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Falsetto Tones and Their Evolution in the Southern Hubei

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Abstract

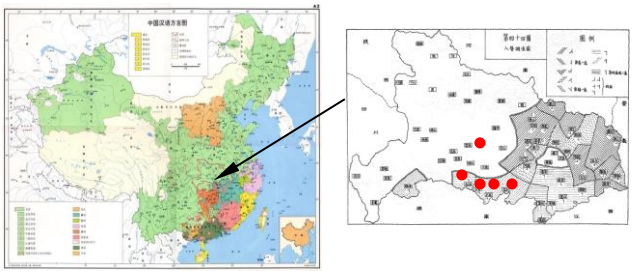
In the southern Hubei of China, the non-modal phonation types, falsetto and breathy, are used for phonological distinctions and the dialects are uni- (modal-only), di- (falsetto and modal) or tri-phonational (falsetto, modal and breathy). This study is conducted mainly according to the distribution of the falsetto tones. In the five investigated towns, di-phonational varieties co-exist with their corresponding uni-phonational varieties. The acoustic and auditory methods are applied to analyze the first-hand sound data to define falsetto tones and the tonal systems. Consecutive changes are found with the perspective of language evolution. The di- and uni- phonational tonal systems are undertaking the reduction of phonation types and tones. The phonologization of the tonal variations into varieties is strongly driven by phonetic and phonological reasons. The change of the phonation types and the relative tonal distance are found to be the causes for tonal changes. This study of the varieties with their affluent variations will benefit the understanding and definition of tones and shed light on the studies of tonal changes and evolution.

Keywords: tone, falsetto, phonation, tonal distance, language evolution

1. Introduction

1.1. Aim and previous studies

The five investigated towns of the southern Hubei include Shayang (沙洋), Songzi (松滋), Gong'an (公安), Shishou (石首) and Jianli (監利). Except for Shayang (the northern dot on Map 1 [Right]), the other four towns (the four southern dots) are geographically connected from the east to the west. Falsetto is commonly used in these towns. With the study of non-modal tones, tonal variations and varieties, this paper aims to introduce multi-phonational tones, tonal changes and to benefit the studies on tonal definition and tonal evolution.



Map 1: *The five towns in the Language Atlas of China (1987) [Left] and On the 'Map of Rusheng Distribution' in Report on a Survey of Dialects of Hupeh (1947) [Right]*

In the southeastern part of the Map of Chinese Dialects in Language Atlas of China (1987) [1] (LAC, hereafter) (Map 1 [left]), a borderline is found. To its west, the color is green/uniform while it is colorful/different to its east. This is a border between the mandarin and the non-mandarin Chinese. The five towns are located at about the middle of this borderline, which is pointed by the arrow on Map 1. On the Map of the Rusheng Distribution in Hubei [2] (Map 1, [Right]), these towns are also on the boundary which divides Hubei into halves, one having Rusheng and the other not having. Non-modal phonation types, falsetto and breathy, are commonly used and there are abundant tonal varieties and variations. Refer to [3] for the details of the breathy tones in this area.

Linguists have noticed the paralinguistic function of falsetto half a century before. It is defined as an independent phonation register in language system together with modal and whisper. [4][5][6] Based on this function, the physiological and physical features of falsetto are studied. The average F0 of falsetto is found ranging from 235 to 650 Hz. [4][5] The degree of the closing of vocal cords is found lower in falsetto compared with modal voice. Cricothyroid muscle moves to stretch the cord ligament to be thin in the production of falsetto. [7][8][9][10][11] Falsetto shows more energy in the fundamental, less energy in higher harmonics. (Quoted from [12]) H2*-H4* seems to differ between the registers independently of F0. [12] As for the linguistic functions of this non-modal voice, falsetto is found to be use as diminutive morphemes and tones in Cantonese, Wu and Xiang dialects. [13][14][15]Our previous work studies the falsetto rusheng and its evolution in Songzi [16][17].

