Acoustic Analysis of Monosyllabic and Disyllabic Tones in the Haimen Dialect: Postprint

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Date: 2020-11-10T00:00:00+00:00

Abstract

The Haimen dialect belongs to the Wu dialect group, possessing 30 initials, 46 finals, and 8 citation tones. Through acoustic analysis of speech samples from four speakers, the tonal values of the eight monosyllabic tones are determined as: yinping 15, yangping 51, yinshang 534, yangshang 241, yinqu 34, yangqu 231, yinru 4, and yangru 213, with minimal variation between male and female speakers. The disyllabic tonal patterns of the Haimen dialect total 18, primarily governed by the first syllable, and are classified into two categories based on whether the second syllable belongs to the ping, shang, or qu categories. When the second syllable is a shang or qu tone, tonal neutralization occurs predominantly on the second syllable. If the first syllable is a non-contour tone, the tone sandhi rule "X + shang/qu → X + 21" applies. If the first syllable is a contour tone, the "tonal envelope" phenomenon is observed. When the second syllable is a ping or ru tone, tonal neutralization occurs on both syllables. In this scenario, yin tones in the first syllable uniformly transform into high falling tones, while yang tones uniformly transform into low falling tones. In the second syllable, yinping and yangping merge, as do yinru and yangru.

Full Text

Preamble

Acoustic Analysis of Monosyllabic and Disyllabic Tones in the Haimen Dialect (Department of Chinese Language and Literature, Peking University, Beijing 100871)

Abstract

The Haimen dialect belongs to the Wu dialect group, with 30 initials, 46 finals, and 8 lexical tones. Through acoustic analysis of speech samples from four speakers, the eight monosyllabic tone values were determined as: yinping 15,

yangping 51, yinshang 534, yangshang 241, yinqu 34, yangqu 231, yinru 4, and yangru 213, with minimal variation between male and female speakers. The Haimen dialect exhibits 18 disyllabic tonal patterns, primarily determined by the first syllable, which fall into two categories based on whether the second syllable carries a ping, shang, qu, or ru tone. When the second syllable is a shang or qu tone, tonal neutralization occurs mainly on the second syllable. If the first syllable is a non-contour tone, the sandhi follows the pattern "X + shang/qu → X + 21." If the first syllable is a contour tone, a "tone envelope" phenomenon emerges. When the second syllable is a ping or ru tone, tonal neutralization occurs on both syllables. In this context, yin tones consistently become high falling tones, while yang tones become low falling tones. The yinping and yangping tones merge, as do the yinru and yangru tones.

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

1.1 Research Significance

Tone sandhi phenomena are widespread in Chinese, where a syllable' s tone may change relative to its original citation form in connected speech, creating new disyllabic tonal positions in two-syllable words. The underlying patterns merit careful investigation. Traditional tone research primarily relied on auditory perception of pitch using Chao Yuen-Ren' s five-point scale for tonal description. However, traditional transcription methods involve certain subjectivity and may overlook special cases such as the role of phonation type in tone. Experimental analysis enables more precise tonal value description and observation of tonal characteristics.

1.2 Dialect Point Selection

The Haimen dialect belongs to the Su-Hu-Jia sub-group of the Taihu sector of Wu Chinese. Multiple scholars have described its monosyllabic tones, and several have documented and traditionally analyzed its disyllabic tones (tone sandhi in two-syllable groups) [1]. The tonal values recorded in previous studies show some discrepancies. To date, the Haimen dialect lacks specific acoustic analysis. The Haimen dialect retains eight monosyllabic tones with the traditional yin-yang division across ping, shang, qu, and ru categories, and its disyllabic tonal system exhibits considerable complexity.

2.1 Geographic Location and Overview of the Haimen Dialect

Haimen City is located in the southeastern part of Jiangsu Province, on the north bank of the Yangtze River estuary. It faces Chongming Island across the river to the south, borders Qidong City to the east, and adjoins Tongzhou

[1]Content based on Wang Hongzhong (2011), with administrative division information updated from Haimen Municipal Government website.

District of Nantong City to the west and north. The city covers a total area of 1,148.77 square kilometers and administers three subdistricts, eight towns, and one township. In 1768, Haimen Department was established on newly formed alluvial land, with immigrants primarily from Chongming. The dialect spoken in Haimen Department during this period was Chongming dialect, which naturally absorbed elements from other immigrant dialects over time.

