

The Significance of the Vocal Signature in Chinese Narrative Performance: A Look at Pitch and Duration Using Praat Acoustic Analysis Software¹

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INTRODUCTION: MEN SPEAK AND WOMEN SING

DURING the first half of the twentieth century, narrative performance constituted one of the most important forms of entertainment, education, and aesthetic pleasure for the average Chinese person in the city of Tianjin.² Until the early years of the twentieth century, male performers dominated most genres of Chinese narrative performance. By the time of the founding of the Chinese Republic in 1912, however, female performers became more widespread on public stages due to the indirect influence of international feminist movements and to the work of progressive Chinese intellectuals anxious to address questions of gender inequality as part of their quest to establish China as a modern power. The vocal styles of female singers became so popular in the city of Tianjin that women eventually took over many of the narrative genres that were sung, driving male performers to specialize in the spoken genres and giving rise to the commonly-heard adage “*nanshuo nuchang*” 男说女唱 (men speak, women sing; Lawson 2011, 41).

Male performers still continued to sing in certain genres, however, and Beijing Drumsong was a genre that boasted both male and female singers. The legendary “King of Drum Singing” (*gujie dawang* 鼓界大王) Liu Baoquan (1869–1942) and two of his distinguished male contemporaries, Bai Yunpeng 白云鹏 (1874–1952) and Bai Fengming 白凤鸣 (1909–1980), continued to perform Beijing Drumsong during the first half of the twentieth century; however, many of their disciples were female. In addition to the popularity of female performers in Beijing Drumsong, the gifted female singer Luo Yusheng developed her own school of singing separate and apart from the above-mentioned schools, reflecting yet another example of what many called the “feminization” (*nuxinghua* 女性化) of the narrative arts.³ Eventually acknowledged as the “Queen of Drum Singing” (*Gujie nuwang* 鼓界女王), Luo was recognized and celebrated as a founder of a female singing style on a par with (and, according to some, superior to) the male schools of singing in the first half of the century.

I first arrived to conduct fieldwork in Tianjin in the mid-1980s. By then, all the early male pioneers of Beijing Drumsong had passed away, and two major schools dominated the

1. We would like to express our gratitude to the anonymous reviewers and to the editors for their invaluable suggestions, all of which have greatly improved the paper.

2. For more information about the role played by the narrative arts in Tianjin, see Lawson (2011, 18–22).

3. Luo eventually became the disciple of Liu Baoquan’s “string master” or *xianshi* 弦師, who was able to train her according to the best traditions of the Liu 刘, Bai 白, and Shao Bai 少白 schools of Beijing drum song. For a discussion about those who influenced her musical style, see Lawson (2015, 2).

performance of Beijing Drum Song, distinguished by a difference in singing style: the “male school” after Liu Baoquan 刘宝全 (1869–1942) and the “female school” after Luo Yusheng 骆玉笙 (1914–2002). Despite the implied gender difference in the two schools of singing in Tianjin, the majority of the performers were female at the time of my field research. I wondered about what constituted the stylistic differences between the two schools of singing, so, after discovering that the short piece “At Break of Day” (“*Choumo yinchu*” 丑末寅初) was common to both schools, popular throughout the narrative arts community, and recorded by Liu, Luo, and several of their students, I compared two recordings of the piece performed by a second-generation student from each of the two schools.⁴ I reasoned that second-generation students would have assimilated the musical characteristics of their teachers’ styles, and I was able to obtain recordings of two second-generation students of the Liu and Luo schools who were more-or-less contemporaries. Xiao Lanyun 小岚云 (1923–1992), a performer who studied with Liu Baoquan as a young woman, was a respected representative of the Liu school; I acquired an unmarked cassette of a radio recording of her performance, probably recorded around 1980 (Xiao 1980). Lu Yiqin 陆倚琴 (1933–), Luo Yusheng’s eldest disciple, allowed me to record her singing this piece during a rehearsal (Lu 1986). Lu’s entire performance is available on track 3 of the CD included in Lawson (2011).

The first analysis is based on my transcriptions of the recordings made by Xiao and Lu, comparing melody, ornamentation, meter, and tonality. I have presented a more detailed musical analysis of these transcriptions elsewhere (Lawson 2017, 73–79), so I will summarize my conclusions for the first analysis below. The second analysis compares pitch and duration at the phrase and syllable level for four different recordings (two recordings for each school of singing) using Praat acoustic analysis software (version 6.0.05, 2015). In addition to using the analysis software, we expanded the second analysis to include recordings made by the two founders of the schools, Liu Baoquan and Luo Yusheng.

FIRST ANALYSIS: TRANSCRIPTION AND ANALYSIS OF THE MALE AND FEMALE SCHOOLS (WITHOUT ACOUSTIC SOFTWARE)

The first analysis focuses primarily on the opening couplet in “At Break of Day,” which features the following syllables: *Chouǎ mò yín chū rì zhuǎn fú sāng* 丑末寅初日转扶桑 (At daybreak the sun rises over the sacred elm).⁵ The opening couplet is particularly significant because this is where narrative singers showcase their distinctive vocal styles, creating what we are calling the “vocal signature.” Stevens (1975, 159) explains that Liu Baoquan (and his disciples) always drew applause from singing in the extreme upper limit of his range, and Luo Yusheng and her

4. While a complete analysis of both versions would include a study of the instrumental passages, the present analysis focuses solely on a comparison of the vocal renditions of the two singers. See Stevens (1975, 238–41) for an English translation of “At Break of Day,” and Lawson (2011, 145–58) for a musical transcription of Lu’s version of the entire piece.