The earliest descriptions of our dialects are found in Songzi County Annals (1944) [18]. "The northern tones are fewer than the southern ones…In the southern villages, the Rusheng characters are pronounced in a high voice with mouth opened widely." The author has noticed the different varieties in Songzi. About 7ix decades later, these two varieties still exist and we know now that the underlined remarks mean falsetto (Figure 1).

After this annals, the phonology of the five towns was transcribed with IPA and Five Point Scale [19], and they were classified in Report of a Survey of Dialects of Hupeh (1947) (Report, hereafter)[2]. For the tonal systems recorded in Report, they are all among the varieties we found. Falsetto and different varieties of each town are not mentioned in Report. That is perhaps mainly the result of the relatively low density of investigation for Report, one place for one town. Our fieldwork is over 10 times denser than Report and thus more possible to find more varieties. Though the investigation was done 'one place for one town', Report still demonstrates the prevalence of free variations. Yangping (1b), Shangsheng (2a) and Yinqu (3a) were described as 'unstable' and were described as having two pitch contours.

Different from Report, LAC whose aim is to classify all the languages across China put Songzi, Gong'an and Shishou into the Southwest Mandarin. The classification of the languages in

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boundary areas is difficult, but we support Report's classification which shows the dialects in the southern Hubei distinct from the common genre of the Southwest Mandarin.

In [20] and [21], the tonal transcription of the five-tone system of Songzi is consistent with Report, though Rusheng is described as 'an octave higher' and '… very high…deeply impressing the locals and non-locals'. Discrepancies are found in the transcription of a four-tone system of Songzi, i.e. shangsheng (2a/2b') is marked as /44/ in [20] but /31/ in [22]. These variations or varieties are again not beyond our variety pool and demonstrate the changing features of tones in this area.

Based on the previous studies, this paper shows an effort to find out the acoustic feature of falsetto tones, to introduce tonal variations and varieties and explain the tonal changes and evolution. .

1.2. Data collection and analysis methods

This study is based on the first-hand sound materials. The fieldwork lasts four years. In total, we collect the sound data from 93 speakers of 56 villages (Table 1). Speakers are local farmers or college students studying in the capital city of Hubei. They are not detected with speaking and hearing disability.

Table 1: *Towns and speakers*

Towns	**Population**	**Area (km^2)**	**Investigated villages**	**Speakers**
Songzi	765,911	2,235	20	45
Gong'an	880,000	2257	8	10
Shishou	580000	1427	8	10
Jianli	1,162,770	3460	17	25
Shayang	680,000	2,044	3	3
Total			56	93

Four wordlists for initials (122 characters), finals (117), tones (166), Rusheng (450) are designed, in which Minimal pairs are included. Citation tones are recorded. Most speakers are required to read the four wordlists. Some speakers are recorded the 3000-character list [23]. The stimuli are shown on Powerpoint slides for speakers, one slide for one Chinese character, to avoid page effect. The recording places are quite offices. At local villages, recording may also take place at speakers' home, a quite living room or bedroom. Though sometimes a pause is needed for animals' singing, the friendly surroundings erase the uneasiness of the speakers. Both acoustic and auditory methods are applied.

1.3. Terminology and symbols

The contemporary Chinese tones are the re-categorization of the Middle Chinese (MC) tonal categories. "1" to "4" and "a, b" are used in this paper to simplify the terms for non-Chinese readers and the figures. The phonological and phonetic terms for MC tones are not distinguished.

Table 2 : *Terms and symbols for MC tones*

1a Yinping	2a Yinshang		3a Yinqu	4a Yinru
1b Yangping	2b Yangshang	2b' Cizhuoshang	3b Yangqu	4b Yangru

2. Analysis and findings

Segmentation is done manually syllable by syllable in Praat to extract finals, the carriers of tones. It is exemplified in Figure 1. Eleven F0 point values of each tone are extracted by VoiceSauce (2015).

