Experimental Study on Disyllabic Tone Sandhi in the Lanxi Dialect (Post-print)

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Abstract

The Lanxi dialect belongs to the Wuzhou group of the Wu language. Based on original recorded speech data and using fundamental frequency as the primary acoustic parameter, this study investigates the citation tones and disyllabic tone sandhi of the Xiangxi Town dialect in Lanxi City. The results show that the Lanxi dialect has seven citation tones, which can be represented using five-point scale values as: yinping 434, yangping 31, shangsheng 433, yinqu 45, yangqu 25, yinru 434, yangru 323. Tone sandhi phenomena in disyllabic combinations are complex, with tone changes occurring in both the initial and final characters, and a certain degree of neutralization has taken place. Preliminary analysis reveals a total of 50 disyllabic tonal patterns, including 32 types of tone sandhi in general two-character groups and 18 distinct types in verb-object structure two-character groups. In disyllabic tone sandhi, the tonal patterns of general two-character groups exhibit strong regularity, whereas the tonal patterns of verb-object structures are more similar to citation tones. Tone sandhi occurs primarily in characters with level and departing tones. In the initial character, apart from simplified tone sandhi, there is a substantial merger between yinqu and yangqu, resulting in the production of a high level tone. In the final character, significant mergers occur between yinping and yinqu, as well as between yangping and yangqu. Additionally, under the condition that the initial character carries a yin tone, yang tone categories may be realized as yin tone categories, leading to further neutralization between yin and yang tone categories.

Full Text

An Experimental Study of Disyllabic Tone Sandhi in the Lanxi Dialect

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Abstract

The Lanxi dialect belongs to the Wuzhou group of Wu Chinese. Based on original recorded materials and using fundamental frequency (F0) as the primary acoustic parameter, this study investigates the monosyllabic tones and disyllabic tone sandhi in the Xiangxi Town variety of Lanxi. The results indicate that Lanxi has seven citation tones, which can be represented in five-degree values as: yinping 434, yangping 31, shangsheng 433, yinqu 45, yangqu 25, yinru 434, and yangru 323. Tone sandhi in disyllabic combinations is highly complex, with changes occurring in both initial and final syllables and a certain degree of neutralization. A preliminary analysis yields 50 disyllabic tonal patterns, including 32 patterns for general disyllabic groups and 18 distinct patterns for verb-object constructions. In disyllabic sandhi, general patterns exhibit strong regularity, while verb-object patterns more closely resemble citation tones. Sandhi primarily occurs in level and departing tones. In the initial syllable, aside from simplified sandhi, there is substantial merging between yinqu and yangqu, resulting in a high level tone. In the final syllable, significant merging occurs between yinping and yinqu, as well as between yangping and yangqu. When the initial syllable is a yin tone, yang tone categories may be realized as yin tone categories, leading to further neutralization between yin and yang registers.

Keywords: Lanxi dialect, tone, fundamental frequency, tone sandhi

1. Introduction

Traditional dialect tone description relies on auditory perception, which effectively distinguishes tonal categories but whose accuracy in representing specific tonal values depends entirely on the transcriber' s perceptual abilities. Consequently, results from different transcribers show considerable variation, and influenced by the transcriber' s native phonological system, often fail to reflect accurate tonal values. Since Liu Fu' s *Experimental Record of the Four Tones* in 1924, the introduction of experimental phonetics has made possible the quantification of the physical properties of tones, partially compensating for the limitations of auditory perception. Tone is a linguistic concept integrating multiple factors including pitch, phonation type, and sonorance (Kong Jiangping, 2015). Although fundamental frequency, as an acoustic physical quantity, cannot be completely equated with tone, it is the most effective physical parameter for revealing tonal pitch characteristics, capable of roughly determining tonal range and demonstrating the contour of pitch movement. Therefore, this experiment employs F0 as the primary parameter for analyzing tonal features.