5. *Chouǎ mò yín chū* refers to the time of day according to the Chinese system of the twelve earthly branches: *Chouǎ mò* signifies the end of the second period between 1:00–3:00 a.m. and *yín chū* refers to the beginning of the third period from 3:00–5:00 a.m., or the time just before dawn.

disciples similarly demonstrated their vocal skills in the opening couplet. A performer's vocal signature was especially important in outdoor performances as a way of luring audiences in the early years of the twentieth century, but the practice of displaying one's vocal chops at the very beginning of a piece continued even in teahouses where, as Stevens (1975, 81) explains, seated patrons had already committed to listening to an afternoon or evening of narrative performances for the price of a glass of tea.

My transcription of Xiao Lanyun's opening couplet demonstrates a disjunct melody, emphasizing a higher part of her register and showcasing a good deal of heightened speech or *parlando*.⁶ Xiao Lanyun's flamboyant style, which amplifies and exaggerates linguistic tone, is akin to a kind of dramatic speech. By contrast, the transcription of Lu Yiqin's performance indicates a more conjunct melody, employing more grace notes and assigning a definite melodic pitch to each syllable, therefore minimizing the spoken element in her more melodically oriented delivery. Further, Lu emphasizes metric regularity throughout the rest of the piece more than Xiao Lanyun (for an example of Xiao's metric irregularity, see Lawson 2017, 78; for a complete transcription of all the vocal lines, see Lawson 2017, 141–49). The basic distinction between Xiao's theatrically delivered performance and Lu's more melodic rendering is evident in the opening lines of their respective performances, illustrated in Figure 1.

While Xiao and Lu establish their uniqueness as singers at the outset of their performances, both freely employ musical formulae common to both schools at the ends of lines and couplets. These formulae represent a part of the piece where the hummable, recognizable cadences—particularly the final cadential formulae shown in Figure 2—lend continuity to pieces within the Beijing Drumsong tradition (see Lawson 2011, 82–93).

T-1 Xiao Lanyun:

a choǔ² mò yín³ chū a⁴ — rì — zhuǎn⁵ fú — — — sā — ang

T-1 Lu Yiqin:

choǔ² mò yín³ chū — — — rì⁵ zhuǎn — an fú — — sā — ang,

Figure 1. Differences between Xiao Lanyun's and Lu Yiqin's opening lines.

6. Beijing Drumsong lyrics are always written in couplets, and I am using Stevens's (1975) convention of labeling the top line of a couplet as "T" and the bottom line as "B." The numbers following the T and B designation indicate the chronological order of the couplets in the piece.

B-9' Lu:

chuī chū láí de zhè gè shān gē - ér shì yě - diào wú qiāng a zhè bú

yuè - guò liǎo xiǎo xī páng (drum)

B-9' Xiao:

chuī chū láí de zhè gè shān gē - e - er shì yě diào wú qiāng a tā shì

yuè guò liǎo xiǎo xī páng (drum)

Figure 2. Similarities between Lu Yiqin’s and Xiao Lanyun’s final cadences.

To this point, a comparison of the two transcriptions suggests that the female school emphasizes the tonic pitch, metric regularity, a smaller range of pitches, and delicate vocal ornaments more than the male school, reflecting the adage that “women sing” (Lawson 2017, 73–80).⁷ Nevertheless, I still had lingering questions as to whether or not there might be other vocal parameters that differentiated the two schools of singing. I wondered if new developments in acoustic technology might reveal other details about the gendered voice in Tianjin narratives beyond my auditory capabilities as a non-culture bearer. Furthermore, my original analysis was based on the way second-generation disciples had assimilated the styles of their teachers. Since I was able to locate recordings of both Liu Baoquan and Luo Yusheng singing the same pieces as their students, I decided to expand the study to include both teachers and students for a larger pool of data. My assumption was that there would be a correlation between teacher and student—a correlation that would differ from the teacher and student representing the other school of singing.

7. See Liu Shufang (1983), Tao (1983), and Xue (1985) for additional information about Luo’s unique singing style in comparison to her male contemporaries.

THE SECOND ANALYSIS: USING PRAAT ACOUSTIC ANALYSIS SOFTWARE

The second analysis was conducted by Shawn Nissen, a researcher in acoustics with experience analyzing professional voice and cross-linguistic communication between Mandarin and English, who was able to employ commercially available sound editing software, namely Adobe Audition (2016) and Praat acoustic analysis software (Boersma and Weenink 2015). Several studies of Beijing Opera have employed acoustical software to study operatic vocalizations (see Qu and Liu 2000; Sundberg et al. 2012). However, to our knowledge, Chinese narrative singing has not been studied using acoustical software. A custom-written MATLAB program was used to check the reliability of the findings.

In the second analysis we decided to look at the global aspects of pitch and duration as the two main parameters, determining that the features of pitch and duration for the opening line were significant enough for a preliminary study, whereas analyzing the sheer enormity of the data on vocal ornaments was well beyond the scope of our initial project. Nevertheless, we did collect significant data regarding the micro-fluctuations of vocal ornaments, with the frequency measures extracted to the nearest hundredth of a Hertz and then normalized to the nearest hundredth of a semitone, as shown in Table 1 (at the end of the article). These data provide ample material to study vocal ornamentation for a future project.