Figure 1 also shows some acoustic traits of falsetto tones. In addition to the primary quality of being much higher than the modal high tones, this speaker produces falsetto tones with less energy. As is shown by the second and third syllables in Figure 1, the stronger the falsetto the lower the energy. For the falsetto tones of our study, they sound like speakers lifting their vocal cords to produce the abnormally high tune for speech. It does not sound as smooth and stretching as Beijing Opera. They sound very tense and uncomfortable. As for our speakers, though the strong falsetto tone of male speakers can reach around 500 Hz as is shown by the third syllable in Figure 1, the pitch height varies within and across speakers. For the speaker of Figure 1, a 59-year-old farmer, the highest points of his falsetto tones range from 230 to 457 Hz with the mean of 297 Hz and the standard deviation of 60 Hz.

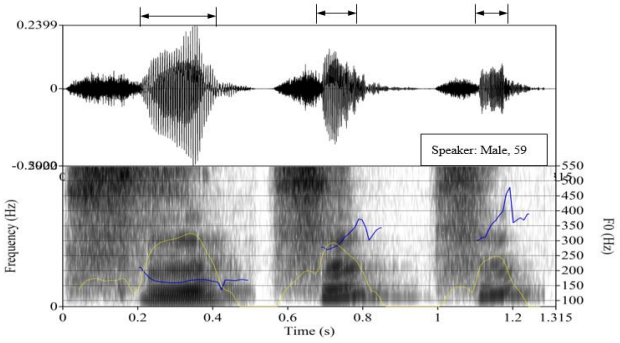

Figure 1 *Segmentation (/sʔ/ in modal high tone, falsetto and strong falsetto, left to right; Male)*

We have finished by now the acoustic analysis of fifteen speakers, thirteen men and two women. Eleven of them applies falsetto. The other four speakers from the corresponding no-falsetto varieties are used for comparisons. All the parameters set in by Voicesauce were calculated. The Straight F0 values are checked and the wrong data is deleted. We have not finished checking the Snack formant values, so the parameters related to this will not be discussed in this paper. Data is normalized by Log z-score. For the comparison of pitch height, the average pitch values of tones are shown.

2.1. Falsetto tones: definition and distribution

Falsetto is applied in all but MC Shangsheng in the investigated towns. Their MC and geographical distribution is shown in Table 3.

Table 3: *Distribution of falsetto tones*.

Town	**MC Tonal category**
Jianli	1a, 4
Shishou	1a, 3a
Gong'an	1a
Songzi	4
Shayang	1b

There are falsetto Shangsheng in Wu dialects [12] and falsetto tone thus covers all the MC tonal categories of the contemporary Chinese dialects.

Figure 2 to 4 illustrate the tonal varieties of Songzi, Gong'an and Shayang, where falsetto is used for the MC Rusheng (4), Yangping (1b) and Yinping (1a). Regardless of the MC sources for specific pitch contours, these five-tone system share similar distributive pattern, a falsetto tone and the other four tones with the contours of being high, low, rising and falling. According to this pattern, the average tonal values of nine male speakers' data are calculated for an overall five-tone system which has one falsetto tone in this area. Figure 5 shows the result. As for our nine male speakers, the highest point of their falsetto tones range from 202 Hz to 472 Hz, with the mean of 275 Hz and the standard deviation of 49 Hz.

In the investigated towns, different varieties suggest the falsetto tones are undertaking three types of change – splitting into a falsetto one and a modal high one (Figure 9); maintaining as an independent tonal category but being produced in modal voice (Figure 10 to 12); being produced in modal voice and merging with the other tones of the system [16].