Two dialects currently exist within Haimen City: one called "Haimen speech" or "Sandy land speech" or "Qi-Hai speech," and another called "Tongdong speech" or "Jiangbei speech." Haimen speech is the predominant dialect, spoken in the central and southern coastal areas, including Haimen Subdistrict, Binjiang Subdistrict, Sanchang Subdistrict, Haiyong Township, and towns such as Sanxing, Changle, Yuelai, and Linjiang, accounting for approximately 70% of the city's population. Additionally, Haimen speech is spoken in most areas of Qidong, parts of Tongzhou District and Rudong County in Nantong City, and in coastal areas of Dafeng and Sheyang in Yancheng City where descendants of Haimen-speaking immigrants reside.

The "Haimen dialect" analyzed in this paper refers to the dialect commonly known as "Haimen speech" or "Sandy land speech," excluding "Tongdong speech." The Haimen dialect belongs to the Su-Hu-Jia sub-group of the Taihu sector of Wu Chinese, represented by Suzhou and Shanghai dialects.

[Figure 1: see original paper] Map of Wu-speaking regions [2]

2.2 Initials

According to the author's investigation, the Haimen dialect has 30 initials:

(1) fv, sz, , h are similar to their corresponding voiceless fricatives f, s, , h in isolated syllables, with a segment of voiced airflow following the voiceless fricative. The voiced portion is not prominent but is prone to losing the voiceless fricative component and undergoing phonetic change to become a voiced fricative in connected speech. This relates to the neutralization of yin and yang in the second syllable of tone sandhi.

(2) Nasals and lateral m, n, , ŋ, l show differences when paired with yin and yang tones, effectively forming two sets: m, n, , ŋ, l for yin tones, and m, n, , ŋ, l for yang tones, in complementary distribution.

(3) The zero initial actually has two variants: and . pairs with yin tones, with yang tones. In today's younger speakers, the latter is very weak and auditorily indistinguishable from the former.

2.3 Finals

According to the author's investigation, the Haimen dialect has 46 finals. iao 表 iou 油 iaŋ 将 uai 怪 uei 桂 uən 滚 uaŋ 光 yoŋ 用

[2] From *Language Atlas of China (2nd Edition)* B9 Wu Dialect Map.

(1) The vowel u and the u coda have relatively spread lip rounding.

(2) In e, ie, ue, the vowel e has slight movement, with an actual phonetic value close to e .

(3) When ø serves as the nuclear vowel in open syllables, it is relatively spread and central. When ø is the nuclear vowel in open syllables following medials u or y, it is not affected by the rounded medial and thus lacks rounding features. It is transcribed here as ø.

(4) In , u , the vowel has a relatively low tongue position, between and æ.

(5) The codas of ai, uai actually have relatively high tongue positions, with phonetic values of ae, uae. They are transcribed here as ai, uai following convention.

(6) The codas of ao, iao actually have relatively low tongue positions, with phonetic values close to a , ia . They are transcribed here as ao, iao following convention.

(7) In o, uo, oŋ, yoŋ, the vowel o has a relatively low and spread tongue position. In o , uo , yo , o has a relatively low tongue position.

(8) The codas of ei, uei are actually relatively lax, with phonetic values of .

(9) In older speakers, aŋ and ŋ groups, as well as a and groups, were previously distinguished, but have now merged into single sets.

(10) ŋ is only used for the character "我" (I/me), with slight oral movement during articulation and the mouth shape tending toward closure.

2.4 Tones

The Haimen dialect has eight tones. The following tone values and descriptions are based on Wang Hongzhong (2011):

Yinping 53 诗东 (poetry/east)
Yangping 24 时同 (time/together)
Yinshang 434 史董 (history/Dong)
Yangshang 231 是动 (yes/move)
Yinqu 34 试冻 (test/freeze)
Yangqu 213 事洞 (matter/cave)
Yinru 4 湿德 (wet/virtue)
Yangru 2 十夺 (ten/seize)

(1) Some yangping tones have a slight contour, close to 224, transcribed as 24.

(2) Some yinqu characters have a mid-level tone of 33 in the city area, transcribed as 34.

(3) The actual value of yangru is a short 23 tone, transcribed simply as 2.