Recordings

The second analysis focused on recordings of “At Break of Day” by the following artists: Liu Baoquan (LBQ) in approximately 1939, Xiao Lanyun (XLY) in approximately 1980, Luo Yusheng (LYS) in approximately 1960, and Lu Yiqin (LYQ) in 1986. Xiao Lanyun, whose vocal performance was studied in the first analysis, was the student of Liu Baoquan, representing the male style; and Lu Yiqin, also featured in the first analysis, was the student of Luo Yusheng, representing the female style. Liu Baoquan’s original recording (unavailable to me) was re-mastered by the China Record Company in 1999 (Liu 1999), and Luo Yusheng’s original recording (also unavailable) was re-mastered by the China Record Company in 2002 (Luo 2002). As mentioned, Xiao’s performance was a radio recording on an unmarked cassette tape from the 1980s and Lu’s performance was recorded during a rehearsal in 1986.

Despite the wide range of dates and performance venues, the four recordings were made when the artists were at the peak of their professional careers. In order to avoid potential bias, Shawn Nissen was not given any information about the identity, gender, or background of the performers until after the data had been collected and analyzed. To him the four singers were referred to as LBQ, LYQ, LYS and XLY.

Using Adobe Audition (2016), the recordings were filtered to remove electronic interference below 50 Hz and high frequency noise (clicks and hiss). The filtering of the audio recordings removed extraneous noise outside of the singers’ vocal range that might disrupt the voice-tracking algorithm.

[Audio Example 1. LBQ \(Liu Baoquan\).](#)

[Audio Example 2. LYQ \(Lu Yiqin\).](#)

[Audio Example 3. LYS \(Luo Yusheng\).](#)

[Audio Example 4. XLY \(Xiao Lanyun\).](#)

Analysis Using Praat Software

Given the importance of the opening line in narrative performance and the exceedingly large amount of acoustic information gleaned from using the Praat software, we decided to focus solely on the opening line in this analysis. Since the opening lines of these four recordings were unique compared to the remaining sections of the performances, combining them together will confound any effects that may be present.⁸

The voiced segments within the first line of each of the four recordings became the focus of the analyses, which included duration and fundamental frequency (Fo), measures of central tendency, variability, and slope. Prior to analysis, the target voice segments were clipped from the larger sound file and saved as individual .wav files using Adobe Audition. These files are provided as Audio Examples 1 to 4. The duration of each voiced segment (e.g., syllable nuclei or voiced phonemes) was computed to the nearest millisecond (ms) using Praat acoustic analysis software (version 5.1.20, 2009). The overall duration was based only on the voiced segments to account for differences in the arrangement and accompaniment. To control for differences in tempo, performance style, and accompaniment among the four singers, relative duration values were also measured by calculating the proportion of each voiced syllable segment to the overall duration of the first line. The frequency measures were calculated by extracting an Fo track plotted over time from each voiced segment using an algorithm based on autocorrelation, as described in Boersma (1993). Fo values were transformed from a linear scale (i.e., Hertz) to a normalized semitone scale (STs) to enable direct comparisons between the singers. The Fo slope values were calculated from the minimum and maximum Fo values as a function of time (Hz per second). Data from areas in which the extraction algorithm failed to track the singer's voice (e.g., due to background instrumentation or extraneous noise) were not included in the analysis.

RESULTS

A detailed listing of the duration and Fo measures across both vocalist and syllable type are included in Table 1, included at the end of the article. The duration values are rounded to the nearest millisecond and notated in fractions of a second (s). The Fo measures are rounded to the nearest centihertz and notated in fractions of a hertz (Hz).

8. Complete versions of two of the performances were transcribed into Western notation and analyzed without the benefit of acoustic software in Lawson (2017, 73–79, 141–49).

Measures of Duration

The overall duration and relative duration of the voiced segments within the recordings differed as follows. Liu Baoquan’s version of the top line had the shortest average durations of voicing at .601 s per syllable, followed by Luo Yusheng at .975 s, Lu Yiqin at 1.033 s, and Xiao Lanyun at 1.364 s.

As displayed in Figure 3, three of the four singers (Liu Baoquan, Luo Yusheng, and Lu Yiqin) produced the syllables at the final half of the line with a longer relative duration, with the longest syllable being the final syllable *sang*, which means “elm tree.” However, Xiao Lanyun performed a somewhat different pattern, in that many of the initial syllables were relatively short, followed by a sustained voice on the syllable *fú*, which is the descriptor meaning “sacred,” rather than on the terminal syllable *sang* (elm tree). Xiao exhibits more variation in voicing duration between the different syllables, singing a relatively short duration on the syllable *chou* (.362 s), as well as the syllable *fú* with the longest relative duration of all four vocalists (3.174 s).