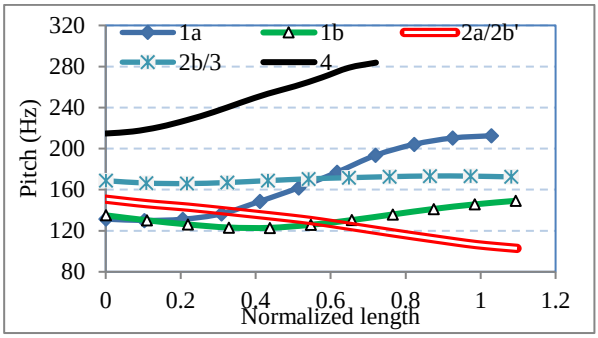

Figure 2: *Songzi Zhangjiaping: falsetto 1b, Male*

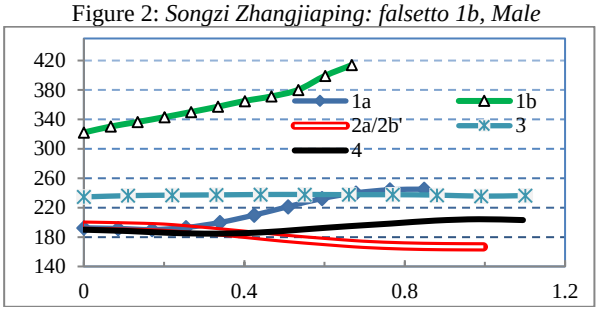

Figure 3: *Shayang Maoli: falsetto 1b, Female*

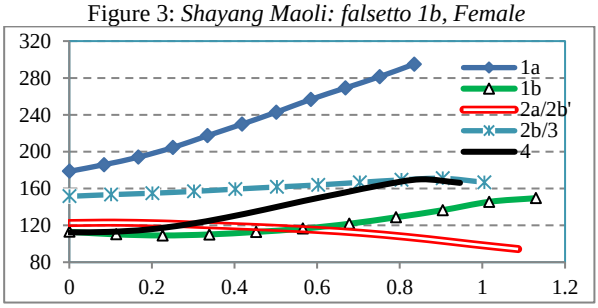

Figure 4: *Gong'an Douhudi, Male*

Figure 6 shows the second type. The data comes from four male speakers. The mean value of the highest point of "high rising" tone of this system is 216 Hz with the standard deviation of 17 Hz. The data of the highest two tones of the two systems, 'falsetto' and 'high' in Figure 5 and 'high rising' and 'high' in Figure 6 , were studied and compared to figure out the acoustic features of the falsetto tones.The Corrected H1*, H2*, H2k*, H4* values were normalized by Log z-score and the values were studied with the consideration of their corresponding F0 values.

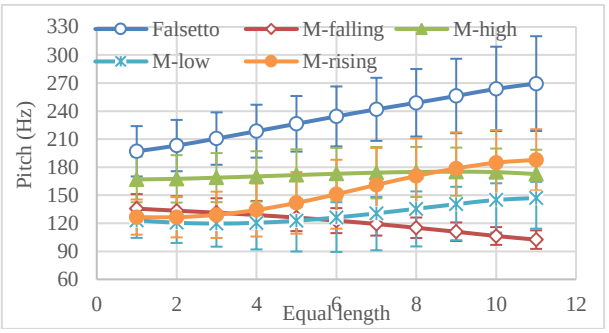

Figure 5: *Five-tone variety with one falsetto tone, 9 males*

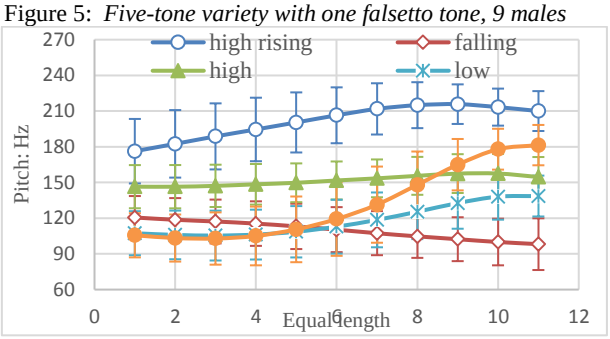

Figure 6: *Five tone varieties without falsetto, 4 males*

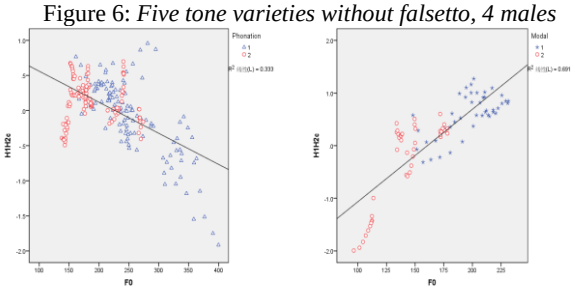

Figure 7: *Falsetto and modal high [left]; Modal high rising and high [right] (x-axis:F0, y-axis: Normalized H1*-H2*; R^2=0.33 [Left], R^2=0.69 [Right])*