Yuan Jin (1997), Shi Xiao (2004), and Huang Yanhua (2007) also described the monosyllabic tones of Haimen dialect, with their recorded values differing from Wang Hongzhong' s, as shown in Table 4 :

24(224) 34(34 or 33) 35 5(slightly low) 2(23) 2(slightly rising)
Table 1 Transcriptions of eight monosyllabic tones in Haimen dialect by different scholars

45(445)

The transcriptions by these four scholars are generally similar, with some local differences. Yinping is universally described as a high falling tone. Yangping, except for Wang Hongzhong (2011) who considers it level then rising, is universally described as a 24 rising tone. Yinshang is described as a high falling-rising tone, though with different descriptions of the initial and final heights. Yangshang shows greater discrepancy, with Yuan Jin (1997) differing significantly from others, who describe it as a low rising-falling tone. Yinqu presents certain issues, with controversy between level and rising tones, while Wang Hongzhong (2011) allows for either level or slightly rising. All four scholars agree on yangqu as a low falling-rising tone 213. The two entering tones are basically consistent, with yinru high and yangru low, and yangru showing slight rise.

Therefore, acoustic analysis should pay special attention to: the specific falling range of yinping, the specific initial and final heights of yinshang, and whether yinqu has a rising component.

3.1 Parameter Extraction

In extracting parameters, Adobe Audition 3.0 was first used to denoise and segment the recordings. PRRAT was then used to extract fundamental frequency (F0) from each recording file. PRRAT uses an autocorrelation algorithm for F0 extraction, which has the advantage of ignoring background noise effects. For male speakers, the Pitch setting range was 50Hz-300Hz; for female speakers, 75Hz-400Hz.

3.2 Normalization

Since each sample has different duration and thus different numbers of extracted F0 values, normalization is required for data averaging. The F0 parameters are first interpolated, then the required number of F0 values is extracted at equal time intervals as needed.

Our implementation uses a script program. For smooth tones, 20 points are automatically extracted at equal intervals per syllable; for checked tones, 15 points per syllable.

3.3 Speakers

The recordings used in this paper include four speakers, two male and two female, all native Haimen dialect speakers:

Huang Huijuan, female, 64 years old, from Anjiao Village, Haimen Town, farmer, non-standard Mandarin.

Dong Caihong, female, 45 years old, from Haimen Town urban area, middle school teacher, speaks Mandarin.

Huang Huishan, male, 72 years old, from Anjiao Village, Haimen Town, retired worker, non-standard Mandarin.

Huang Cheng, male, 47 years old, from Haimen Town urban area, doctor, speaks Mandarin.

3.4.2 Word List Explanation

Each word was read twice by each speaker. Words different from Mandarin are glossed in the lower right corner. Five words were selected for each tone (monosyllabic) or tone combination (disyllabic). However, only two words were selected for the "yinqu + yinqu" combination, which relates to the cross-pattern sandhi phenomenon in Haimen dialect.

Xie Zili (1982) noted that in Suzhou dialect, there exists a "cross-pattern" phenomenon within the yin and yang tone sandhi patterns: three yin-tone characters can respectively serve as the first syllable of three yin-tone sandhi patterns, and two yang-tone characters can serve as the first syllable of two yang-tone sandhi patterns, with some disyllabic groups potentially reading in two or even three sandhi patterns. Based on observation and analysis of the disyllabic tone sandhi examples described in Wang Hongzhong (2011), this paper finds that Haimen dialect also exhibits extensive cross-pattern phenomena. To simplify the analysis, this study avoids the cross-pattern sandhi issue in word selection: when a tone combination has multiple readings, words involving cross-pattern sandhi are excluded. For the "yinqu + yinqu" combination, only two words meeting this condition were found.

4.1 Data Analysis and Statistical Methods

During data extraction, obviously erroneous recordings (those differing from the other three speakers' pronunciations and not conforming to phonological rules) were eliminated. After extracting F0 data for all words, words with the same tone from each speaker were compared. Line charts with data markers were created in Excel using data from same-tone words to observe consistency, and obviously anomalous data were removed.

The mean F0 values at each point were calculated for each tone' s monosyllabic words per speaker. Data from the two male and two female speakers were

averaged separately and compared, with overall averages calculated for all four speakers to obtain average F0 data for each lexical tone for male speakers, female speakers, and all four speakers combined.

Logarithmic processing was applied to the average F0 values for male, female, and all speakers to obtain semitone values. Finally, based on actual conditions and reference to the tonal system, five-point scale values for the eight lexical tones of Haimen dialect were determined.

