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Acoustic and Phonological Analyses of Tones in Taifeng Chinese

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Abstract

Taifeng is located in the Nanling County in Anhui Province. Its local dialect belongs to the Tongjing group of the Xuanzhou dialect, a Wu dialect in the Chinese dialect classification system. The tonal system has never been investigated before. In the present study, acoustic and phonological analyses of the lexical tones in Taifeng were conducted. Only four contrastive tone categories were found in the current Taifeng tonal system – the fewest among Wu dialects – three long tones and one checked tone, classified as M, R, L, ʔH in the phonological analysis. The diachronic correspondence between the tonal system of Taifeng and that of the Middle Chinese is different from other Wu dialects. Taifeng maintains tone splitting by voiceless or voiced onsets, but its tone merger happens across tone registers in Taifeng: a Yang tone merges with a Yin tone. Also, T2 and T3 are both Yang tones, but co-occur with voiced-obstruent and sonorant onsets respectively. They seem to follow different evolutionary paths due to speakers' regions and ages. Specifically, three patterns have emerged for T2: merging with R, L or showing a transitional contour between R and L. This merging pattern was discovered for the first time.

Index Terms: Taifeng dialect, Wu dialects, tone, tone merger

1. Introduction

Wu dialects are notable among Chinese varieties in keeping the so-called "muddy" onsets, whispery voiced word-initially stops, fricatives and affricates, thus retaining the three-way contrast of the Middle Chinese (MC) obstruents as being voiced, voiceless aspirated or voiceless unaspirated [1].While most other dialects have lost the voicing contrast, Wu dialects maintain a neat correspondence between onset voicing and tone register in the tone split of the MC, which distinguishes four tonal categories, referred to as Píng (平, level), Shǎng (上, rising), Qù (去, departing), and Rù (入, entering) in the philological tradition. In the tone split process, tones co-occuring with voiced onsets end up in the Yang register, often lower in pitch, and tones with voiceless onsets in the Yin register, often higher in pitch, thus giving rise to eight tones in total. In some cases, voiced onsets are further divided into voiced obstruents and sonorants, and voiceless onsets into unaspirated and aspirated consonants, as in Wu dialects.

Preservation of voicing contrast in obstruents coincides with the fact that Wu dialects have more contrastive tones—arranged in the two registers of Yin and Yang—than other Chinese dialects. In his highly-acclaimed study of modern Wu dialects, Chao [1] observed that tones in Wu dialects fall into two groups: one group characteristically has eight tones, with the MC four tonal categories of Ping, Shang, Qu and Ru mapped to Yin and Yang registers based on onset voicing; the other group has seven tones, with the Yang Shang tone merging with the Yang Qu tone. In a more recent study, You [2] pointed out that Wu dialects usually have eight or seven lexical tones, depending on whether Yang Shang and Yang Qu become one category. Both six-tone systems, such as the new Ningbo dialect, and five-tone systems, such as the new Shanghai dialect, are rare to find in the Wu dialects. One prevailing explanation for the smaller tone inventory has been the effect of dialect contact, and in many cases contact with neighboring non-Wu dialects may have been a contributing factor [2].

In the Chinese dialect classification system [3],Wu dialects are divided into several sub-groups, such as Taihu (Northern), Oujiang, Wenzhou, Chuqu and Xuanzhou. Systematic studies of tones in the Xuanzhou sub-group were recently presented in Jiang [4]. In the 20 sites therein reported, 13 dialects have only five tones and others have 6 or 7. Coincidentally, You *et al.* [5] also reported two dialects in the Xuanzhou area with only five tones. As a result, Li [6] surmised that five tones are probably the fewest in Wu dialects, noting that the Xuanzhou Wu dialect has been in close contact with the Jianghuai Mandarin in the central Anhui region, which contrasts five tones.

Our study is concerned with investigating the acoustics and phonology of the tonal system in the Taifeng area. The local dialect is part of the Tongjing dialect, which is itself included in the Xuanzhou sub-group of Wu dialects. Taifeng is in the encircled area in Figure 1 below.