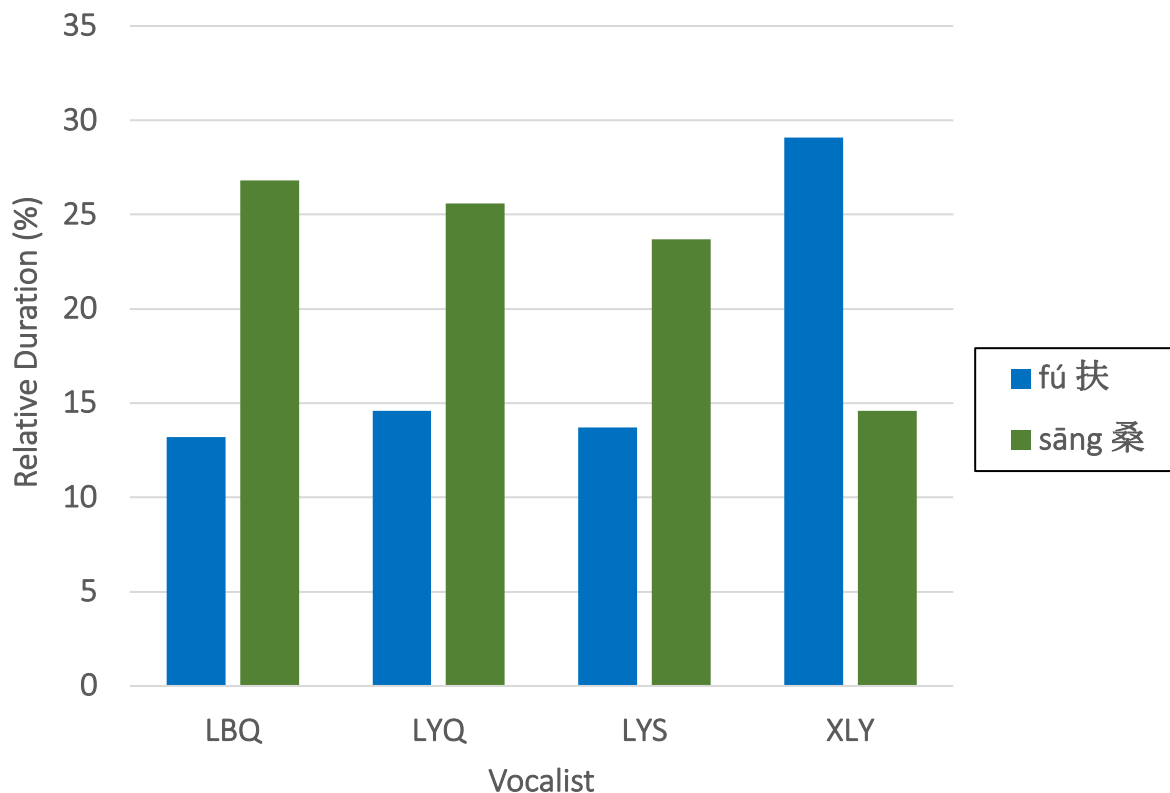


Figure 3. The Relative Duration of the voicing segments of *fú* (sacred) and *sāng* (elm) across all four vocalists.

Measures of Fundamental Frequency

The overall mean values of fundamental frequency (Hz) were relatively similar across all four vocalists, ranging from 415.4 to 440.5 Hz, with an average difference between vocalists of 0.58 semitones (STs). An evaluation across the entire first line indicates that Lu Yiqin and Xiao Lanyun exhibited an increase in Fo variation with mean Fo standard deviation measures of 2.7 and 2.8 STs, respectively, whereas Liu Baoquan and Luo Yusheng were found to vary their Fo at 2.0 and 1.9 STs per syllable.

As shown in Figure 4, Xiao Lanyun also sings the opening line with a much greater degree of overall Fo range of 27.2 STs (minimum = 151.92 Hz; maximum = 732.23 Hz), whereas the other three vocalists had overall ranges between 18.6 to 19.2 STs. Xiao's increase in range is primarily accomplished by extending to lower pitch levels. In addition, Xiao used a greater Fo range for each individual syllable at 13.6 STs per syllable, compared with the other vocalists that exhibited ranges of 6.8 to 8.4 STs per syllable.