4.2 Analysis Results

The male speakers' pitch range is 235.93Hz - 123.02Hz [3], spanning 11.28 semitones. Converted to a five-point scale, each degree equals approximately 2.256 semitones.

[Figure 2: see original paper] Line chart of semitone values for monosyllabic tones by male speakers

The chart shows that yinping is a falling tone with a large falling range. Yangping is a rising tone with a large rising range. Yinshang is a high falling-rising tone with the starting point higher than the ending point. Yangshang is a rising-falling tone ending at the lowest point of the pitch range. Yinqu is a rising tone with small amplitude. Yangqu is a low falling-rising tone with a relatively high ending point. Entering tones are short and abrupt: yinru is high with slight contour, falling then rising, but with amplitude less than one degree (the contour is ignored); yangru is low, falling then rising, with greater contour amplitude than yinru. Converting semitone values to five-point scale values:

Yinping Yangping Yinshang Yangshang Yinqu Yangqu Yinru Yangru
Table 2 Tone values for male speakers

The female speakers' pitch range is 267.27Hz - 159.50Hz, spanning 8.937 semitones. Converted to a five-point scale, each degree equals approximately 1.788 semitones. The semitone curves for female speakers' monosyllabic tones are as follows:

[Figure 3: see original paper] Line chart of semitone values for monosyllabic tones by female speakers

Yinping is a falling tone with relatively large amplitude, starting at the highest point of the pitch range. Yangping is a rising tone starting at the lowest point of the pitch range with relatively large amplitude. Yinshang is a high falling-rising tone with the starting point higher than the ending point. Yangshang is a rising-falling tone. Yinqu is essentially a level tone; although its tail rises slightly to the fourth degree, the overall amplitude is small, transcribed as 33. Yangqu is a low falling-rising tone. Entering tones are short and abrupt: yinru is high with slight contour, falling then slightly rising; yangru is low, slightly

[3] F0 values are retained to two decimal places here and in the following section.

falling then rising, with greater contour amplitude than yinru. Converting to five-point scale values:

Yinping Yangping Yinshang Yangshang Yinqu Yangqu Yinru Yangru
Table 3 Tone values for female speakers

Comparing tonal differences between male and female speakers: The male pitch range is 235.93Hz - 123.02Hz, while the female range is 267.27Hz - 159.50Hz. The range widths are roughly equivalent, with the female range about 30Hz higher than the male range.

Comparing tone values between genders:

Yinping Yangping Yinshang Yangshang Yinqu Yangqu Yinru Yangru
Table 4 Comparison of monosyllabic tone values between male and female speakers

The differences are minimal. Yinping falls and yangping rises with large amplitude. Yinshang is a high falling-rising tone with the starting point higher than the ending point, with small rising amplitude in both genders. Yangshang is a rising-falling tone in both, and yangqu is a low falling-rising tone. Entering tones are short and abrupt, falling then rising, but with small amplitude. Therefore, yinru is transcribed as level for males, and the latter half of yinru and first half of yangru are transcribed as level for females.

Relatively speaking, the ending point of yinping is lower for males; the starting point of yangping is lower for females. The latter portions of yinshang and yangshang are higher for males than for females. For qu and ru tones, male values are higher than female values. Yinshang, yangshang, yangqu, and entering tones show contours, with greater contour amplitude in male speech than female speech. Yinqu shows a more obvious difference: male yinqu is clearly rising, ascending one degree, while female yinqu has a weak rising tendency with fluctuation amplitude less than one degree, making it closer to a level tone.

Using the semitone formula, F0 values can be converted to semitone values and then to five-point scale values. Calculation yields 9.137 semitones, approximately 9.2 semitones, which converts to about 1.84 semitones per degree on the five-point scale.

