商這三個基本參數來定義發聲類型的種類。對於白語中具有中降調、低開商和低速度商的特殊發聲類型而言，刺耳音或許是比高音調嗓音更合適的術語。

主題詞
劍川白語　電聲門信號　發聲類型　聲調

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