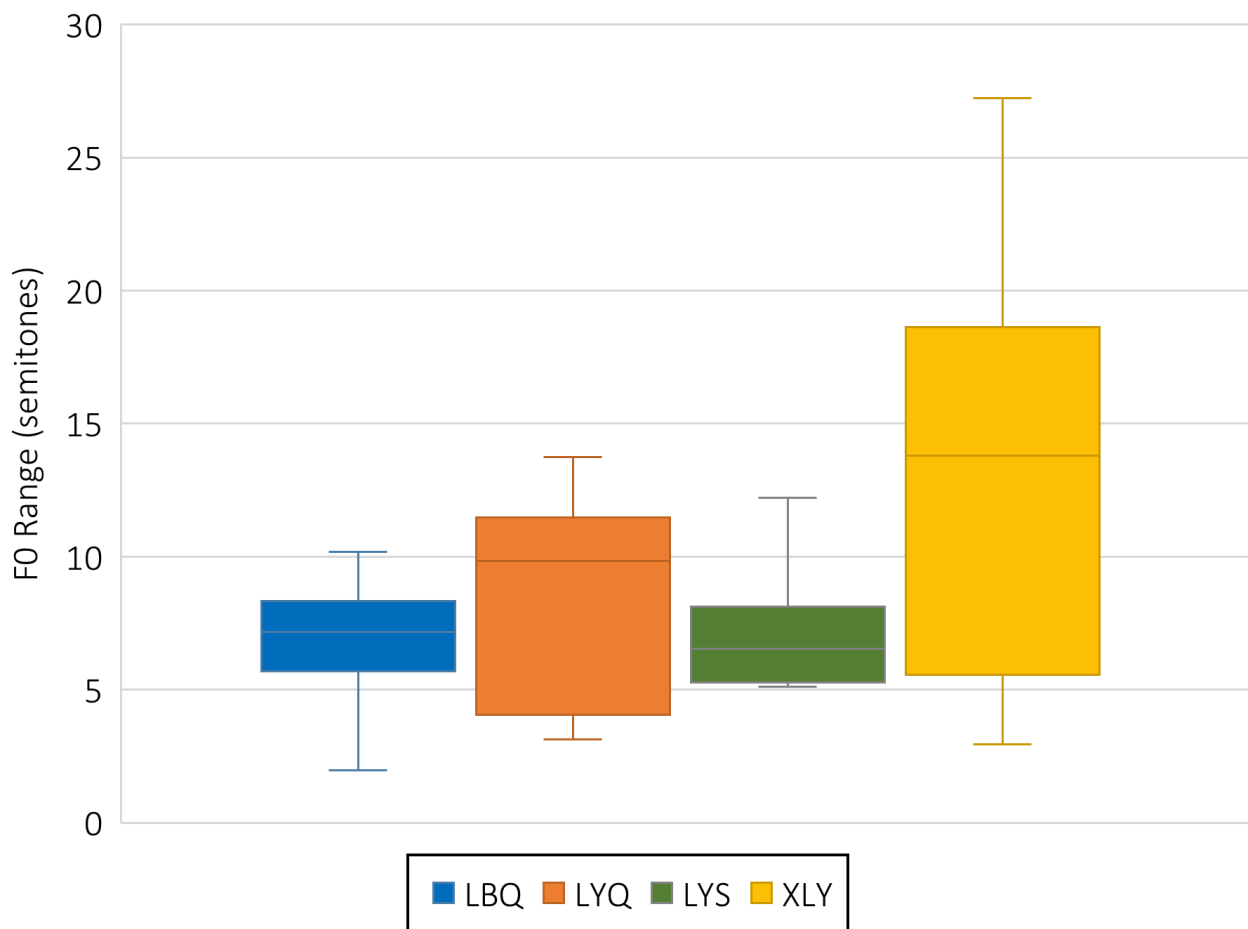


Figure 4. The overall Fo range in semitones across all four vocalists.

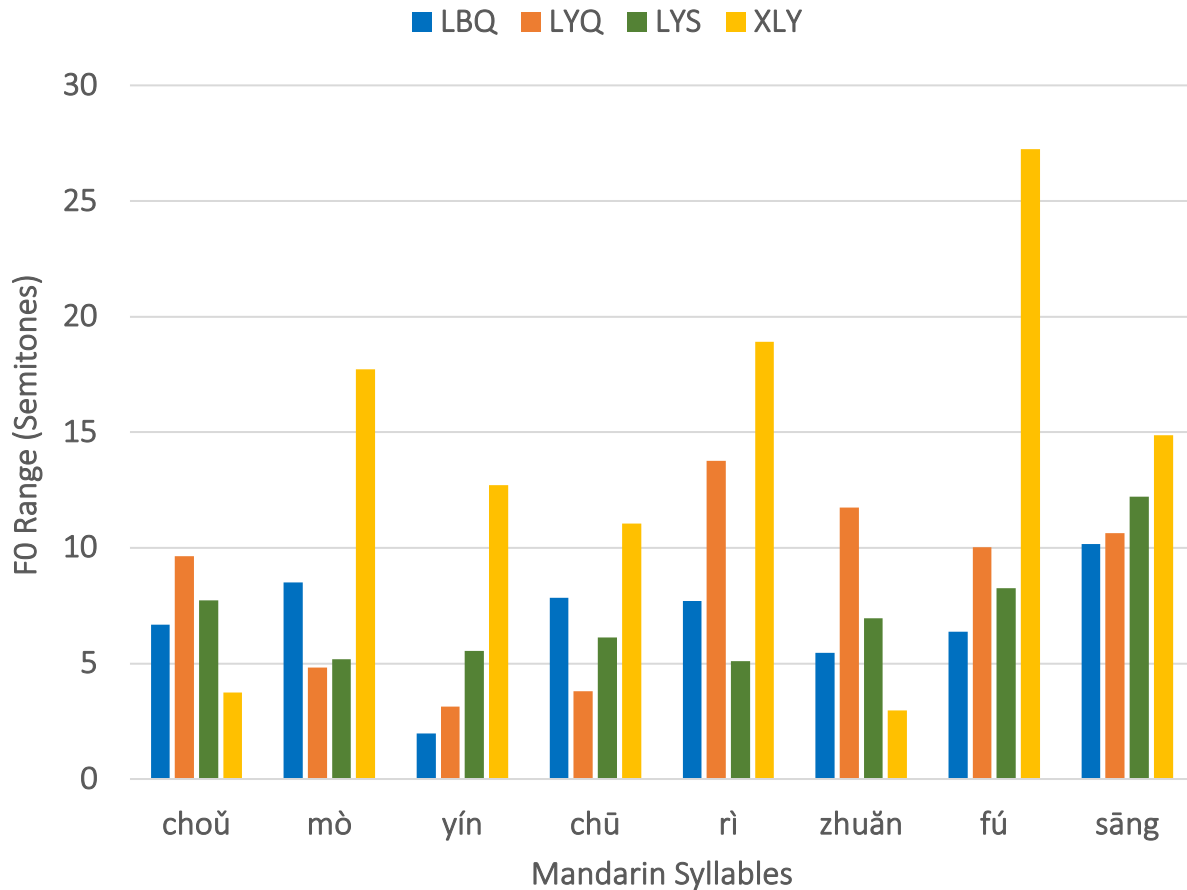


Figure 5. The Fo range in semitones of each Mandarin syllable across all four vocalists.