Figure 1. *Map of the Xuanzhou sub-group of Wu dialects, where the black circle indicates the location of Taifeng*

Presently, no fieldwork has been undertaken on the Taifeng tones. In the following sections, results from an acoustic analysis of the tones will be presented, followed by a phonological analysis of the tonal system. The relationship between the Taifeng tones and their MC counterparts will be explored and a typological comparison with other Wu dialects will be drawn.

2. Materials

2.1. Syllable list

Following the standard practice of fieldwork on tones, we chose characters (monosyllabic words) from each of the eight tonal categories in the MC and examined how they would behave in

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the current tonal system. Moreover, we divided the Yang Ping tone into two subcategories, one with voiced obstruent onsets and one with sonorant onsets, leading to nine tonal categories to begin with, marked as T1 to T9.

Following Zhu [7], we used simple CV syllables without prenuclear glides or vocalic endings to minimize complexity in f0 extraction. The last two tones T8 and T9 are short checked tones in syllables with glottal stop endings, originating from the Ru tone in the MC system. T5 corresponds to the Yang Shang tone, which is a long tone. In the current system of Taifeng, T5 has evolved to become a short checked tone, ergo, ending in a glottal stop like T8 and T9.

The speakers recruited for the experiment were able to pronounce these syllables without any difficulty. The list of syllables used in the experiment is provided in Table 1.

Table 1: *The syllable list*

MC	Onset			Tone	Character and IPA
Ping	Yin	–voi		T1	扒[pa] 包[pɔ] 刀[tɔ]
	Yang	+voi	obs	T2	爬[pʰa] 跑[pʰɔ] 淘[tʰɔ]
			son	T3	拿[la] 麻[ma] 毛[mɔ]
Shang	Yin	–voi		T4	把[pa] 打[ta] 赌[tu]
	Yang	+voi		T5	抱 [pʰɔʔ] 老 [lɔʔ] 咬 [ŋɔʔ]
Qu	Yin	–voi		T6	坝[pa] 布[pu] 报[pɔ]
	Yang	+voi		T7	大[tʰa] 骂[ma] 渡[tʰu]
Ru	Yin	–voi		T8	答[taʔ] 读[tuʔ] 屋[uʔ]
	Yang	+voi		T9	拔 [pʰaʔ] 达 [tʰaʔ] 毒 [tʰuʔ]

2.2. Recording and Data processing

15 participants were recruited for the experiment. All of them were born and raised in the Taifeng township, fluent in this dialect in daily communication. Data collected from two speakers were finally excluded from analysis, for their accent was seemingly distinct from other participants. The remaining 13 speakers – eight males and five females – have an average age of 48.6 (*sd*=15.4), ranging from their 20s to early 70s. None of them reported any hearing or speaking difficulties.

The experiment was carried out in a sound-proof room. X-recorder [8] was used, as well as Lexicon-IO22 audio adaptor and desktop microphones. The sampling rate and resolution were set to be 44KHz and 16 bits respectively. Each speaker was asked to read all the characters three times.

Praat 6.0 [9] was employed to provide segmental annotations for syllable boundaries, initials (onsets) and finals (rimes). For each syllable, pitch contour on the final (i.e. tone-bearing unit) was extracted and spurious pitch cycles were manually modified. 11 pitch values were obtained at equal intervals for each tone-bearing final. Durations of initials and finals were also measured.