This paper presents an experimental study of tones in the Lanxi dialect. While several studies have examined Lanxi monosyllabic tones with acoustic analyses, no systematic description of disyllabic tone sandhi exists. The Jinhua dialect, as a representative of the southern Wu Wuzhou group and closely related to Lanxi, has received relatively mature research attention. Although Lanxi and Jinhua are similar with minor differences in monosyllabic tones, disyllabic sandhi pat-

terns show marked distinctions, necessitating targeted investigation. This study employs acoustic analysis methods to describe and analyze the monosyllabic tones and disyllabic tone sandhi patterns of the Xiangxi Town variety of Lanxi.

2. Dialect Point Introduction

2.1 Overview of the Lanxi Dialect

Lanxi is located in central-western Zhejiang Province [Figure 1: see original paper], situated along the middle reaches of the Qiantang River on the northern edge of the Jinqu Basin. It extends 67.5 km east-west and 38.5 km north-south, covering a total area of 1,313 square kilometers. It lies 20.5 km from Jinhua urban district and 132 km from Hangzhou. The municipal water system belongs to the Qiantang River system, with a population of approximately 660,000 (data from Lanxi Municipal People' s Government website, 2016). According to the *Language Atlas of China* (1989), the Lanxi dialect belongs to the Wuzhou group of Wu Chinese, which includes nine counties and cities divided into ten dialect points: Jinhua (including Tangxi), Lanxi, Dongyang, Yiwu, Pujiang, Yongkang, Wuyi (excluding Xuanping), Pan' an, and Jiande (partial). This group exhibits substantial internal variation, with mutual intelligibility between points being relatively difficult and each constituting an independent system. Lanxi speech is closest to and mutually intelligible with Jinhua speech, while showing greater differences with other points in the Wuzhou group (Zhao Zeling, 2003). The Lanxi dialect also exhibits minor internal variation; this study focuses on the Xiangxi Town variety for tone sandhi investigation.

2.2 Phonology of the Lanxi Dialect

2.2.1 Initials According to Zhao Zeling (2003), the Lanxi dialect has 28 initials: p, P , b, m, v, h, , , , , s, z, t , d, n, l, k, k , g, , , , , , , Ø.

2.2.2 Finals According to Zhao Zeling (2003), the Lanxi dialect has 53 finals (including three syllabic nasals): , i, u, y, , i , u , y , ia, a, e, ie, ue, ye, , iæe, uæe, yæe, , i , æ̃, ẽ, iæ̃, ẽ, uæ̃, ẽ, yæ̃, ẽ, ĩ , ũ , ŋ, i ŋ, u ŋ, y ŋ, iŋ, oŋ, ioŋ, n, , i , u , y , ie , ye , , i , u , a , o , io , .

2.2.3 Tones According to Zhao Zeling (2003), the Lanjiang Town variety of Lanxi has seven tones (excluding neutral tone). The 1998 *Lanxi Municipal Gazetteer* describes urban Lanxi tone values with minor differences. Wu Jiani (2016) conducted an experimental acoustic analysis of urban Lanxi monosyllabic tones, yielding various values. The discrepancies among these three tonal systems primarily concern yinping, shangsheng, yangqu, yinru, and yangru. Yinping is described as a level-rising or level tone in the first two systems but as a level tone in Wu (2016). Shangsheng shows variation across all three systems in both value and contour (level, falling, or falling-rising). Yangqu is described as a rising tone in all three systems, with only minor differences in starting

and ending points. Yinru and yangru are short tones with generally consistent contours across the three systems; although Wu (2016) assigns yangru a value of 11, it is still described as an abrupt low rising tone.

While previous descriptions of Lanxi monosyllabic tones differ, the overall variation is not substantial. However, no research exists on Lanxi disyllabic tone sandhi or its acoustic analysis. This study employs experimental phonetics methods to conduct further acoustic analysis of monosyllabic and disyllabic tone sandhi patterns in the Xiangxi Town variety of Lanxi.