The semitone values converted from the average F0 of all four speakers for each tone are shown below:

Yinping Yangping Yinshang Yangshang Yinqu Yangqu Yinru Yangru
Table 5 Semitone values converted from average F0 of four speakers for monosyllabic tones

The line chart derived from this table:

[Figure 4: see original paper] Line chart of semitone values for monosyllabic tones in Haimen dialect

From this, the five-point scale values for each tone are:

Yinping Yangping Yinshang Yangshang Yinqu Yangqu Yinru Yangru
Table 6 Tone values for monosyllabic tones in Haimen dialect

Based on the tone value table and semitone curves, Haimen dialect has one falling tone: yinping 51. Two rising tones: yangping 15 and yinqu 34 (with smaller rising amplitude for yinqu). Yinping and yangping are largely opposite in value, though yinping's lowest point is actually higher than yangping's highest point. Multiple contour tones exist: one rising-falling tone, yangqu 231. Among smooth tones, there is one high falling-rising tone and one low falling-rising tone. The high falling-rising tone starts higher, while the low falling-rising tone starts lower. Entering tones actually both have contours, though with small amplitude. Yinru' s contour amplitude is smaller, while yangru' s contour is relatively more obvious, though the falling portion of its first half also has small amplitude.

Among all tones, the highest point "5" appears in yinping, yangping, and yinshang. In actual values, yinping' s "5" is the highest, with others significantly lower. The lowest point "1" appears in yinping, yangping, yangshang, yangqu, and yangru. In actuality, the "1" in yinping and yangru is significantly higher than in others.

Comparing these results with Table 1, our findings show greater amplitude of change for yinping and yangping in Haimen dialect. Yinshang is similarly recorded as falling-rising, but the relationship between starting and ending heights differs. Yangshang and yangqu are largely consistent. Regarding yinqu, due to its small rising amplitude, it can be transcribed as either level or rising. Both yinru and yangru in our results show contours. Since entering tones are short and abrupt with small contour amplitude, previous records did not reflect this feature.

5.1 Data Analysis and Statistical Methods

The mean F0 values at each point were calculated for each speaker' s disyllabic words in each tone combination, and averages were obtained across all four speakers. The disyllabic pitch range for all four speakers is 130.08Hz-288.39Hz. Logarithmic processing yielded semitone values. Comparisons were made among 64 tone combinations, particularly focusing on the performance of different tones in the second syllable position following the same tone. Grouping by the first syllable of disyllabic words, semitone value curves were plotted for each tone combination to observe tonal merger phenomena. Merged disyllabic tonal positions were summarized, and average F0 and semitone curves were obtained for each position, with tone values described according to the five-point scale.

5.2 Analysis Results

First, grouping by the first syllable' s tone, semitone value tables and curves for each tone combination are presented. Calculation shows 13.78 semitones, with approximately 2.756 semitones per degree on the five-point scale.

When the first syllable is yinping, the semitone curves for disyllabic groups are as follows [4]:

[Figure 5: see original paper] Semitone value curves for yinping combined with various tones

When yinping is in the first syllable position, compared to the citation tone 51, it remains a falling tone but with reduced amplitude. From the chart, the tone value can be described as 53 or 54, uniformly transcribed as 54.

Following yinping, yinping remains a falling tone but with reduced amplitude and lower starting point, with a tone value of 32. Yangping and yinping have similar contours after sandhi, nearly overlapping and becoming a falling tone. "Yinping + yinping/yangping" can be merged into one tonal position. Yinru becomes a mid-level slightly falling tone; due to the small falling range, the fall can be ignored and transcribed as 3. Yangru and yinru have nearly identical contours after sandhi, so "yinping + yinru/yangru" can be merged into one tonal position. Shang and qu tones show relatively consistent sandhi curves, all becoming the low falling tone 21 not found in monosyllabic patterns. Therefore, "yinping + yinshang/yangshang/yinqu/yangqu" can be merged into one disyllabic tonal position.

When the first syllable is yangping, the semitone curves for disyllabic groups are as follows:

[Figure 6: see original paper] Semitone value curves for yangping combined with various tones

Yangping in the first syllable position has two sandhi patterns: before yinshang, yangshang, and yangqu it remains a rising tone but with reduced amplitude, with a tone value of 24, which can be considered an incomplete articulation of the citation tone. Before ping tones, entering tones, and yinqu it becomes a low falling tone with small amplitude, transcribed as 22 or 21. Since no contrast is formed, it is uniformly transcribed as 21.

Yinping after yangping shows reduced amplitude and lower starting point, with a tone value of 43. Yangping after yangping becomes similar to yinping. "Yangping + yinping/yangping" can be merged into one tonal position. Yinshang after yangping becomes low falling tone 21, while yangshang and yangqu become low falling tone 31, both descending tones. "Yangping + yinshang/yangshang/yangqu" can be merged into one tonal position "24+21." Yinqu remains a mid-level rising tone with small amplitude. Both entering tones are relatively level, with tone values of 4, yinru slightly higher than yangru but with minimal difference. "Yangping + yinru/yangru" can be merged into one tonal category.