As shown in Figure 5, the vocalists chose different syllables or sections of the opening line in which to showcase their vocal range. Liu Baoquan and Luo Yusheng displayed a similar pattern of ornamentation by maintaining a fairly attenuated Fo range for the majority of the initial syllables and then singing the terminal syllable *sāng* with the greatest range. The Fo data indicate that Lu Yiqin divided the opening line into two halves, each punctuated by an increase of Fo range on the initial syllable of each portion (*choǔ* and *rì* [sun]) followed by a declination in range across the following syllables. In general, Lu Yiqin produced the last four syllables of the opening line with an increase in range. In terms of Fo range, Xiao Lanyun exhibited a more varied style with dramatic fluctuations. In two sections, Xiao alternated between a syllable with relatively little Fo variation to a syllable with a large degree of change in Fo (i.e., *choǔ* to *mò*; *zhuǎn* [rises] to *fú*). Overall, Xiao exhibited the greatest Fo range when singing the syllable *fú*, whereas the other three vocalists placed greater emphasis on *rì* or the terminal syllable *sāng*. An example of the previously mentioned differences in duration and Fo range are shown in the extracted Fo track for all four vocalists displayed in Figure 6.

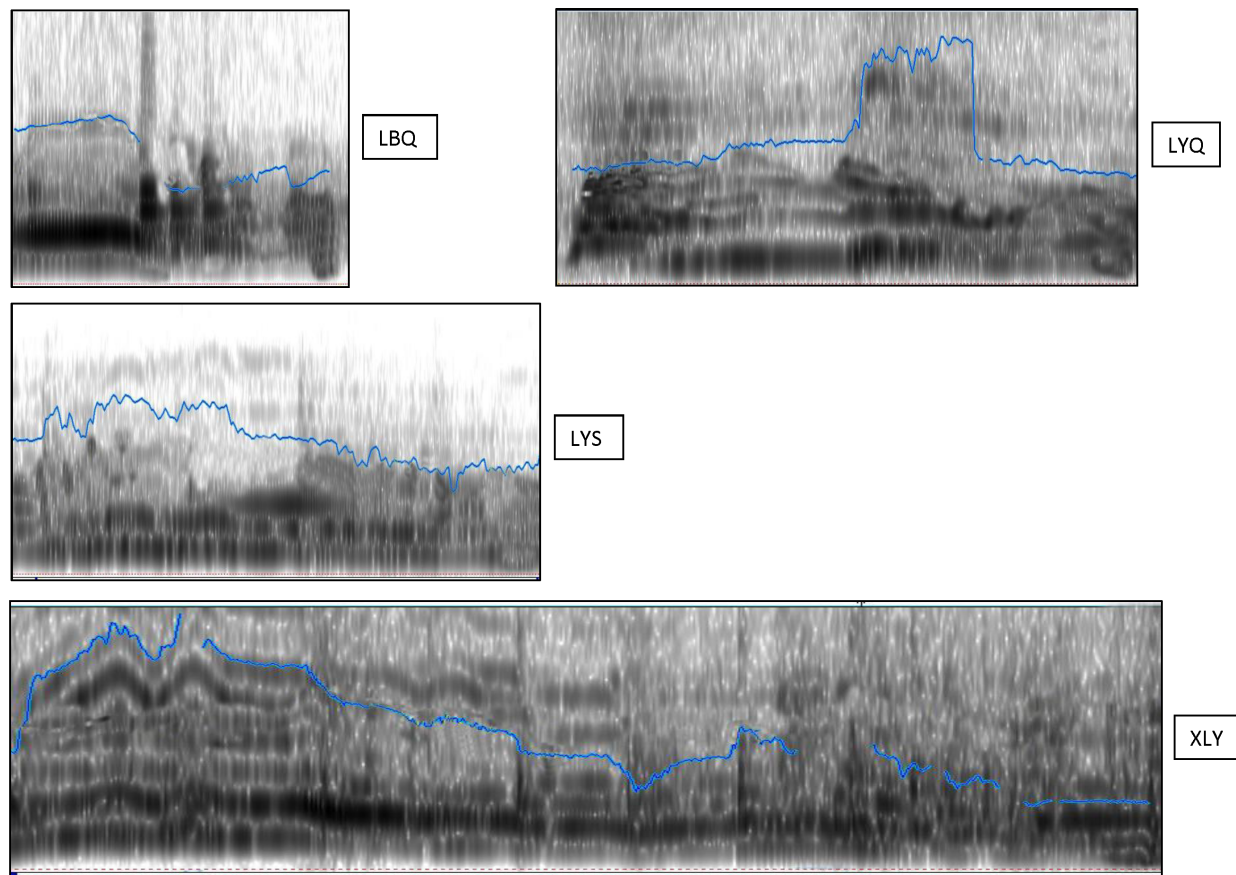


Figure 6. Fo tracks for the syllable *fú* across all four vocalists (approximate duration normalizations).