3. Research Methods

Experimental data were collected from four speakers (two male, two female), all native speakers of the Xiangxi Town dialect: (1) Female 1: Zhong Yang, 49, from Xiangxi Town, college-educated journalist, former middle school teacher, speaks only Mandarin and Lanxi dialect, currently resides in Jinhua urban district; (2) Female 2: Zhong Weiyan, 43, from Xiangxi Town, college-educated enterprise employee, speaks only Mandarin and Lanxi dialect, has lived in Lanxi urban district, Shaoxing, and Lishui, currently resides in Jinhua urban district; (3) Male 1: Yang Shijun, 50, from Yang Village, Xiangxi Town, college-educated teacher, speaks Mandarin and some neighboring village dialects, has always lived in Xiangxi Town; (4) Male 2: Zhang Yaping, 45, from Shi Village, Xiangxi Town, college-educated teacher, speaks Mandarin and some neighboring village dialects, previously lived in Jinhua urban district. The fourth male speaker comes from a different village approximately 1.6 km from the other three speakers' village; experimental analysis reveals minor phonetic differences remain, particularly evident in disyllabic sandhi with yinping as the initial syllable. When Male 2' s tonal values are inconsistent, his data are excluded from averaging.

Speech samples were recorded in quiet environments using digital recorders or mobile phones in wav format (16-bit, mono, 22,050 Hz sampling rate), with each word uttered twice. As this experiment only extracts F0 data and does not require extremely high fidelity, mobile phone recording does not affect results.

Experimental materials consist of monosyllabic and disyllabic word lists. For monosyllables, five sets of example characters with identical initials and finals were selected for each tone (with complementary voicing in yin-yang pairs). For disyllables, there are 49 possible tonal combinations between initial and final syllables; however, because some combinations yield more than one sandhi outcome, a total of 74 tonal pattern combinations were examined (excluding mergers). Five to six example words were selected for each pattern, with final syllables primarily having stop or affricate initials to facilitate syllable boundary identification during data extraction. The monosyllabic and disyllabic word lists used in the experiment are presented below.

The acoustic analysis proceeds from F0 data to explore the F0 patterns of monosyllabic and disyllabic units in the Xiangxi Town dialect and determine tonal

values. Recorded samples were first noise-reduced using Adobe Audition, then F0 parameters were extracted for each character in monosyllabic and disyllabic words using Praat software. F0 calculation employed the autocorrelation algorithm, which utilizes the quasi-periodicity of vocal fold vibration to compute speech signal periods and offers the strongest noise resistance among F0 extraction algorithms (Kong Jiangping, 2015). After removing onset and offset sections based on amplitude curves, F0 was extracted from selected intervals. Due to averaging across multiple speech samples with varying durations, temporal normalization was required: scripts extracted 20 F0 values at equal intervals within the selection (15 values for the short entering tones) to enable averaging and comparison.

After excluding anomalous samples, mean F0 values were calculated for each example word, then averaged across all examples for each tonal pattern combination, and finally averaged across the four speakers. To better correspond with human perception, the resulting F0 data were converted to semitone values using the semitone method (Liu Fu, 1924; Kong Jiangping, 2015). With the lowest f0 in the pitch range set at 0 semitones, the corresponding semitone value for each F0 measurement was calculated and plotted as semitone curves (with extraction points on the x-axis and semitone values on the y-axis). Based on these semitone values, five-degree values were assigned to yield preliminary tonal values for each category, as detailed below.

4. Monosyllabic Tone Parameter Analysis

Separate averaging of semitone values for female and male speakers yields the results shown in the figures below. Raw data show the average pitch range for the two female speakers is 170–264 Hz, and for males 99–172.6 Hz, with female F0 values higher than male values in every tonal category. After semitone conversion, the data become more comparable across different pitch ranges.

[FIGURE:2 and FIGURE:3 would appear here]

Regarding other characteristics, although apparent differences exist between genders, individual variation is in fact the primary cause of these differences. First, the four speakers show significant differences in pitch range, with the widest (Female 1) spanning 10.5 semitones and the narrowest (Female 2) only 6 semitones. Second, the dialect' s overall pitch range tends to be narrower at syllable onset and wider at syllable offset, though this feature varies considerably across speakers; Male 2 shows the most extreme pattern with less than 4 semitones at the front and 10 semitones at the back—a difference of 6 semitones —while other speakers show much smaller onset-offset disparities. Third, minor contour differences appear in individual tones: for example, all speakers except Female 2 show a falling-level contour for shangsheng, while Female 2' s shangsheng exhibits a final rising trend; the four speakers vary substantially in the degree of concavity for the two falling-rising tones (yinping and yangru); and the high rising yinqu tone shows either a convex or concave arch across speakers.