When the first syllable is yinshang, the semitone curves for disyllabic groups are as follows:

[4]The legend indicates the tone of the second syllable; the same applies below.

[Figure 7: see original paper] Semitone value curves for yinshang combined with various tones

Except before yinshang, where yinshang becomes a rising tone with small amplitude, it uniformly becomes a falling tone with value 43.

After yinshang, yinshang becomes low falling tone 21; yinping and yangping become falling tones with small amplitude, value 43; yangshang, yinqu, and yangqu all become rising tones with small amplitude, value 23. "Yinshang + yangshang/yinqu/yangqu" can be merged into one tonal position "43+23," which is consistent in pattern and height with the monosyllabic yinshang 534. Yinru becomes a short abrupt level tone 4, yangru becomes a short abrupt level tone 3. The pitch difference between the two entering tones here is small, but yinru remains higher than yangru.

When the first syllable is yangshang, the semitone curves for disyllabic groups are as follows:

[Figure 8: see original paper] Semitone value curves for yangshang combined with various tones

Yangshang in the first syllable position has two sandhi patterns: before ping and entering tones it becomes low falling tone 21, before shang and qu tones it becomes rising tone 34. After yangshang, yinping shows reduced amplitude and lower starting point, becoming falling tone 43; yangping becomes similar to yinping after sandhi. Yinshang, yangshang, yinqu, and yangqu all become low falling tone 21 after yangshang; yinru becomes short level tone 4; yangru becomes rising tone 34.

When yangshang combines with yinping/yangping and yinru/yangru, the sandhi results are similar to those of yangping combined with these same tones, and can be merged into respective tonal positions. "Yangshang + yinshang/yangshang/yinqu/yangqu" can be merged into one tonal position "23+21," consistent in pattern and height with monosyllabic yangshang 231.

When the first syllable is yinqu, the semitone curves for disyllabic groups are as follows:

[Figure 9: see original paper] Semitone value curves for yinqu combined with various tones

Yinqu in the first syllable position has two readings. Before shang and qu tones it reads as slightly rising 45, consistent in pattern with citation tone 34 and similar in height. Before ping and entering tones it becomes falling tone 43. After yinshang, yinping and yangping are falling tones with small amplitude, transcribed as 43. Yinru is short level tone 4, yangru slightly lower. All four shang and qu tones read as relatively low falling tones, though with some differences in starting height. "Yinqu + yinping/yangping" is consistent in value with the earlier "yinshang + yinping/yangping" and can be merged into one tonal category. "Yinqu + yinru/yangru" is consistent with the earlier

"yinshang + yinru/yangru" and can be merged into one tonal category. When "yinqu + yinshang/yangshang/yinqu/yangqu," the second syllable becomes low falling tones of varying heights that do not form contrasts, and can be merged into one tonal category "45+21."

When the first syllable is yangqu, the semitone curves for disyllabic groups are as follows:

[Figure 10: see original paper] Semitone value curves for yangqu combined with various tones

Yangqu uniformly becomes low falling tone 21 in the first syllable position. After yangqu, yinping becomes falling tone 43, yangping slightly lower than yinping. Yinru after yangqu becomes short level tone 4, yangru slightly lower with rising amplitude. All four shang and qu tones after yangqu uniformly become rising tone 23.

Yinping, yangping, yinru, and yangru after yangqu have the same values as after yangping and yangshang, and can be merged into respective tonal positions "21+43" and "21+4." "Yangqu + yinshang/yangshang/yinqu/yangqu" have consistent values and can be merged into one tonal position "21+23," consistent in pattern and height with monosyllabic yangqu 213.

When the first syllable is yinru, the semitone curves for disyllabic groups are as follows:

[Figure 11: see original paper] Semitone value curves for yinru combined with various tones

Yinru uniformly becomes short falling tone 43 in the first syllable position. After yinru, yinping shows reduced amplitude and lower starting point, with tone value 43; yangping is slightly lower than yinping but with minimal difference. Both yinru and yangru become relatively high short level tones 4. All four shang and qu tones after yinru read as falling-rising tone 323. "Yinru + yinping/yangping" can be merged into one tonal position "43+43," where the first syllable changes from a contour tone to a falling tone and the second syllable' s yinping amplitude is reduced while yangping becomes similar to yinping. "Yinru + yinru/yangru" can be merged into one tonal position "43+4," with both syllables undergoing sandhi. "Yinru + yinshang/yangshang/yinqu/yangqu" have consistent values and can be merged into one tonal position "43+323," consistent in pattern and height with monosyllabic yinru [5].

