PRODUCTION AND PERCEPTION OF DOUBLE CONTOUR TONES IN QIYANG CHINESE

Wei Hu

Foreign Language College, Nankai University, China
Zopg502@126.com

ABSTRACT

This paper is to study Qiyang double contours from acoustic and perceptual perspective. A noteworthy sandhi pattern and the perception experiment results indicate that Qiyang qushengs (departing tones) are underlying double contours, i.e. 4232(yinqu) and 2142(yangqu), because their falling tails are phonologically active and lexically encoded. This seriously challenges the current tone geometries [1, 3, 9], as none of them capitulate such complex tone representations. A likely solution is to represent qushengs' downside tail as floating contour features, whose availability in lexicon and special status of being unassociated may account for qushengs' perceptual ambiguities.

Keywords: double contour, floating feature

1. INTRODUCTION

Qiyang Chinese is an old Xiang dialect spoken in Qiyang county, south Hunan Province. It has 6 citation tones and its yinqu and yangqu have fall-rise-fall pitch contour as revealed by two acoustic studies by Zeng [10] and Wang [8]. Both authors name these rare complex tones "double contours", but they disagree on the nature of Qiyang qushengs. The crux is whether the falling end is of linguistics significance and part of the phonological knowledge of Qiyang people. Zeng and Wang did separate perception experiments with separate results. Zeng claims the natives do hear the fall tails of yinqu and yangqu [10] while Wang said Qiyang people cannot discern the qushengs with fall tail from those without [8].

Their perception tests, however, do not follow the standard paradigm and are defective in many respects. For instance, they cut qushengs' fall tails off and the subjects just hear much-shortened tones and syllables. In Wang's study, the natives' insensitivity may attribute to the fact that the "be-tailed" qushengs still differ much acoustically from any other tones in Qiyang and are unlikely to be misperceived. In contrast, Zeng's subjects feel reduced qushengs weird probably because the syllables are much shorter than the normal, with much segmental (not just tonal) signals lost as well. All in all, simply cutting the final fall of qushengs is ill-considered. First, it is a standard practice of gating paradigm which is unfit for our purpose. Second, it has been proven that contour tones require longer duration to be perceived [4]. Finally, excising the later portion of a tone may pay high price because Khouw & Ciocca [6] finds that the later portion is more important cue for tone identification than the earlier section is. Before exploring how native speakers perceive and process the fall tails of Qiyang qushengs with more rigorous designs, we repeat their production tests to analyze the double contours' performance in citation as well as in connected speech.

2. PRODUCTON EXPERIMENT

2 female and 2 male Qiyang speakers recite a prepared wordlist which contains 50 syllables for each citation tones and words in all the 36 tonal combinations. The recording is analyzed by Praat, which help us divide a selected pitch section of a syllable rime equidistantly into nine parts. The f_0s of the resultant ten points are then converted into T values by using the formula below.

$$T_i = 5*(\log(P_i)-\log(Min)/(\log(Max)-\log(Min)) \quad (1)$$

P_i in Hz is the pitch value of one of the 10 points. Min and Max are highest and lowest f_0s found in an informant's recording. The 10 consecutive T_is represent the normalized pitch register and contour of a particular tone. They correspond to Chao's 1-5 tone letters. Hence, normalized citation tone system of each informant is obtained and that of ZGL is in Figure 1. Our work replicates Wang's and Zeng's findings. The disyllabic sandhi tones are normalized by the same method.

Figure 1 illustrates that all tones of Qiyang end with a fall and none is level or simplex contour (fall or rise). Obviously qushengs, having 2 turns and 3 sections, are the most complex and we simply cannot regard their initial and final falls as onset f_0 perturbation and declination at the end of articulation, because they are too lengthy to be trivialized as phonetic details. Table 1 shows the falls cover substantial portion of the qushengs.

Figure 1: The normalized individual citation tone system of ZGL (female, aged 30).