Finally, differences exist in tonal values and relative relationships: for instance, starting points for yangqu vary across speakers, with Male 2' s significantly higher; Female 2' s yinqu value is notably lower, even below yinping. Relative to individual differences, gender differences are not prominent in monosyllabic tones, indicating that citation tone values in this dialect are not entirely stable and vary across individuals.

[FIGURE:2 and TABLE:1 would appear here]

After averaging male and female data and reconverting to semitone values, the results shown in the figure and table above were obtained. These semitone values were then converted to five-degree values according to the five-degree tone marking method to distinguish existing tonal categories. The highest value in the averaged monosyllabic and disyllabic pitch range is 9.74 (approximately 10) semitones; dividing this into five degrees yields 2 semitones per degree: 0–2 semitones = degree 1, 2–4 = degree 2, and so forth. Based on where each tonal category' s starting point, ending point, and turning point fall within these five degrees, the seven tones can be represented in five-degree values as follows:

- Yinping: 434
- Yangping: 31
- Shangsheng: 433
- Yinqu: 45
- Yangqu: 25
- Yinru: 434
- Yangru: 323

Individual tone analysis: - Yinping is a concave tone in the middle of the pitch range, with similar starting and ending heights, valued at 434. - Yangping is a low falling tone, descending from the middle of the pitch range to its lowest point, marked as 31. - Shangsheng is a high falling-level tone, with a falling then level contour (some speakers show falling then rising), an overall small falling range, starting near but not reaching the highest point, valued at 433. - Yinqu is a high rising tone with a small rising range, reaching the highest point of the pitch range, with a very brief relatively flat section at the onset before rising, valued at 45. - Yangqu is a large-range rising tone also reaching the highest point, often with a brief flat or slightly falling section at the onset; however, since its starting value is near two semitones (the lowest starting value among tones), this phenomenon likely results from articulatory constraints and phonetic environment with minimal perceptual contribution, thus the value remains 25. - Among the two entering tones, yinru is higher with a small falling-rising trend, thus marked as high concave 434, which, while sharing the same value as yinping, shows an overall smaller falling range. - Yangru shows a clear falling-rising contour at a low pitch, marked as low concave 323.

Lanxi entering tone finals carry a glottal stop, though many characters show a clear weakening tendency. In terms of duration alone, entering tone characters show considerable variation across speakers, with yinru and yangru behaving

differently. All speakers show longer average duration for yangru than yinru, with Male 1 showing the greatest disparity (yangru averaging four times longer than yinru). Female 2' s yinru and yangru characters no longer show the short, abrupt characteristic, indicating that entering tones in Lanxi are also undergoing de-stressing, with yangru likely developing faster than yinru.

As shown in [Figure 4: see original paper], Lanxi citation tones exhibit relatively even distribution of tonal contours and values, including one level tone, two rising tones, two concave tones, and two falling tones, with same-contour tones showing substantial high-low distinctions, clear features, and relatively complete utilization of the pitch range. Additionally, citation tones show a tendency toward narrower range at syllable onset and wider range at syllable offset.

5. Disyllabic Tone Parameter Analysis

Lanxi disyllabic tone sandhi is highly complex and related to grammatical structure. Most disyllabic groups follow general sandhi rules, but depending on grammatical structure, other categories such as verb-object construction sandhi and numeral-classifier sandhi also exist. This study temporarily excludes numeral-classifier sandhi, focusing only on preliminary acoustic analysis and description of general disyllabic groups and verb-object construction groups.

The analytical method for disyllables is consistent with that for monosyllables. Semitone curves for each original tonal combination pattern are presented below. For comparative convenience, groups sharing the same initial tone are plotted together, with extraction points on the x-axis and semitone values on the y-axis, analyzed separately for general disyllabic groups and verb-object construction groups.

5.1 General Disyllabic Group Sandhi

[Detailed descriptions of each tonal combination would follow, referencing FIGURE:3 through FIGURE:9]

The general pattern shows that when yinping serves as the initial syllable, its concave contour 434 simplifies to a level tone, generally falling within the 33 range of the five-degree scale. In final position, level and departing tones show similar sandhi results, all becoming rising tones (generally 45), with yinping final slightly lower. Shangsheng as final retains its contour but with raised values. Yinru as final shows reduced concavity, approaching a level tone. Yangru as final shows considerable variation across speakers and lexical items, lacking consistent patterning despite a mean falling-rising contour.

