Tone features in Qimen Hui Chinese Dialect

[1]Minghui Zhang, [2]Fang Hu

[1]Department of Linguistics, Graduate School, Chinese Academy of Social Sciences
[2]Institute of Linguistics, Chinese Academy of Social Sciences
[1]GoldenZmh@hotmail.com, [2]hufang@cass.org.cn

ABSTRACT

This paper examines tone features on the basis of an acoustic phonetic analysis of F_0 and duration data from 10 speakers in Qimen Hui Chinese Dialect. The results show that there are 3 level tones, 2 rising tones, and 1 falling tone in Qimen. The fact that speakers use different F_0 contours in the realization of different types of level tones sheds light on the understanding of underlying mechanisms of tonal production. Other relevant issues of tonal phonology, such as contour tones, binary usage of features, and tone register, were also discussed.

Keywords: tone features, Qimen Hui Chinese dialect, level tone, contour tone, tone register.

1. INTRODUCTION

Tones are conventionally divided into level tones and contour tones; the former can be defined as a tone made by specifying a single level, for which a level pitch is an acceptable variant; the latter can be defined as a tone represented by a pitch glide which requires specification by several points rather than by rules from environment ([1]).

However, there is no consensus among linguists regarding the distinctive features for the phonological representations of level and contour tones. First, a number of linguists argued that the feature system must be able to provide 5 distinctive tonal levels, which is specified by at least 3 binary features for adequate description ([2], [3], [4], [5], [6], [7]). But there are also a few theories adopting a gradient approach to pitch levels, which is based on multi-valued features ([8], [9], [10]). Second, there is a long debate on whether contour tones should be analyzed as concatenation and juxtaposition of level tones ([4], [10], [11], [12], [13], [14]) or be viewed as a single unit remains intact in the underlying level ([2], [15], [16]). In the development of autosegmental phonology based on tonal data from Chinese dialects, [15] and [16] argued that tone is a complex phonological entity composed of two autosegmental features: one specifies the pitch range, i.e. register, and the other specifies the pitch performance through the duration. And the tonal contour is concatenated of the binary terminal features (not of tones *per se*) attached to the nod that specifies the pitch performance of a tone.

This paper does not intend to have a theoretical discussion on tonal phonology. Rather, it focuses on the phonetics and phonology of tone features in a specific Chinese dialect. The Qimen Hui Chinese dialect has 6 tonal categories, namely *yin-ping*, *yang-ping*, *shang*, *yin-qu*, *yang-qu* and *yin-ru*. On the one hand, this paper gives a detailed acoustic phonetic description of the six tones in terms of fundamental frequencies (F_0) and duration. On the other hand, it examines what kind of oppositions is essential for tonal phonology in Qimen.

2. METHODOLOGY

Audio recordings are made from 10 native adult speakers with a balanced gender ratio and none of them were reported speech disorders or hearing impairments.

Five meaningful monosyllable words are selected as the test words for each target tone. The test word is placed in the carrier sentence [X, n̩^{22} tʰu^{33} X fæ̃^{33} ʂa^{41} tæ̃^{23}] (X, you read X for me to listen) and 5 repetitions are recorded into a laptop PC through a TerraTec DMX 6Fire USB sound card with a SHURE SM86 microphone. The sampling rate is 11,025 Hz. Each test word is annotated in praat 5.3.48 ([17]), within which the vowel was labelled as the tone-bearing unit (TBU). Ten equidistant sampling points of F_0 values through the whole duration of TBU are automatically extracted and calculated. The Logarithm Z-score (LZ-score) Procedure is adopted for the normalization of F_0 data ([18]). As postulated in Formula (1), x_i represents the original F_0 value of one sampling point, y_i is the 10-based logarithm value of x_i, so the final LZ-score value z_i can be calculated by subtracting the arithmetic average m_y and dividing by the standard deviation s_y. Then all the LZ-score values are transformed into Relative Degree (RD) values to rescale them into Chao's five-digit tone letters ([19]). As given in formula (2), z_{max} and z_{min} are the maximum and minimum LZ-score values of one speaker, respectively. As shown in Formula (3), the Duration Relativization procedure ([20]) is adopted for normalization of duration, where D_i represents the absolute duration of one tone, and M_i represents the average duration of all the 6 tones.