When the first syllable is yangru, the semitone curves for disyllabic groups are as follows:

[Figure 12: see original paper] Semitone value curves for yangru combined with various tones

[5]This curve appears quite different from monosyllabic yinru 4, but as shown in the chart in section 4.2.4, yinru is actually a slight falling-rising tone. Therefore, consistency is considered here.

Yangru uniformly becomes slightly falling short tone 2 in the first syllable position. After yangru, yinping and yangping both become falling tone 32; yinru and yangru both become short level tone 3, with yinping slightly higher than yangping and yinru slightly higher than yangru. "Yangru + yinping/yangping" can be merged into one tonal position "2+43," and "yangru + yinru/yangru" into "2+4." All four shang and qu tones become falling-rising tones, though the falling portion is not obvious and its lowest point does not reach below "1." However, to reflect the tonal pattern, it can be described as 213. "Yangru + yinshang/yangshang/yinqu/yangqu" have consistent values and can be merged into one tonal position "2+213," consistent in pattern and height with monosyllabic yangru 213.

5.3 Summary

Tone sandhi in Haimen dialect is complex, with no disyllabic words remaining unchanged. Typically, either the second syllable undergoes sandhi or both syllables change. Some changes involve only slight modifications in amplitude or height, while others change tonal pattern, often exceeding the monosyllabic tonal system. Extensive tonal neutralization occurs. After neutralization, disyllabic tones can be summarized into a limited number of patterns, as shown in 6.2.

6.1 Monosyllabic Tone Patterns

Haimen dialect' s monosyllabic tone patterns can be summarized as 8 patterns (Table 8). Among them, there are 6 smooth tones and 2 checked tones. The high checked tone is yinru (4), the low is yangru (213).

There are 2 rising tones: yangping (15) with large rising amplitude, and yinqu (34) with small amplitude, close to a level tone. Among smooth contour tones, there are 2 concave tones: high yinshang (534) and low yangqu (213). There is 1 convex tone: yangshang (231).

6.2.1 Pattern Quantity and Distribution

Based on the above analysis, Haimen dialect has 18 disyllabic tone patterns, as follows [6]:

1) 54+32 (yinping+yinping, yinping+yangping)

2) 43+43 (yinshang+yinping, yinshang+yangping, yinqu+yinping, yinqu+yangping)

3) 43+43 (yinru+yinping, yinru+yangping)

[6]Patterns 12 (24+21) and 14 (23+21) have similar values with stable differences in articulation, but may tend to merge perceptually, requiring further experimental verification.

4) 54+3 (yinping+yinru, yinping+yangru)

5) 43+4 (yinshang+yinru, yinshang+yangru, yinqu+yinru, yinqu+yangru, yangqu+yinru, yangqu+yangru)

6) 43+4 (yinru+yinru, yinru+yangru)

7) 21+43 (yangping+yinping, yangping+yangping, yangshang+yinping, yangshang+yangping, yangqu+yinping, yangqu+yangping)

8) 2+43 (yangru+yinping, yangru+yangping)

9) 21+4 (yangping+yinru, yangping+yangru, yangshang+yinru, yangshang+yangru, yangqu+yinru, yangqu+yangru)

10) 2+4 (yangru+yinru, yangru+yangru)

11) 54+21 (yinping+yinshang, yinping+yangshang, yinping+yinqu, yinping+yangqu)

12) 24+21 (yangping+yinshang, yangping+yangshang, yangping+yangqu)

13) 43+23 (yinshang+yangshang, yinshang+yinqu, yinshang+yangqu)

14) 23+21 (yangshang+yinshang, yangshang+yangshang, yangshang+yinqu, yangshang+yangqu)

15) 45+21 (yinshang+yinshang, yinqu+yinshang, yinqu+yangshang, yinqu+yinqu, yinqu+yangqu)

16) 21+23 (yangping+yinqu, yangqu+yinshang, yangqu+yangshang, yangqu+yinqu, yangqu+yangqu)