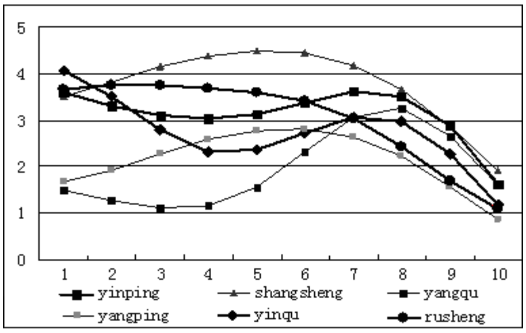


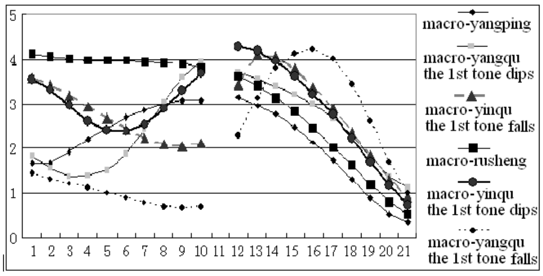
Table 1: The durational percentages of the 3 sections in Qiyang qushengs.

	Onset fall	Mid rise	Offset fall
Yinqu	35%	33.7%	31.3%
Yangqu	32.3%	38.8%	28.9%

As to the tone sandhi, Qiyang displays patterns which render unified phonological explanation impossible. And Zeng [10] and Wang [8] hold divergent, even contradictory views on which tone in what contexts changes to what. Our result is encouraging as we do unearth regular patterns. Qiyang disyllabic tone sandhi shows two patterns. In pattern I, the 2nd syllable loses its lexical tone and receives the 1st syllable's end portions or right edge tonemes. We view the 2nd syllable in this case as neutral-toned (though the 2 syllables are roughly equal in length) because whichever lexical tones they have in citation, these tones are neutralized, mainly to a fall. This reminds us of Wu dialect tone sandhi like Shanghai [3]. Pattern I normally occurs in vernacular, frequently-used words or when informants speak fast enough. For qusheng-initial words, there are 2 subtypes. A) The initial qusheng turns into a fall (high fall for yinqu; low fall for yangqu) and the 2nd syllable has convex or quasi-convex. B) Qusheng becomes dipping and the 2nd syllable uniformly bears a high fall. Pattern II is typically found in words which are literal or of verb-object structure. The 2nd syllable is not reduced but obviously advantageous in terms of intensity and duration, while the 1st tone shows sandhi forms which we will not discuss here.

Focusing on pattern I, we obtain pitch envelops that are precisely the prominent initial tones if we put the f_0 contours of the 2 syllables together (see Figure 2). Provisionally, we call these disyllable envelop, i.e. the sandhi forms of the 2 tones in a row, as "macro-yinping", "macro-yangping", "macro-yinqu", "macro-yangqu", etc.

Figure 2: Pattern I tone sandhi (informant ZGL).

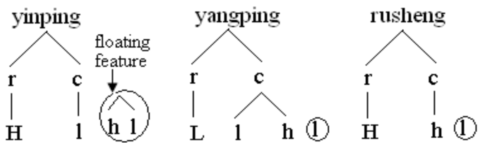


3. PHONOLOGICAL ANALYSIS

The phonetic facts given above puzzle all the available tone feature geometries. Duanmu [3]'s geometry tolerates simplex contours only because its working assumption is that Chinese normal syllable are bimoraic and each mora bears one toneme. Convex and concave are only possible through docking the 3rd toneme on the 2nd mora. Then the four-toneme Qiyang qushengs are knotty in that the 2nd mora will be crowded with the last 3 tonemes, a weird scene. Yip [9]'s and Bao [1]'s models are even less tolerant of [hlhl] contour. More crucially, their models' pillar principle that lexical tone cannot cross 2 registers makes yangqu an impossible representation because its onset fall and ending fall are apparently of different registers.

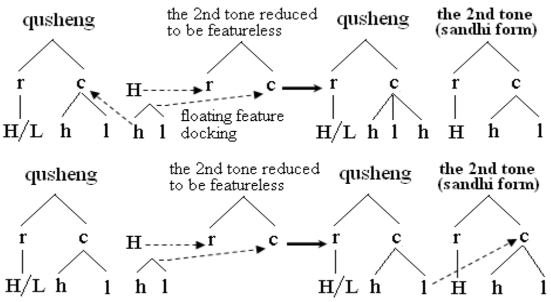
Analytically, we crucially revise Bao's model to accommodate floating register and contour features, which enable us to represent yinping, yangping, rushing as below (for qushengs, see Figure 4).