Figure 7 shows the result of the relationship of the H1*-H2* values and pitch of the two highest tones in the two systems (Figure 5 and 6). As for the system where there is one falsetto tone, negative correlation is shown (Figure 7, Left), H1*-H2* values decreasing with F0 increasing from the high modal to strong falsetto tones. But for the varieties without falsetto, H1*-H2* values increase with the transition from the high to highest pitch (Figure 7 [right]).

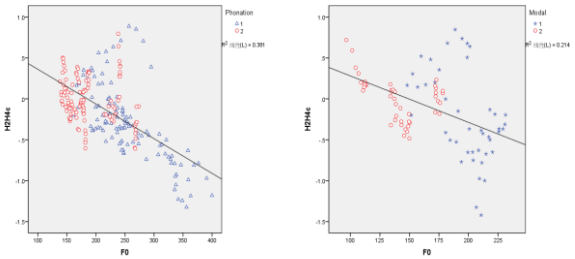

Figure 8: *Falsetto and high modal [left]; Modal high rising and high [right](x-axis:F0; y-axis: Normalized H2*-H4*; R^2=0.38 [Left], R^2=0.21 [Right])*

The mean values of H1*, H2* and H2*-H4* of falsetto tones are consistently lower than those of the modal tones in the system where falsetto is used (Figure 5). The mean value lines of these parameters for the falsetto tone stand alone and do not mingle with any mean value lines for the modal tones. As for

the tonal system where falsetto is not used, the mean value lines of 'high rising' in term of H1* and H2*-H4* mingle with the value lines of the other tones and do not show the independence. The mean value line with H2* of 'high rising' is isolated from other lines. That is, no matter whether it is produced in falsetto, the second harmonics of the highest tone of the system show lower energy than those of the other tones. The correlation of F0 and H2*-H4* is shown in Figure 8.

These harmonics parameters provide the acoustic evidence to distinguish the falsetto tones in relatively low pitch, which bridge the falsetto and modal register in the tonal evolution.

2.2. Tonal variations and varieties

Variations prevail among the investigated towns. The tone values are not stable within the same speaker, variety or across them. Report suggests the variations in Yangping (1b), Shangsheng (2a/2b') and Qusheng (3). As for the rest two tonal categories in this area, i.e. Rusheng (4)and Yinping (1a), variations are also common. As for Rusheng (4), the wide range of the falsetto rusheng (4) of the speaker for Figure 1 and 2 is a good example. And For Yinping (1a), the varieties and variations of Shishou offer us good examples. With a comparison of 1a (marked with an arrow) in Figure 9 to 12, two types of contour are found – one tending to be level and another rising. Two causes are found for this free variation. (1) The split of the falsetto tones. Part of the falsetto tones are no longer produced in falsetto, their tone tail lows and the contour changes from rising to level/less rising (Figure 9); (2) The tone head of 1a occupies relatively large space, which offers chances for the free variation (Cf. Figure 10, 11 and 12).

When the relative distance between tones is not spacious but limited, the merging of tones occurs to enlarge the relative distance between tones and thus make the tones more distinguishable in term of pitch. In Shishou, the MC Qusheng splits into 3a and 3b. Four ways of tonal interaction are found. 3a (the dotted line in Figure 9 to 12) stays with 3b (Figure 9), stands alone as an independent category (Figure 10), or merges with Rusheng (Figure 11) or Yangping (Figure 12).