The measure of absolute Fo slope can be used to describe the static or dynamic manner of the pitch movements by calculating the Fo movement as a function of the duration of the syllable. Although Liu Baoquan generally used less overall Fo range, he exhibited the highest mean absolute Fo slope values across all syllables at 0.28 Hz/s, followed by Xiao at 0.21 Hz/s, Lu at 0.20 Hz/s, and Luo at 0.14 Hz/s. Similar to previous measures, Xiao exhibited a high amount of variability in the slope measure, producing the syllable with the lowest absolute slope (*zhuǎn* = 0.04 Hz/s) and the syllable with the highest slope value (*mò* = 0.60 Hz/s).

DISCUSSION

Penultimate Syllable

Liu Baoquan, founder of the male school, Luo Yusheng, founder of the female school, and Lu Yiqin, female disciple of Luo Yusheng's female style, all sang the opening line with duration patterns consistent with the common prosodic pattern of phrase-final lengthening. Phrase-final (or prepausal) lengthening is the process whereby a speaker prosodically marks the end of a syntactic phrase or clause by lengthening the duration of the syllables at the end

of an utterance (Oller 1973). In Mandarin speech, phrase-final lengthening has been found in the final syllable and the penultimate syllable of a syntactic phrase (Fon 2002). Significantly, Xiao Lanyun—the female disciple of Liu Baoquan’s “male” school—exhibited the most distinct vocal signature in terms of 1) the duration of voiced segments and 2) the variability and range of vocal *F₀*. Xiao Lanyun chose to extend the duration of the penultimate syllable *fú* (sacred) by approximately 30% of the overall voicing duration of the opening line rather than lengthening the final syllable *sāng* (elm tree) like the other three singers. This choice may have been based on the syllable’s position in the phrase, the open structure of the syllable, the lexical tone underlying the syllable, or the lexical content of the character *fú*. Whatever her reason for elongating the penultimate syllable, her unique rendition dramatically differentiates her performance from the other three singers.

Vocal Range and Style

All four vocalists sang the opening line with a similar mean *F₀* and degree of *F₀* deviation from the mean. The overall *F₀* deviation may have been due to larger sweeping *F₀* changes throughout the duration of the voiced segments or smaller, more frequent *F₀* changes used as ornamentation of the underlying *F₀* contour. However, Xiao Lanyun did sing the opening line with a much greater degree of overall *F₀* range compared to the other three vocalists. After being converted to semitones, this difference in range was largely due to a lower pitch minimum on the syllables *rì* and *fú* and a relatively high *F₀* on the penultimate syllable *fú*. Xiao also demonstrated the highest degree of *F₀* range within the individual syllables. Significantly, Xiao would often precede a syllable with a large degree of intrinsic *F₀* range with a relatively stable syllable. For example, Xiao precedes the syllable *fú*, the syllable with the highest *F₀* range across all four vocalists, with the second most stable syllable of *zhuǎn* (rises). This stable/variable pattern on consecutive syllables accentuates the vocalist’s *F₀* range.

In terms of the duration and *F₀* patterns examined in this study, the vocal styles of Liu Baoquan and Luo Yusheng are relatively similar, even though they are recognized as representatives of male and female styles of Beijing Drumsong. However, their respective students, Xiao Lanyun and Lu Yiqin, demonstrate significant differences in vocal style from their teachers and from each other as representatives of the second generation of the male and female styles.

CONCLUSIONS

This study underscores the value of looking into nuances detectable through acoustic software, which enabled the researchers to discover hidden aspects of performance unattainable through traditional transcription and analysis. The first conclusion from this study is recognizing the relative similarity between Liu Baoquan and Luo Yusheng—the two teachers and representatives of the male and female schools, respectively. In interviewing consultants in the Tianjin narrative arts community, aficionados repeatedly explained that

Liu Baoquan and Luo Yusheng exemplified different styles that were perceived as male and female. In looking at the four recordings, I assumed there would be a correlation between teacher and student rather than between the two teachers; however, when comparing the acoustical data from all four recordings, Liu's and Luo's performances seemed relatively similar.

The second conclusion is that the differences between the students Xiao Lanyun and Lu Yiqin and their teachers Liu Baoquan and Luo Yusheng were marked. Based on the assumption that a comparison of second-generation students would demonstrate an assimilation of their teachers' styles, my original comparison between Xiao Lanyun and Lu Yiqin confirmed an obvious difference in style: Xiao Lanyun sang in a dramatic *parlando* style and Lu Yiqin reflected a more *legato*, melodic style. What I was unable to discern from my original comparison of the two students was how much the two students amplified the differences between the Liu and Luo schools in an apparent attempt to create unique vocal signatures distinct from those of their teachers. Although Stevens (1975, 60) intimates that students must eventually develop their own unique vocal styles, the data collected from the analysis in this preliminary—and admittedly limited—study suggest that creating personal signatures appears to be at least as important as mimicking their teachers' styles. Although the importance of creating a unique vocal signature is corroborated by research into master-disciple relationships (Lawson 2017, 88–105), the degree to which disciples actually pushed the boundaries of their teacher's styles was surprising. In particular, the degree to which Xiao Lanyun differed from her male teacher, Liu Baoquan, as well as from the other two female singers, is especially significant because she was differentiating herself as a female student of her male teacher.