Figure 3: The representation of some Qiyang tones.



The floating features leave unassociated lexically. They ensure a neat and sound account of all the phonetic facts. In citation the syllable is lengthened before a pause. Then the floating features dock on the added rimal section and the tones are fully realized. Similarly, in disyllabic words, the 2nd syllable, with its tone features lost, will receive the floating features of the 1st syllable. For instance, the floating [hl] migrate rightward as a unit; the 2nd fall tone in the macro qusheng pattern is explained. As in Figure 4, when the floating [h] spread leftward to qusheng's contour node as a single feature, the 1st tone will dip as [hlh] or 313; when the quesheng has its rightmost contour feature [l] spread to the 2nd syllable, then a convex 353 forms.

Figure 4: The qusheng-initial tone sandhi.



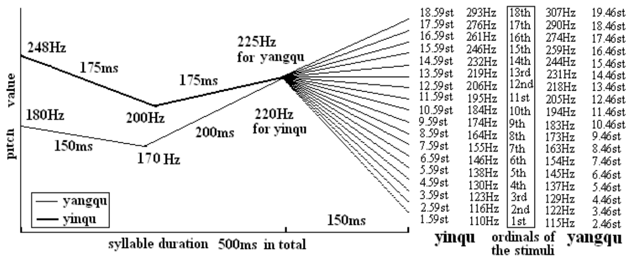
We prove that qushengs' fall tails are legitimate phonological units, without which sandhi pattern I cannot be recapitulated in such simple, unified way. Next we will experimentally examine how the unassociated status of qushengs' offset falls is related to the ways Qiyang people perceive them.

4. PERCEPTION EXPERIMENTS

The experiments consist of only identification tasks. Following Brunelle [2], we ask the subjects to rate the naturalness or goodness of the pre-designed stimuli they just hear. Four degrees are printed on an answer sheet as options they subjects must choose in deciding whether the stimulus is or how it is like a target morpheme (e.g. [tou], a yinqu morpheme meaning "bean"). The options are "is bean exactly (4 points)", "should be bean (3 points)" "might be bean" (2 points)" and "is not bean (1 point)". For each tone, 3 token syllables are used as targets; they all are frequently-used morphemes, so that the frequency effect of the tested syllables is controlled.

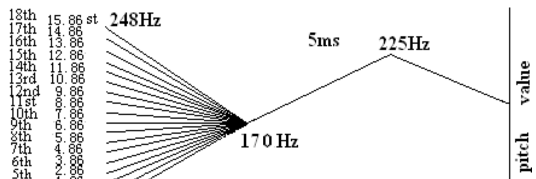
Test 1 is to examine what roles the fall tail plays in Qiyang people's perception of yinqu and yangqu. We used re-synthesized stimuli. Take yinqu stimuli for example. From the production file, we select a token whose start, end and turning point f_0s are nearly perfect matches to those of the normalized yinqu. The f_0 contour covers 500 ms (this give enough time for the listener to judge), which is divided into onset fall(175ms), middle rise(175ms) and offset fall(150ms) to roughly match the temporal division in Table 1. As in Figure 5, the endpoint of qusheng is manipulated by Praat to generate stimuli continuum. The endpoint is lowered or raised by every 2 semitones (st) from the original 174Hz (9.59st) until it covers the range from 110Hz to 293Hz. The same manipulation procedure applies to yangqu stimuli too and we put the 2 sets of stimuli in a single Figure 5 to save space. The prediction is that if the fall tail is trivial and is not a part of the subjects' phonological knowledge, the f_0 adjustments will not have impact on the subjects' ratings; if the fall is lexically encoded, subjects will be more confident in identifying qusheng when the end portion keeps falling than after the end portion starts to rise.

Figure 5: The tone stimuli continua in test 1.



In test 2, the start point f_0 of yangqu is manipulated in order to evaluate its contribution to the identification of yangqu (see Figure 6). There are 18 stimuli for each tested tone in each test. The manipulated tone tiers are then re-synthesized with 3 segmental files. So the total of stimuli is (3 tasks *3 morphemes *18 stimuli=) 162. The stimuli are randomized. 10 Qiyang natives (16-54 of age) participated in the experiments. 1620 responses are collected and calculated. Finally we put the result in Figure 7 to illustrate the relation between tone identification (mean) score and the slope of the onset/offset falls in qushengs.

