Proceedings of 3rd International Conference on Interdisciplinary Humanities and Communication Studies
DOI: 10.54254/2753-7064/63/20242562

An Acoustic Analysis on Mono-Syllabic Tones in the Ruian Wu Dialect

Xiaocao Lin[1,a,*]

[1]*Institute of Humanities, Zhejiang Normal University, Jinhua, China*
a. 18867714748@163.com
**corresponding author*

Abstract: The Ruian dialect, part of the Oujiang branch of Wu Chinese, is situated at the intersection of the Yangtze River Delta and the Pearl River Delta regions. It is generally accepted that this dialect has eight distinct tones. Previous studies primarily employed traditional methods of auditory transcription, leading to discrepancies in tone values and contours, and lacking the necessary precision for an objective tonal system description.This study focuses on the Ruian dialect and conducts an acoustic study on speech samples from three generations of participants—elderly, middle-aged, and young—describing their tonal patterns. The study concludes that the tonal systems of the elderly and middle-aged participants are generally stable, with the following tonal patterns: Yinping 阴平(44), Yangping 阳平(331), Yinshang 阴上(35), Yangshang 阳上(14), Yinqu 阴去(51), Yangqu 阳去(22), Yinru 阴入(323), and Yangru 阳入(212). In contrast, the younger generation has seen a change in the Rusheng (入声), shifting from contour tones to falling tones, where the tone value of Yinru is 32 and Yangru's is 21.

Keywords: Wu Chinese, Ruian dialect, Mono-Syllabic, Acoustic Study.

1. Introduction

Ruian, situated along the southeastern coast of Zhejiang Province, lies at the junction of the Yangtze River Delta and the Pearl River Delta. The city's geographic coordinates range from 120°10′ to 121°15′ E and 27°40′ to 28°0′ N. It is bordered by the East China Sea to the east, Wencheng County to the west, Pingyang County to the south, and Wenzhou City to the north, with Qingtian County to its northwest. Ruian's landscape primarily consists of coastal hills, with the southern region forming part of the Nan'yan Mountain range, extending eastward to Da'ao Mountain. The Feiyun River traverses the region from west to east. [1] The Ruian dialect is part of the Oujiang subgroup of Wu Chinese and exhibits minimal internal variation compared to other Oujiang dialects in southern Zhejiang. Its synchronic differences primarily occur between the eastern and western townships. [2] It is commonly recognized that the Ruian dialect contains eight distinct tones: Yinping, Yangping, Yinshang, Yangshang, Yinqu, Yangqu, Yinru, and Yangru. [3-5] Table 1 summarizes tonal data from various studies on the Ruian dialect. While the descriptions of Yangping, Yinshang, and Yangqu tones are consistent across sources, variations exist in the tone values of Yinping, Yinqu, Shang tones, and Ru tones. Notably, there are differences in the description of the Yangshang tone: Chen's study describes it as a rising-falling tone with a value of 214, while Zhang and Xu describe it as a falling tone with values of 24 and 13, respectively.

DOI: 10.54254/2753-7064/63/20242562

Table 1: Ruian Dialect Tone Values Recorded in Different Studies.

Tone / Source	Yinping	Yangping	Yinshang	Yangshang	Yinqu	Yangqu	Yinru	Yangru
Ruian Dialect Pronunciation Dictionary（2004）[3]	44	31	35	24	42	22	323	212
Chen Haifang（2009）[4]	55	31	35	214	53	22	434	323
Zhejiang Dialect Resource Collection: Ruian（2019）[5]	44	31	35	13	53	22	323	212

Previous studies relied on the traditional method of "auditory transcription," which cannot objectively and accurately capture subtle phonetic nuances. The limited number of participants used in these studies introduces randomness and makes it difficult to fully represent the tonal system of the Ruian dialect. This raises two key questions: Can acoustic study provide a more precise depiction of the tonal patterns in the Ruian dialect? And do tonal patterns vary across different age groups of participants? In this study, we employ acoustic methods to minimize errors caused by researcher subjectivity and to gather accurate, objective acoustic data. Research has shown notable age-related tonal variations in Wu dialects [6,7]. To provide a more complete picture of the dialect, this study, guided by the perspective of sociolinguistic variation, collects tonal data from male and female participants across three generations: elderly, middle-aged, and young. The tonal patterns of the Ruian dialect for males and females in each generation are described separately. The findings are then compared with previous research results to observe tonal variations in the Ruian dialect.

2. Study Design

2.1. Survey Scope and Participants

The subjects of this acoustic study are participants of the Ruian urban dialect, which includes the dialects spoken in the original Chengguan Town, as well as suburban villages such as Lingxia, Zhou'ao, Dongyong, and Baiyanqiao. To examine the tonal differences across participants of different ages and genders, 46 residents from the Ruian urban area were selected, ensuring that their birthplace, place of upbringing, and current residence are all within the Ruian city limits. The sample maintains a 1:1 gender ratio, with 12 participants in the elderly group, 18 in the middle-aged group, and 16 in the young group. The survey was conducted in 2024, with the elderly participants aged 60-90 years at the time of the survey, middle-aged participants aged 35-59 years, and young participants aged 18-34 years.

DOI: 10.54254/2753-7064/63/20242562

2.2. Survey Corpus

The survey wordlist was based on the eight tones of the Ruian dialect, each divided into three groups. Each group consisted of minimal pairs where the initials and finals were the same, but the tones differed. The wordlist was derived from the *Dialect Survey Wordlist* [8], and the actual pronunciation characteristics determined the final set of research words. For polyphonic or polysemous characters, appropriate phrases or explanations were provided (Table 2).