In order to eliminate individual differences, formula (1) was used to obtain the z-score f0 normalization value(z_{lf0i}) for each speaker, based on the mean(m_{lf0}) and standard deviation(s_{lf0}) of the logarithmic F0 values.

$$Z_{lf0_i} = \frac{lf0_i - m_{lf0_j}}{s_{lf0_j}} = \frac{\log_{10} f0_i - \frac{1}{n}\sum_{j=1}^{n}\log_{10} f0_j}{\sqrt{\frac{1}{n-1}\sum_{j=1}^{n}(\log_{10} f0_i - \frac{1}{n}\sum_{k=1}^{n}\log_{10} f0_k)^2}} \quad (1)$$

3. Results

3.1. Pitch patterns

We analyzed pitch patterns of monosyllabic words produced by each speaker. The data showed that out of the nine tonal categories (T1 to T9) derived from the MC tone system, only four contrasting contours have remained, as seen in Figure 2 (right): M, a mid-level contour; L, a low falling-rising contour; R, a low rising contour; ʔH, a short high-level contour.

Construed in phonological terms, the four contrasting contours can be represented as M, L, R and ʔH, based on their contrasting contour shapes. T1 is mapped to the M tone. The H tone has the highest pitch and shortest duration because the two checked syllables are realized as a short ʔH. T5 is also realized as ʔH. The L tone is a low dipping tone and not surprisingly, has the longest contour. T3, T6 and T7 are realized as the R tone, and T4 as the L tone for all speakers.

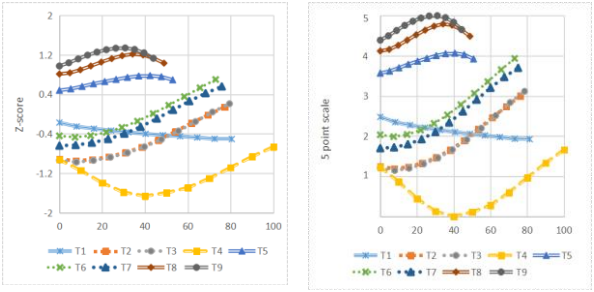

Figure 2 : *Pitch patterns of Group 1on z-score scale (left) and five-point scale(right)*: M-33, R-24, L-212, ʔH-5

In order to facilitate comparisons, pitch values of tones were normalized and converted into the five-point scale, also knowns as “tone letters” [10], plotted in the right panel of Fig. 2.

The mapping of T2 was found to exhibit regional and age-graded variations. Note that T2 and T3 in the Taifeng dialects are both Yang Ping tones, differing only in onset voicing (voiced obstruents vs. sonorants in the traditional distinction). Three patterns are identified in the realization of T2, associated with three groups of speakers, as follows:

Group 1: T2 merges with T3, mapping to the R tone on the surface. The f0 tracks corresponding to T2 and T3 are identical. Five speakers, two males and three females with an average age of 46, produced this pattern. They all live in the natural villages outside the Zhengtan village in the Taifeng township. The pitch patterns of Group 1 are plotted in Figure 2. The three checked tones merge into a short high-level tone, with T8 and T9 higher than T5. T1 is mapped to the M tone. This has been the most consistent pattern among all speakers. T4 is realized as a low dipping tone, represented as L in the Taifeng tone system. In addition to the merger of T2 and T3, T6 and T7 are also realized as the R tone. In Group 1, four tones are realized as the R tone: T2, T3, T6 and T7. The small separation of the rising f0 contours between T6/T7 (above) and T2/T3 (below) can be regarded as an allophonic effect related to the onset voicing and pitch register correlation, widely attested in Wu dialects: syllables with voiced onsets are in the lower register and syllables with voiceless onsets in the higher register.

Group 2: T2 exhibits an alternating pattern in speakers of Group 2. Most words in T2 were read as the L tone, merging with T4, but some were read as the R tone. Two older male speakers with an average age of 67.5 used the alternating pattern. The pitch patterns are plotted in Figure 3. Considerable

separation from T3 can be easily observed, so there is no merger with T3. In fact, T2 in this scenario resembles the L tone more than the canonical R in T3 in contour shape. In other words, it tracks the L tone closely. Phonologically, T2 is posited as the L tone and the tonal contrast of M, L, R and ʔH remains intact.