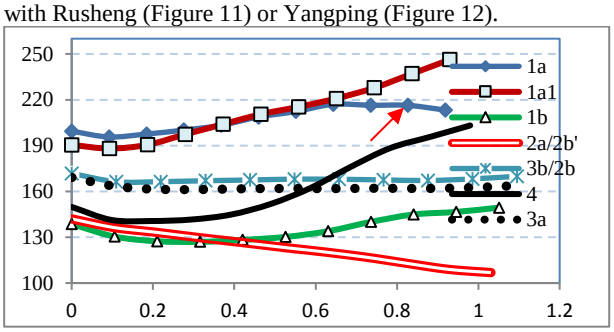

Figure 9: *Shishou Xinchang, Male*

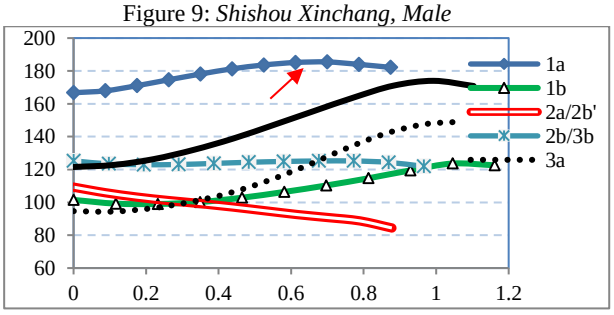

Figure 10: *Shishou Taohuashan, Male*

Some speakers' independent 3a shows lower tone head and higher tail than the cases of 3a in Figure 11. This free variation shows the speakers' strategy to enlarge the relative distance between tones and thus make the tone more distinctive from the nearby 4 (smooth line) and 1b' (the line with triangles).

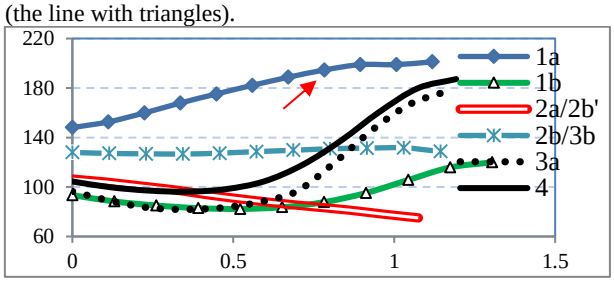

Figure 11: *Shishou Xiaohekou, Male*

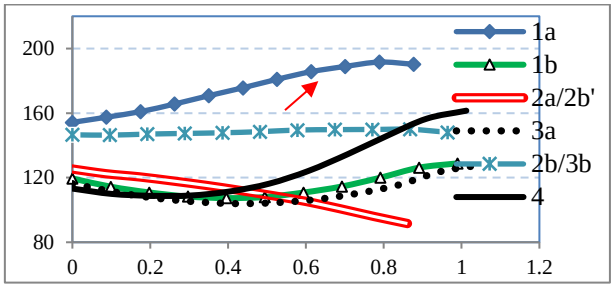

Figure 12: *Shishou Gaojimiao, Male*

These varieties together with free variations present a panorama of dynamic tonal changes.

3. Conclusion

Falsetto tones commonly distribute in the southern Hubei and covers almost all the MC tonal categories. Falsetto, this non-modal phonation type, should be considered in the understanding and definition of tones. The studies on tonogenesis and tonal development have proved the close relationship of phonation type and tones [24][25][26][27]. The ignorance of phonation type or non-modal phonations in the definition of tones will fail to transcribe the multi-phonational tones and then cause problems in further typological and evolutionary studies. Scholars has proposed new models and approaches to include phonation type in defining tones [28][29].

Though language changes are involved with complicated elements of historical sources, speakers, listeners and social factors [30][31][32], The abundant variations and varieties in this study suggest strong power of the tonal system, constraining and conniving as well the tonal changes. The relatively large distance between tones allows limited variations to occupy the redundant distance. When the distance between tones is too close that may affect the identification of different tones, interplays of tones occur to enlarge their relative distance.

Following these findings, we will further our studies by including more data and constructing quantitative models of tonal dispersion and evolution.

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