17) 43+323 (yinru+yinshang, yinru+yangshang, yinru+yinqu, yinru+yangqu)

18) 2+213 (yangru+yinshang, yangru+yangshang, yangru+yinqu, yangru+yangqu)

Their distribution is as follows:

Yinping Yangping Yinshang Yangshang Yinqu Yangqu Yinru Yangru
Table 7 Distribution of 18 disyllabic tone patterns in Haimen dialect

6.2.2 Types of Disyllabic Tone Patterns

Based on the above analysis, we find that Haimen dialect' s disyllabic tones show two significantly different categories depending on whether the second syllable

is a "ping/ru tone" or a "shang/qu tone." When the second syllable is a shang or qu tone, it can be further divided based on whether the first syllable' s tone is a contour tone.

When the second syllable is a shang or qu tone, tonal neutralization occurs mainly on the second syllable. If the first syllable is a non-contour tone, the first syllable' s tonal amplitude is reduced (yinping and yangping) or its value slightly rises (yinqu), while the second syllable becomes low falling tone 21. This yields the formula: X + shang/qu → X + 21.

If the first syllable is a contour tone, the tonal pattern and height of the disyllabic word with first syllable X are consistent with the monosyllabic tone X pattern. This demonstrates that Haimen dialect' s tone sandhi, like other Northern Wu dialects, exhibits a "tone envelope" phenomenon, which some scholars (such as Wang Hongjun 1999) call "feature-spreading sandhi" [7]. Wang Hongjun (1999) notes that "feature-spreading sandhi" is characterized by "syllables after the first in the sandhi domain lose their original tonal pattern, and the first syllable' s tonal pattern spreads across all moras in the sandhi domain according to certain linking rules." For example, the monosyllabic tone "yangqu" has the value "213," while the disyllabic tone "yangqu + yinshang/yangshang/yinqu/yangqu" has the value "21+23." This disyllabic pattern is generated by: the second syllable loses its original citation tone, and the tonal features of the preceding yangqu 213 are distributed across the two syllables of the disyllabic unit, with the first half of the contour tone (21) assigned to the first syllable and the second half (23) to the second syllable.

Exceptions to this pattern are the combinations "yinshang + yinshang" and "yangping + yinqu," which according to the rules should become patterns 13 and 12 respectively, but actually read as patterns 15 and 16. This represents the manifestation of "cross-pattern sandhi" [8]. "Yinshang + yinshang" should pattern-wise be pattern 13, but actually crosses into pattern 15. "Yangping + yinqu" should be pattern 12, but actually reads as pattern 16.

When the second syllable is a ping or ru tone, tonal neutralization occurs on both syllables. In this case, yin tones in the first syllable uniformly become high falling tones, while yang tones become low falling tones. In the second syllable, yinping and yangping merge, as do yinru and yangru.

The sandhi of the first syllable is as follows:

Original tone: Yinping Yinshang Yinqu Yinru Yangping Yangshang Yangqu Yangru

[7]The "features" in "feature-spreading" are "tonal features," a concept from generative phonology referring to "level tones of single pitch values" (Wang Hongjun 1999:233). "Each Arabic numeral in the five-point scale corresponds to a tonal feature of single pitch value" (Wang Hongjun 1999:239).

[8]This is the manifestation of "cross-pattern sandhi." "Yinshang + yinshang" should pattern-wise be pattern 13, but actually crosses into pattern 15. "Yangping + yinqu" should pattern-wise be pattern 12, but actually reads as pattern 16.

Sandhi result: 54 43 45 43 21 23 21 2

The sandhi of the second syllable is as follows [9]:

Original tone: Yinping Yangping Yinru Yangru
Sandhi result: 43 (32) 43 (32) 4 (3) 4 (3)

7. Conclusion

The Haimen dialect has eight lexical tones, with the following monosyllabic tone values: yinping 15, yangping 51, yinshang 534, yangshang 241, yinqu 34, yangqu 231, yinru 4, yangru 213.

The Haimen dialect has 18 disyllabic tone patterns, as follows:

Yinping Yangping Yinshang Yangshang Yinqu Yangqu Yinru Yangru
54+32 43+43 43+43 21+43 54+21 45+21 43+23 45+21
43+323 24+21 21+23 24+21
34+21 21+23 2+213

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

[9]The "32" for ping tones and "3" for entering tones only appear after yinping.