(1) $y_i = \lg x_i \; ; z_i = \frac{y_i - m_y}{s_y}$

(2) $RD_i = \frac{z_i - z_{min}}{z_{max} - z_{min}}$

(3) $DR_i = \frac{D_i}{M_i}$

3. RESULTS

Figure 1 gives mean F_0 values in Hertz on the ordinates for each tonal point on the abscissas from each speaker. The 6 tones, *yin-ping*, *yang-ping*, *shang*, *yin-qu*, *yang-qu*, and *yin-ru* are numbered from 1 to 6 in the legends.

The average pitch ranges of male and female speakers both approximate to 160 Hz wherein 100-260 Hz is for males and 130-290 Hz is for females.

The *yin-ping* tone has a low level F_0 curve with a slightly falling onset, from 144 to 131 Hz for males and from 202 to 175 Hz for females, which occupies about 45% of the entire duration.

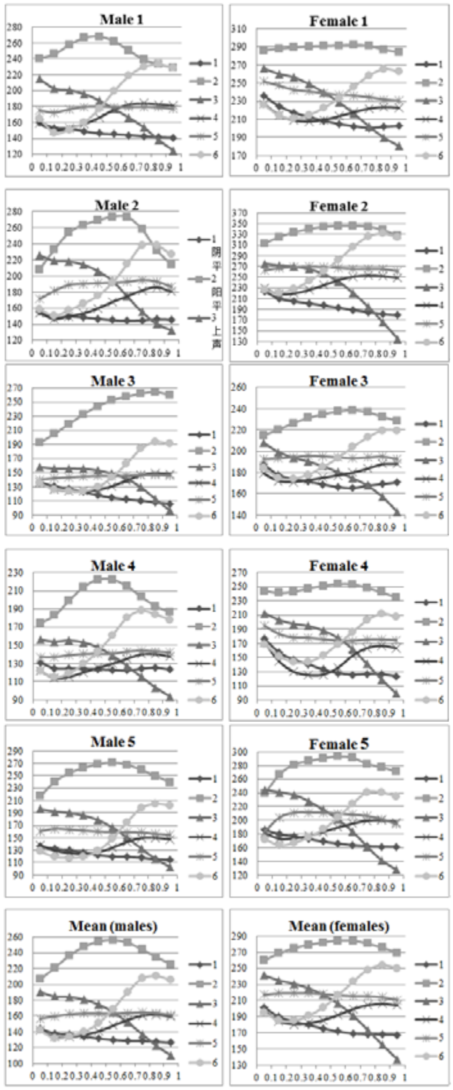
The *yang-ping* tone is remarkable for its extra high F_0 value and curve shape. In both males and females, the *yang-ping* tone has the highest F_0 value and a convex shape. It was however transcribed as a high level tone in dialectological works ([21], [22]). Note that the average highest F_0 point is about 256 Hz in males, normally about 270 Hz or above in all male speakers except Male 4. And that is about 284 Hz in female speakers. It was reported that the pitch range of male falsetto is about 275-634 Hz ([23]). That is, speakers, at least the male speakers, were utilizing falsetto in the production of *yang-ping* tone. It seems that the detected convex F_0 contour as well as falsetto-like phonation does not mean that the speakers were producing a rising-falling tone. More likely, the convex contour is an articulatory strategy to facilitate the realization of a high F_0 target. The dialectologists are insightful in that the *yang-ping* tone is a high, actually extra-high tone.