Figure 6: The tone stimuli continua in test 2.



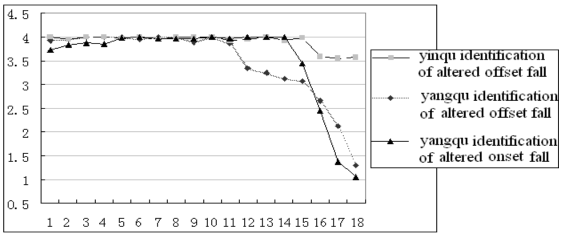
In Figure 7 we see different mean goodness scores for the yinqu and yangqu fall tails as they gradually become flat and then upward. For yinqu identification, all the 18 stimuli are scored above 3.5 points, which indicates subjects are insensitive to the altered slope of the offset fall. In contrast, for yangqu identification, subjects' rating declines abruptly to 1.5-lower across the 13th-to-18th stimuli. The 13th stimulus coincides with a level-off tail, and the forthcoming rises (the 15th-18th) apparently induce poor identification. This means that the offset fall of yangqu is perceptually active.

Figure 1 reveals that the only reliable difference between yinqu and yangqu is the onset portion so the onset fall should be vital in discriminating queshengs. Test 2 finds evidence for that. When the start point f_0 of yangqu rises to around 210Hz, the identification begins to deteriorate, a sign of perceptual importance of this portion. Presumably (not experimentally here), when the starting point of yinqu get lower adequately, it will turn into yangqu or yinping perceptually. So the onset fall of yinqu is perceptually important. However, the same is not true for the yangqu's onset fall, whose change into a rise (14th-to-1st stimuli) exerts no influence on the identification. Thus, we gain a peculiar temporal distribution of cues for qushengs.

Table 2: Cues for different sections of qushengs.

	Start point f_0	Onset fall	Offset fall
Yinqu	Crucial	Crucial	Trivial
Yangqu	Crucial	Trivial	Crucial

Figure 7: The mean identification scores (on vertical axis) of stimuli (abscissa axis is the stimuli ordinal).



5. DISCUSSION

Since our finding is not very conclusive, we need to explain why the fall tail is meaningful in yangqu while irrelevant in yinqu. The first reason may be there are still other functioning cues, e.g. the distance between the start and end of a tonal rise. Yangqu starts low so when it endpoint f_0 is raised high enough, the longer distance f_0 travels may make the rising tail far more prominent and easier to be heard. The second reason given below is conceptual and more linguistically valuable.

It is an accepted view in psycholinguistics that online processing of acoustic inputs is mediated by phonological representations and the abstract phonology knowledge does affect perception [5, 7]. Lahiri & Reetz [7] differentiate among three perceptual outcomes when features are mapped onto representations: ***Match***, ***Mismatch*** and ***NO-Mismatch***. ***Match*** occurs if the signal and the underlying form have the same features; ***Mismatch*** occurs if they have conflicting features. ***NO-Mismatch*** occurs if there is neither match nor contradiction of features, i.e. when a feature is underspecified in the underlying form and feature matching cannot be completely evaluated, resulting in ambiguity and inconsistency in subjects' identification of or prediction about the signals.

Besides ***Underspecification*** however, there is another type of abstract (nonlinear) representation, i.e. ***Unassociation*** where unanchored features float. Whether ***Unassociation***, like ***Underspecification***, is categorized as ***NO-Mismatch*** is a significant issue. ***Unassociation*** is different from ***Under-specification*** because the feature concerned is in the underlying representation. It is like ***Under-specification*** in there being no direct association between the feature and its receiver. Feature's status is uncertain and its accessibility in perception and processing might be unsecured, hence inducing inconclusive perception outcomes. Obviously, more sophisticated cue manipulations are required before clear picture is finally obtained.

Ascribing the perceptual inconsistency of qushengs' final falls to their unassociatedness, we can conclude that Qiyang qushengs are genuine phonological double contours and tone geometry must be enriched with floating features.

6. REFERENCES

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