When yangping is initial, it shows little sandhi. In final position, yinqu remains unchanged; yinping becomes a mid rising tone (45); yangping and yangqu become low rising tones; shangsheng retains its contour with raised values; yinru and yangru show slight rising.

When shangsheng is initial, it generally becomes a high level tone, only becoming a high rising tone before a yangping final. In final position, yinping shows reduced concavity and lower values; yangping's onset rises due to the high initial; shangsheng remains falling-level but higher; yinqu shows unchanged contour but substantially lower values; yangqu shows lower offset; yinru and yangru differ substantially from citation tones and show low consistency.

When yinqu is initial, it uniformly becomes a high level tone (55). In final position, yinqu and yangping merge as mid rising tones; yinping' s sandhi is relatively lower but perceptually similar, also marked as 34. Yangqu final produces two sandhi forms: one similar to yinping/yangping/yinqu sandhi, the other essentially identical to the citation tone. Shangsheng final is slightly higher than citation. Yinru and yangru finals show minimal differences from citation tones.

When yangqu is initial, it becomes a high tone, roughly splitting into high rising (45) and high level (55) variants. In final position, yinping and yinqu sandhi are similar (34); yangping becomes low rising; shangsheng and yangqu retain citation contours but with raised or lowered values respectively; yinru simplifies to level; yangru shows inconsistency but generally falls within degree 2.

When yinru is initial, it shows a clear two-way split: a higher variant (7–9 semitones) with flat or minimally falling contour appearing before yangqu, yinru, and yangru finals; and a lower variant (5–7 semitones) with clearer falling contour appearing before yinping, yangping, yinqu, and shangsheng finals. In final position, yinping, yangping, and yinqu become high rising tones; shangsheng final values rise (54); yangqu final values are lower with a brief falling section; yinru and yangru finals approximate citation tones.

When yangru is initial, its original falling-rising contour becomes falling. In final position, yinping and yinqu become high rising; shangsheng shows minimal contour change; yangping and yangqu become low rising; yinru approximates citation but with rising tendency; yangru is essentially identical to citation.

5.2 Verb-Object Construction Disyllabic Sandhi

In Lanxi, some verb-object construction groups exhibit sandhi distinct from general patterns. The same method analyzes verb-object sandhi (only combinations differing from general patterns are analyzed; unlisted combinations follow general sandhi rules).

[Descriptions of verb-object patterns referencing FIGURE:10 through FIGURE:15]

Verb-object sandhi shows two main characteristics: (1) yangping becomes high rising after yangping or yinqu; (2) yinqu initial shows dispersed variation. In verb-object constructions, tonal changes are minimal and mostly resemble citation tones, more similar to simple concatenation of monosyllables than general sandhi, as seen in "yinping+yangping" where the initial yinping even preserves its complete citation falling-rising contour.

Notably, when the initial is a departing tone, the final has a complete set of verb-object sandhi forms; when the initial is yinqu, two sandhi outcomes even emerge. However, when other tones serve as initials, verb-object sandhi distinct from general patterns appears mainly before level tones. Verb-object sandhi also merges with general sandhi (e.g., "yangping+yangping" verb-object merges with "yangping+yinping" and "yangping+yinqu" general patterns). Internal merging also occurs within verb-object patterns (e.g., "yinping+yinping" and "yinqu+yinping" verb-object merge as 33 33).

Although verb-object construction sandhi should apply to verb-object groups, the boundary between its application and general sandhi is not entirely clear in Lanxi. Many non-verb-object groups follow verb-object sandhi (e.g., "qingcha" [clear tea], "touming" [transparent], "pichu" [eliminate]), while some verb-object groups follow general sandhi, and numerous groups allow both patterns.

6. Discussion of Disyllabic Tone Patterns

Based on the acoustic analysis above, we can derive five-degree descriptions for each sandhi pattern. Five-degree descriptions are relative; some adjustments were made for systematicity and inter-category comparison, though these lack further perceptual evidence and remain primarily descriptive rather than constituting strict disyllabic tonemes.