Finally, it is important to acknowledge the strong self-assurance displayed by female singers in the Tianjin narrative arts during the early to middle years of the twentieth century. Luo Yusheng deliberately developed her own female singing style apart from and in contradistinction to the male style of Liu Baoquan. Second, although Luo Yusheng's recording is more similar to her competitor Liu Baoquan's recording than Xiao Lanyun's is to her teacher Liu Baoquan's recording, both Luo Yusheng and Xiao Lanyun were clearly establishing themselves as *female* artists: Luo Yusheng as a female counterpart to Liu Baoquan's male school and Xiao Lanyun as a female disciple within Liu's male school. In both cases, the goal to create a female vocal sound in the Tianjin narrative arts was clear. Further, Lu Yiqin's vocal style, while based on Luo Yusheng's school of singing, also demonstrates her own desire to create an individual female vocal signature distinct from that of her teacher.

In conclusion, the assumption that there would be a correlation between teacher and student in comparing the male and female schools in the Beijing Drumsong tradition was not supported by the data. Instead, the need for a student to create a vocal signature different from that of her teacher seems paramount. Moreover, the particular uniqueness of Xiao Lanyun's voice as a female disciple in a male school of singing, the distinctiveness of Luo Yusheng's female style vis-à-vis Liu's male style, and the individuality of Lu Yiqin's own vocal

style independent of her female teacher suggest the confidence and determination of female singers in establishing distinct vocal signatures in the early to mid-twentieth century in Tianjin—a conclusion that was demonstrated forcibly and unequivocally by the analyses using Praat acoustical software.

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Vocalist	Syllable	Duration (s)	Rel. Dur (%)	Fo Med	Fo Mean	Fo SD (STs)	Fo Min	Fo Max	Fo Range	Fo Range (STs)	Fo Slope (Hz/ms)
LBQ	chǒu 丑	0.357	7.42	356.45	370.54	1.74	315.37	463.83	148.46	6.68	0.42
	mò 末	0.540	11.23	448.57	426.47	2.56	301.81	493.09	191.28	8.50	0.35
	yín 寅	0.184	3.83	454.50	450.78	0.46	414.15	464.12	49.96	1.97	0.27
	chū 初	0.487	10.13	621.52	599.12	2.43	441.86	694.70	252.83	7.83	0.52
	rì 日	0.675	14.04	529.09	528.55	1.80	386.27	602.23	215.97	7.69	0.32
	zhuǎn 转	0.644	13.39	383.28	403.36	2.33	342.39	469.17	126.77	5.45	0.20
	fú 扶	0.635	13.20	392.34	420.47	2.32	340.41	491.85	151.44	6.37	0.24
	sāng 桑	1.287	26.76	333.98	325.39	2.34	237.44	427.23	189.79	10.17	0.15
LYQ	chǒu 丑	0.695	8.41	323.83	344.35	2.37	257.41	449.53	192.12	9.65	0.28
	mò 末	0.683	8.27	433.77	415.34	1.36	338.32	447.24	108.92	4.83	0.16
	yín 寅	0.743	8.99	481.29	465.08	1.07	423.21	507.02	83.80	3.13	0.11
	chū 初	0.708	8.57	563.71	563.66	0.78	496.93	619.17	122.24	3.81	0.17
	rì 日	0.728	8.81	529.06	464.34	5.23	273.14	604.40	331.26	13.75	0.46
	zhuǎn 转	1.386	16.77	332.31	401.84	4.20	324.18	639.20	315.01	11.75	0.23
	fú 扶	1.203	14.56	402.45	446.71	3.44	365.24	651.89	286.66	10.03	0.24
	sāng 桑	2.117	25.62	328.31	309.41	3.24	215.45	397.97	182.52	10.62	0.09
LYS	chǒu 丑	0.487	6.25	420.12	385.52	2.56	305.10	476.81	171.72	7.73	0.35
	mò 末	0.615	7.89	422.49	417.67	0.79	351.26	474.04	122.78	5.19	0.20
	yín 寅	1.148	14.73	476.84	464.99	1.07	359.36	494.87	135.52	5.54	0.12
	chū 初	1.145	14.69	428.33	444.07	1.50	394.08	561.02	166.94	6.11	0.15
	rì 日	0.488	6.26	501.81	531.28	1.91	461.68	620.26	158.58	5.11	0.32
	zhuǎn 转	0.994	12.75	324.21	362.61	2.31	289.57	432.62	143.05	6.95	0.14
	fú 扶	1.069	13.71	428.18	427.93	2.06	319.95	515.51	195.56	8.26	0.18
	sāng 桑	1.850	23.73	307.90	288.77	3.21	209.02	423.27	214.25	12.21	0.12
XLY	chǒu 丑	0.362	3.32	387.85	393.54	0.74	380.86	472.58	91.73	3.74	0.25
	mò 末	0.613	5.62	377.84	382.65	5.03	204.82	569.96	365.15	17.72	0.60
	yín 寅	0.616	5.65	601.07	567.26	2.45	306.54	638.69	332.15	12.71	0.54
	chū 初	2.055	18.84	473.02	499.56	2.41	343.82	651.13	307.31	11.05	0.15
	rì 日	0.719	6.59	454.86	450.33	0.60	157.50	469.82	312.32	18.92	0.43
	zhuǎn 转	1.773	16.25	454.63	448.23	0.74	399.79	474.23	74.44	2.96	0.04
	fú 扶	3.174	29.09	438.08	456.15	5.27	151.92	732.23	580.31	27.23	0.18
	sāng 桑	1.598	14.65	258.03	294.25	5.31	204.07	481.95	277.88	14.88	0.17

Table 1. Descriptive statistics for duration and Fo measures as a function of vocalist and Mandarin syllable.