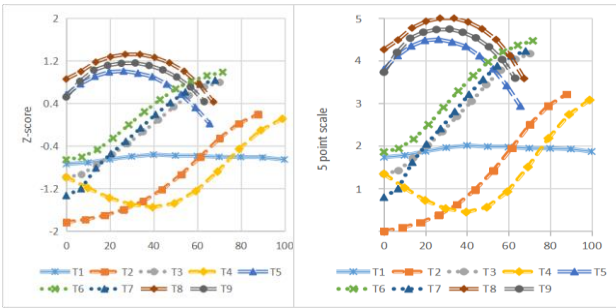

Figure 3: *Pitch patterns of Group 2 on z-score (left) and the five-point scale (right):* M-22, R-24/13, L-213, ʔH-5.

Comparing Group 1 and Group 2, several differences are worthy of note. The realization of T2 is the most obvious one. Other than that, the M tone has slightly lower f0 average, but is much longer, and the low dipping T4 has a higher ending f0, leading to the difference in the numerical transcriptions of 212 vs. 213, which is allophonic. The falling f0 offglide in the ʔH tone is more pronounced in Group 2. While it is not clear why the f0 downtrend happens in the speech of some speakers here, also in Group 3, the conjecture has been it is probably related to the glottalization as these syllables all have glottal stop endings.

Group 3: T2 merges with T4, realized as the L tone. As shown in Figure 4, the f0 tracks of T2 and T4 are almost identical. Five speakers, four males and one female with an average age of 44.2, produced this pattern. They are all from the Zhengtan village in the Taifeng township. The pitch patterns of Group 3 are plotted in Figure 4. Like the other two groups, T5, T8 and T9 are mapped to the short ʔH tone and the f0 dropping is minimal. T3, T6 and T7 are realized as the R tone, with the contour of T3 slightly lower in register. In all three scenarios, T1 is mapped to the M tone.

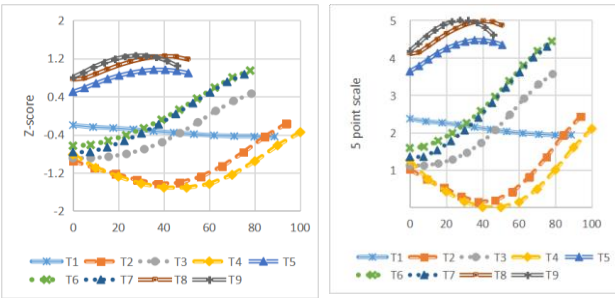

Figure 4: *Pitch patterns of Group 3 on z-score (left) and the five-point scale (right):* M-33, R-24, L-213, ʔH-5.

The tone mapping process is summarized in Table 2, where merged tones are color matched. Despite of variations in the mapping of T2, the analysis of pitch patterns suggest that there are only four contrastive tones in the synchronic system of Taifeng, represented as M, L, R and ʔH, and their corresponding tone values are M-33, L-212, R-24, ʔH-5. Tonal patterns of Speaker 15 will be discussed separately as they showed some deviations from the general patterns described above.

Table 2: *Tone mapping from the MC tonal categories to surface tones in Taifeng*

MC	Onset			Tonal Category	Surface Tone	
Ping	Yin	–voi		T1	M-22, 33	
	Yang	+voi	obs	T2: G. 1	R-24	
				T2: G. 2	L-213	R-13
				T2: G. 3	L-213	
			son	T3	R-24	
Shang	Yin	–voi		T4	L-212, 213	
	Yang	+voi		T5	ʔH-5	
Qu	Yin	–voi		T6	R-24	
	Yang	+voi		T7	R-24	
Ru	Yin	–voi		T8	ʔH-5	
	Yang	+voi		T9	ʔH-5	

3.2. Duration of tones

Table 3: *Mean duration of tones in seconds*

Tone	Group	Mean	SD	Number
T1		0.310	0.096	105
T2	1	0.255	0.052	45
	2	0.351	0.090	18
	3	0.327	0.077	46
T3		0.269	0.066	108
T4		0.352	0.082	108
T5		0.182	0.068	106
T6		0.264	0.062	108
T7		0.261	0.076	108
T8		0.187	0.082	108
T9		0.173	0.072	108

The duration of the tone contour for each syllable was measured and presented in Table 3. Based on the above discussion, T2 is divided into three groups. Since only simple CV syllables were used in the experiment, the measurements were taken for vowels.