General and verb-object patterns are presented separately in tables:

[TABLE:2 and TABLE:3 would appear here]

General disyllabic sandhi yields 32 patterns, with changes in both initial and final syllables. Initial syllables show high consistency within categories, either completely uniform or clearly splitting into two classes. Yinping simplifies from concave to level; yangping remains unchanged; shangsheng mostly becomes high level; yinqu becomes high level; yangqu splits; yinru splits; yangru loses its rising tail. Shangsheng, yinqu, and yangqu initial merging into high level creates vertical neutralization, though shangsheng' s overall downward shift lacks clear motivation for merger.

Final syllable sandhi occurs mainly in yinping, yangping, and yangqu, typically becoming high or low rising tones. In Lanxi, rising tones characterize departing tones; 34 can be seen as a variant of yinqu 45, and 13/24 as variants of yangqu 25. This suggests a "departing-toneization" of final level tones, consistent with Cao Zhiyun et al. (2016) on Jinhua. Additionally, yinping and yinqu finals only change to yinqu, while yangping and yangqu finals change to both yangqu and yinqu, showing "yang tone read as yin tone" (Cao Zhiyun et al., 2016). Notably, this occurs only when the initial is a yin tone. In Jinhua, when yang tones are read as yin, the original fully voiced initials also become corresponding unaspirated voiceless initials.

Merging is extensive: initial merging of yinqu and yangqu creates vertical neutralization; final merging of level and departing tones creates horizontal neutral-

ization.

Verb-object patterns yield 24 forms, totaling 50 distinct disyllabic patterns when combined with general patterns. Verb-object sandhi is grammatical sandhi, operating across phonological and semantic levels. Its most notable feature is minimal tonal change, mostly resembling citation tones, more like simple concatenation than general sandhi. Changes mainly involve: (1) yangping becoming high rising after yangping or yinqu; (2) dispersed variation of yinqu initial.

In Jinhua, yinqu initials that become mid level 33 in verb-object constructions derive from Middle Chinese clear departing characters, while those becoming high level derive from Middle Chinese Xian-Shan entering characters that have merged into yinqu (Cao Zhiyun et al., 2016). However, in Lanxi, these Xian-Shan entering characters retain their stop finals and have not merged into yinqu, yet yinqu still shows two verb-object sandhi patterns, requiring further investigation.

Common phenomena across both sandhi types include: concave tones tend to simplify to falling, rising, or new level tones for articulatory ease; entering tones lack consistency due to short duration, with tonal distinction relying more on relative height than contour; yinping as final shows a two-way split (mid-level in verb-object, high-rising in general) that is perceptually close and shows some speaker confusion, yet remains systematically distinct. Due to numerous sandhi types, minimal pairs are scarce at the disyllabic level, rendering pronunciation unstable with variation across repetitions and speakers—a consequence of low information load.

7. Conclusion

The Xiangxi Town variety of Lanxi has seven tonal categories: yinping is a falling-rising tone 434, yangping a low falling tone 31, shangsheng a high falling-level tone 433, yinqu a high rising tone 45, yangqu a low rising tone 25, yinru a short high concave tone 434, and yangru a short low concave tone 323. These differ substantially from previous studies: yinping shows clear falling-rising characteristics where earlier descriptions used level-rising or level; shangsheng is falling-level where previous descriptions used level or level-falling; this study provides more precise characterization of the falling-rising nature of both entering tones.

Disyllabic tone sandhi is complex, with changes in both syllables and substantial merging. There are 50 disyllabic tonal patterns: 32 for general groups and 18 additional patterns for verb-object constructions, excluding other grammatical sandhi types like numeral-classifier patterns. General patterns are highly regular, while verb-object grammatical sandhi more closely resembles citation tones. Sandhi occurs mainly in level and departing tones. Initial yinqu and yangqu show substantial merging into high level tones. Final yinping/yinqu and yangping/yangqu merging is significant, and when the initial is a yin tone,

yang tone categories may be realized as yin tone categories, leading to further neutralization.

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Note: Figure translations are in progress. See original paper for figures.