In addition to high and low level tones, there is a mid level tone, *yang-qu*, in Qimen. The F_0 curves for *yang-qu* maintains even: about 163 Hz for males and 216 Hz for females.

In summary, different articulatory strategies are employed to achieve different types of level tonal targets, namely plain level for mid level, a slightly falling onset for low level, and a convex F_0 shape accompanied by falsetto phonation for high level.

The *shang* tone is the only falling tone in Qimen, which is composed of a slow-falling portion (the first 45% of the duration) and a rapid-falling portion. The falling ranges are 190-110 Hz for males and 241-137 Hz for females. Note that the offset of the *shang* tone is lowest point of F_0 range for both male and female speakers.

Figure 1: F_0 curves of individual and average speakers in Qimen dialect: male speakers (left) and female speakers (right).



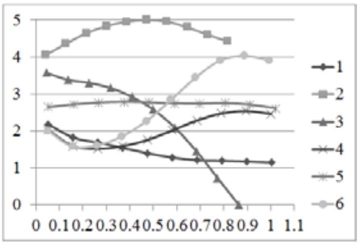
The *yin-qu* and *yin-ru* tones are the two rising tones and they both have a concave shape. First, they have a nearly overlapping onset F_0 curve. In male speakers, the initial falling is about 9 Hz for *yin-qu* and about 10 Hz for *yin-ru*; in female speakers, the initial falling is about 17 Hz for *yin-qu* and about 10 Hz for *yin-ru*. The two tones differ in the subsequent rising part, namely below 30 Hz for *yin-qu* and about 79 Hz for *yin-ru*. In other words, *yin-qu* is a low rising tone and *yin-ru* is a high rising tone, although they have a similar onset.

In addition to F_0, the duration also contributes to acoustic phonetic characterization of tones. Table 1 summarizes mean durations in millisecond of the 6 tones in Qimen dialect. It can be seen from the table that the *yang-ping* and *shang* tones are obviously shorter than the other 4 tones in both male and female speakers. And the other 4 tones have different orderings in duration in male and female speakers. Qimen tones do not contrast in duration. However, a two-factor (gender × category) analysis of variance yielded a significant effect of tonal category (F (5, 1495) = 107.65, P < 0.001), and no significant effect of gender (F (1, 1499) = 0.01, P > 0.001) or interaction (F (5, 1495) = 2.43, P > 0.001). Very likely, the detected durational difference is intrinsic to tones. That is, *yang-ping* and *shang* tones are short because they are extra high and falling respectively.

Table 1: The mean durations and standard deviations (in parentheses) in millisecond of the 6 tones in Qimen dialect.

Tone Category	Males	Females
1 *yin-ping*	381 (58)	381 (55)
2 *yang-ping*	303 (42)	317 (57)
3 *shang*	326 (31)	331 (52)
4 *yin-qu*	377 (53)	383 (45)
5 *yang-qu*	392 (46)	382 (55)
6 *yin-ru*	383 (51)	371 (49)

Figure 2: Qimen tones (normalized data).



By means of LZ-score Procedure, RD Transformation, and Duration Relativization, the raw data of pitch and duration were normalized in a two-dimensional diagram. As shown in Figure 2, the ordinate corresponds to Chao's five-digit tone letters, and the abscissa shows the relative duration. This diagram explicitly demonstrates how the 6 tones contrast with each other in pitch and duration, since the normalization procedure has successfully reduced the anatomical/physiological variation in gender and speaker, but still preserved the phonemic as well as intrinsic variation of tones. In summary, Qimen tones are transcribed as follows: *yin-ping* /22/, *yang-ping* /55/, *shang* /41/, *yin-qu* /23/, *yang-qu* /33/, and *yin-ru* /25/.