One clear pattern is that merged tones have almost identical duration. For example, T3, T6, T7 and T2 of Group 1 are all around 0.26s and they are mapped to the R tone. T4 and T2 of Group 3, which are mapped to the L tone, also have similar duration. The duration of T2 of Group 2 is identical with that of T4, which is a L tone. T5, T8 and T9 are mapped to the short ʔH tone. Since they are checked syllables, their duration is much shorter than long syllables, about 0.18s.

4. Discussion

4.1. Tone system of Taifeng Chinese

Based on our analysis, the tone system of Taifeng has evolved to the four-tone system, in which three are long tones (R, L and M) and one is a checked tone (ʔH). Taifeng clearly has the smallest tone inventory in Wu dialects. Four-tone systems in Wu dialects were reported in the literature before. For example, Zhu [11, pp.77-82] discussed two four-tone systems in the Jing county of Anhui province. One key difference is that checked tones merge with other long tones in those two dialects while Taifeng maintains the checked tone. Keeping checked tones has been a strong phonetic feature of Wu dialects. In this regard, the tone system of Taifeng is a rarity as it not only retains the checked tone, but also has only four tones, in contrast to most dialects in the Taihu subgroup of Wu dialects, which typically feature seven or eight contrastive tones. Taifeng also has fewer tones than other dialects in the same Tongjing dialect cluster of the Xuanzhou sub-group. For example, the closely related Yanchi dialect distinguishes five tones, four long tones and one checked

tone [12]. Compared with Taifeng, Yanchi has a long H tone, in addition to M, L, R and a short ʔH, which they share.

For Taifeng, what is most striking is the merger of T5—a Yang Shang tone—with two checked tones T8 and T9. As seen in Table 1, all words in T5 are monosyllables ending in glottal stops. Previous studies show that when a Yang Shang tone merged with a Ru tone, the latter (i.e. the checked tone) lost its glottal ending and become a long tone [13, pp.441-446+479]. The underlying mechanism of Taifeng T5 merger deserves further explorations.

4.2. Split and merger of T2 and T3

T2 and T3 originate from the MC Yang Ping tone. They are classified as Yang tones because they co-occur with voiced consonants. Typically, a Ping tone splits into a Yang Ping tone and a Yin Ping tone based on whether the syllable onset is a voiced or voiceless consonant. Taifeng is unique in that the MC Ping tone is split into three tones instead of just two: T1 onsetting with voiceless consonants corresponds to the Ying Ping tone; T2 onsetting with voiced obstruents corresponds to the Yang Ping tone; and T3 onsetting with sonorants also corresponds to the Yang Ping. In a nutshell, the Yang Ping tone splits further in light of the two different classes of voiced consonants: voiced obstruents and sonorants. The distinction of voiced consonants is not generally made in the evolution of tone systems in Wu dialects. The acoustic analysis shows that T2 and T3 behave quite differently in the tone mapping process, which justifies their distinction in the tonal system.

In our survey of over 40 Wu dialects, the Yang Ping tone never splits into two different surface tones the way Taifeng does. In those dialects, T2 and T3 are always one tone, whether the Yang Ping tone merges with other tones or remains a tonal category of itself. No reference is made of the distinction between voiced obstruents and sonorants in the tone split process. Integrity of the Yang Shang tone is also preserved in the neighboring Jianghuai Mandarin. Geographically, it is in close contact with the Xuanzhou Wu dialect, to which Taifeng belongs ([5]; [11]; [12]; [14, pp.15-18]; [15, pp.63-80]; [16]~ [19]; [20, pp.215-220]; [21]; [22, pp.45-52]; [23]). From a typological perspective, the tone split of Yang Ping in Taifeng is expected to shed more light on previously unnoticed similar patterns.