4. DISCUSSION AND CONCLUSION

Physically, tonal contour is an F_0 curve: level, rising, falling, concave, convex, etc. The most important thing is to determine whether the contour is phonetic or phonological. As manifested in Qimen, the *yin-ping* and *yang-ping* tones are both phonologically level tones, although they have phonetically complex contours. Based on the production data, it is tenable to conclude that the Qimen dialect obviously has a three-way distinction of level tones. Interestingly, similar three-level-tone patterns were reported in literature, notably Yoruba ([24], [25]) and Thai ([26]). The three level tones in Yoruba and Thai have nearly identical contour shapes with the Qimen tones except that the Qimen high level tone is extra high due to the phonation type of falsetto. Moreover, Thai has an identical six-tone pattern with Qimen, namely three level tones, two rising tones and one falling tone. According to a series of perception studies ([27], [28], [29], [30]; see also [31] for review), it is concluded that pitch level is the sufficient cue for the distinction of three level tones, although F0 contour also contribute to tonal identification.

The *yin-qu* and *yin-ru* pair was another case. They both are phonetically concave, but the onset falling could be attributed to general constraints in the production and perception of low rising tones ([32]). Moreover, if they were concave, there would be no rising tones in Qimen. This option was thus ruled out by Occam's Razor.

The second issue concerns if the phonological tonal contour can be decomposed into a concatenation of level components. Qimen tone sandhi data gives a positive answer. The *shang* tone /41/ becomes /44/ or /22/ before or after the *yang-ping* tone /55/, respectively ([21]). The *yin-ru* tone /25/ usually becomes a short tone /5/ when occurring in the leftmost position in a sandhi domain. Although somehow synchronically opaque, Qimen contour tones are decomposed into level components in tone sandhi processes.

Third, the Qimen tone data do not support the register-contour theory ([15], [16]). First, the *yang-qu* tone has ambiguous dual structures, i.e. [H, l] or [L, h] (the symbols H and L specify the register; h and l specify the contour). Which one is the underlying form? Second, [15] and [16] argue that tonal contour should form within a single register that remains constant over a morpheme. The *yin-ru* tone has a nearly identical onset with the *yin-qu* tone, which explicitly violates Bao's claim that "a tone system avoids two tones with the same start or end points but different pitch differentials" ([16]). The *yin-qu* and *yin-ru* tones obviously have cross-register behaviors in Qimen tonal phonology.

In summary, Qimen distinguishes three level tones, two rising tones, and one falling tone.

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6. REFERENCES

[1] Maddieson, I. 1978. Universals of tone. In: Greenberg, J. H. (ed.), *Universals of Human language*, Vol. 2. Stanford: Stanford University Press, 335-365.

[2] Wang, S.-Y. W. 1967. Phonological features of tone, *International Journal of American Linguistics*, 33, 93-105.

[3] Sampson, G. 1969. A note on Wang's phonological features of tone. *International Journal of American Linguistics*, 35: 62-66.

[4] Woo, N. 1969. *Prosody and Phonology*. Ph. D. dissertation. Massachusetts Institute of Technology.

[5] Maddieson, I. 1971. The inventory of features. In: Maddieson, I. (ed.), *Tone in Generative Phonology*. University of Ibadan Research Notes 3, parts 2 and 3. Ibadan: University of Ibadan, 3-18.

[6] Fromkin, V. A. 1972. Tone features and tone rules. *Studies in African Linguistics*, 3 (1), 47-76.

[7] Anderson, S. R. 1978. Tone features. In: Fromkin, V. A. (ed.), *Tone: A Linguistic Survey*. New York: Academic Press, Inc., 133-175.

[8] Clements, G. N. 1983. The Hierarchical Representation of Tone Features. In: Dihoff, I. R. (ed.), *Current Approaches to African Linguistics*, vol. 1. Dordrecht: Foris.

[9] Snider, K. L. 1990. Tonal Upstep in Krachi: Evidence for a Register Tier. *Language* 66, 453-474.

[10] Tsay, S-C. J. 1994. *Phonological Pitch*. Ph. D. dissertation. University of Arizona, Tucson.