In terms of tone merger, the surface realization of T2 is subject to regional and age-graded variations, as discussed in the previous section. Total merger happens in Group 1 when T2 merges with T3, surfacing as the R tone. The five speakers in this group are all mid-aged, living in the countryside outside the Zhengtan village. Total merger also happens in Group 3 when T2 merges with T4, surfacing as the low dipping tone, represented as the L tone. Like Group 1, the five speakers in this group are also mid-aged, living in the Zhengtan village. Group 2 consists of two older male speakers, who read most words in the L tone, merging with T4. A small number of syllables were read as the R tone, but its contour shape follows the trajectory of the low dipping tone (i.e. the L tone) more closely.

The merging of T2 with T4 needs further inspections in that the former is a Yang tone and the latter a Yin tone. It is generally assumed that tone merger does not happen across tone registers in Wu dialects, but here in Taifeng, a Yang tone merges with a Yin tone. In the similar vein, T3, another Yang tone, merges with T6 and T7, where T6 is a Yin tone. System-internal motivations will be looked into in future studies while external factors such as dialect contact might provide clues too.

4.3. Analysis of Speaker 15

The pitch patterns of Speaker 15, age 23, are plotted in Figure 5. The speaker reported that she had no difficulty distinguishing the four contrastive tones, but the plotted contours show that distinctiveness of tone shape is somehow compromised in some tonal categories. For example, her production of the M tone is much higher than other speakers. A higher M is easily confusable with the H tone. While in Taifeng a higher M will not be confused with the H checked tone, the elevated pitch height of M could lead to restructuring of the tone system. In her speech, the glottal ending was dropped in some syllables, resulting in longer syllable duration [13]. In fact, the average duration of the H tone she produced is longer than other speakers. T3, T6 and T7 are mapped to the R tone, which looks a much flatter rise due to the higher f0 beginning. T2 and T4 are both realized as a concave tone, starting at the similar point. T2 falls to the lowest point of the pitch range and then rises to the midpoint while the overall contour of T4 is in the higher range.

Still, Speaker 15 is able to distinguish four contrasting tones despite of greater variability in pitch patterns. Another characteristics of her speech is the presence of extensive creakiness. In nearly all syllables she produced, there was easily detectible creaky voice, even at the low starting portion of the R tone. Other speakers only show occasional creakiness in their speech.

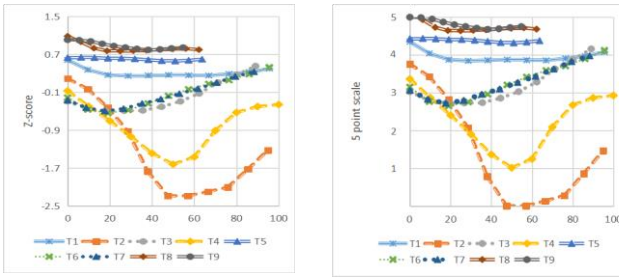

Figure 5: *Pitch patterns of Speaker 15 on z-score (left) and the five-point scale (right)*

5. Conclusions

The synchronic tone system in the Taifeng dialect contrasts four tones: three long tones and one short tone, represented as M, L, R and ʔH. The nine MC tonal categories T1 to T9 are mapped to the four surface tones in the following way: T1 is mapped to M; T3, T6 and T7 to R; T4 to L. The mapping of T2 is subject to regional and age-graded variations: it is mapped to R, merging with T3, T6 and T7 among some speakers and to L, merging with T4 among other speakers. An alternating pattern is observed in older speakers.

The Taifeng tone system is unique in the split and merger of two Yang Ping tones, T2 and T3, with the conditioning factor being whether the syllable onset is a voiced obstruent or sonorant. The prevailing pattern of tone split in Wu dialects tend to treat voiced onsets indiscriminately.

The four-tone system of Taifeng represents the smallest inventory in Wu dialects. Its tone split and merging patterns could point to an ongoing process of tonal evolution.

6. Acknowledgements

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