[11] Maddieson, I. 1972. Tone system typology and distinctive features. *Proceedings of the International Congress of Phonetic Sciences*. The Hague: Mouton & Co., 957-961.

[12] Hyman, L. 1993. Register Tones and Tonal Geometry. In: van der Hulst, H., Sinder, K. (eds), *The Phonology of Tone: the Representation of Tonal Register*. Dordrecht: Foris.

[13] Duanmu, San. 1990. *A Formal study of Syllable, Tone, Stress and Domain in Chinese Languages*. Ph. D. dissertation. Massachusetts Institute of Technology.

[14] Duanmu, San. 1994. Against Contour Tone. *Linguistic Inquiry* 25, 555-608.

[15] Yip, M. 1980. *The Tonal Phonology of Chinese*. Ph. D. dissertation. Massachusetts Institute of Technology.

[16] Bao, Z. M. 1999. *The Structure of Tone*. Oxford: Oxford University Press.

[17] Boersma, P., Weenink, D. Praat: doing phonetics by computer [Computer program]. Version 5.3.68, retrieved 20 March 2014 from http://www.praat.org/.

[18] Zhu, X. 2009. *Phonetics*. Peking: The Commercial Press.

[19] Chao, Y. R. 1930. A System of Tone-Letters, *La Maitre Phonetique* 45, 24-47. Reprinted in 1980, *Fangyan*, 2, 81-82.

[20] You, R., Yang, J. (eds). 2001. *Experimental Research on the Tones in Wu Chinese Dialects*. Shanghai: Fudan University Press.

[21] Hirata, S. (ed.). 1998. *Studies in Hui dialects*. Tokyo: Kohbun.

[22] Chen, Y. 2006. *A Comparative Study on the dialects in Qimen County*. M.A. thesis. Guizhou University.

[23] Hollien, H., Michel, J. 1968. Vocal fry as a phonational register. *Journal of Speech and Heading Research* 11, 600-4.

[24] Hombert, J.-M. 1976a. Consonant types, vowel height, and tone in Yoruba. *UCLA Working Papers in Phonetics*, 33, 40-54.

[25] Hombert, J.-M. 1976b. Perception of tones of bisyllabic nouns in Yoruba. *Studies in African Linguistics,* Supplement 6, 109-121.

[26] Abramson, A. S. 1962. The vowels and tones of Standard Thai: Acoustic measurements and experiments. *International Journal of American Linguistics*, 28(2), Part II; Also *Publication Twenty of the Indiana University Research Center in Anthropology, Folklore, and Linguistics*, Bloomington.

[27] Abramson, A. S. 1972. Tonal experiments with whispered Thai. In Valdamn, A. (ed.), *Papers on Linguistics and Phonetics to the Memory of Pierre Delattre*, pp. 31-44. The Hague: Mouton.

[28] Abramson, A. S. 1975. The tones of central Thai: some perceptual experiments. In Harris, J. G. & Chamberlain, J. (eds.), *Studies in Tai Linguistics*, pp. 1-16. Bangkok: Central Institute of English Language.

[29] Abramson, A. S. 1976. Thai tones as a reference system. In Gething, T. W., Harris, J. G. & Kullavanijaya, P. (eds.), *Tai Linguistics in Honor of Fang-Kuei Li*, pp. 1-12. Bankok: Chulalongkorn University Press.

[30] Abramson, A. S. 1978. Static and dynamic acoustic cues in distinctive tones. *Language and Speech*, 21(4), 319-325.

[31] Gandour, J. T. 1978. The perception of tone. In Fromkin, V. A. (ed.), *Tone: A Linguistic Survey*, pp. 41-76. New York: Academic Press.

[32] Shen, X-N. S., Lin, M. 1991. A Perceptual Study of Mandarin Tone 2 and 3. *Language and Speech,* 34 (2), 145-156.