Table 2: Wordlist for the Acoustic Study of Mono-syllabic Tones in the Ruian Dialect.

Tone	Wordlist		
Yinping	丹(red)	叭 (an onomatopoeic word that simulates the sound of a horn)	低 (low)
Yangping	痰(phlegm)	排 (arranged in rows, as in 一~)	提 (holding something with a ring, handle, or noose in your hand)
Yinshang	胆(gallbladder)	摆 (put things on display)	底(the bottom part)
Yangshang	淡(tasteless)	罢(generally at the end of a sentence, indicating completion)	弟 (younger brother)
Yinqu	担 (carrying pole, as in 扁~)	拜(etiquette to show respect)	帝 (the supreme deity in Western religions, as in 上~)
Yangqu	弹 (a projectile that is ejected with elastic force, as in 子~)	败(fail)	地 (ground, as in 土~)
Yinru	搭(place on a support)	百(hundred)	的 (target Center, as in 目~)
Yangru	达 (reach, as in ~到)	白 (white)	敌(enemy)

2.3. Data Collection and Analysis

The study was conducted in soundproofed residential buildings in Ruian City. The recording used an external sound card (Yamaha UR22c), a microphone (SAMSON GT3), and the Praat software developed by Paul Boersma and David Weenink, with the Chinese localization and modifications provided by Bei Xianming and Xiang Ning. The sampling rate was set to 44,100 Hz, with a 16-bit depth, and recordings were made in mono. To prevent inertia caused by the continuous reading of words with the same tone category, the research words were read aloud in isolation, two times each, with a roughly 2-second interval between repetitions. The recordings were saved in Windows PCM (*.wav) format.

Acoustic analysis of the wordlist was conducted using Praat software. Each word's fundamental frequency (F0) was measured at 9 evenly distributed points, and the average F0 values were calculated for the three groups within each tonal category.

The F0 data were normalized using T-value formula, where the T-value for each measurement point was converted into a five-point scale. The formula is as follows[9]:

$$T = [(\lg x - \lg b) / (\lg a - \lg b)] * 5 \quad (1)$$

DOI: 10.54254/2753-7064/63/20242562

A T-value between 0 and 1.0 corresponds to a scale 1 on the five-point scale, 1.0 to 2.0 corresponds to scale 2, 2.0 to 3.0 to scale 3, 3.0 to 4.0 to scale 4, and 4.0 to 5.0 to scale 5. Finally, a tone pattern diagram was generated, with sampling points plotted on the horizontal axis and five scales on the vertical axis. These graphs were used to compare tone patterns across participants of different ages and genders.

3. Study Results

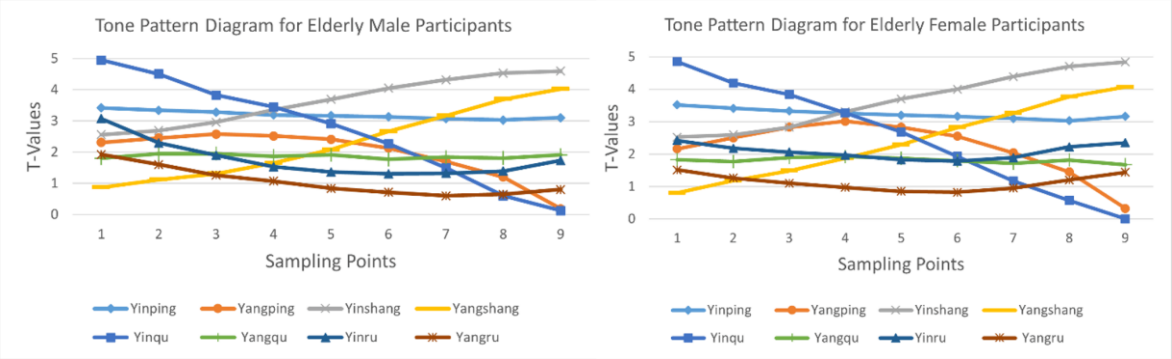

Figure 1: Tone Pattern Diagram for Elderly Male and Female Participants.

Figure 1 illustrates the tone pattern diagrams for elderly male and female participants.

Yinping: The curve shows a slight dip initially, followed by a slight rise, with the overall change remaining within scale 1, all within scale 4. Audibly perceived as a level tone, it is transcribed as 44.

Yangping: The curve displays a convex shape. It starts within scale 3 and ends within scale 1. For the male group, the rise is less than 1, with the inflection point located on scale 3, transcribed as 331. For the female group, the inflection point is on scale 4, different from the males, and is transcribed as 341.

Yinshang: The curve rises smoothly, starting in scale 3 and ending in scale 5, transcribed as 35.

Yangshang: The curve rises smoothly, beginning in scale 1 and ending between scale 4 and scale 5. Based on auditory perception, it is transcribed as 14.

Yinqu: The curve shows a smooth descending pattern, starting on scale 5 and ending on scale 1, transcribed as 51.

Yangqu: The curve is a level tone located in scale 2, transcribed as 22.

Yinru: The curve forms a concave arch, starting in scale 3, with the inflection point on scale 2 and ending in scale 3, transcribed as 323.

Yangru: The curve forms a concave arch, starting in scale 2, with the inflection point on scale 1 and ending in scale 2, transcribed as 212.

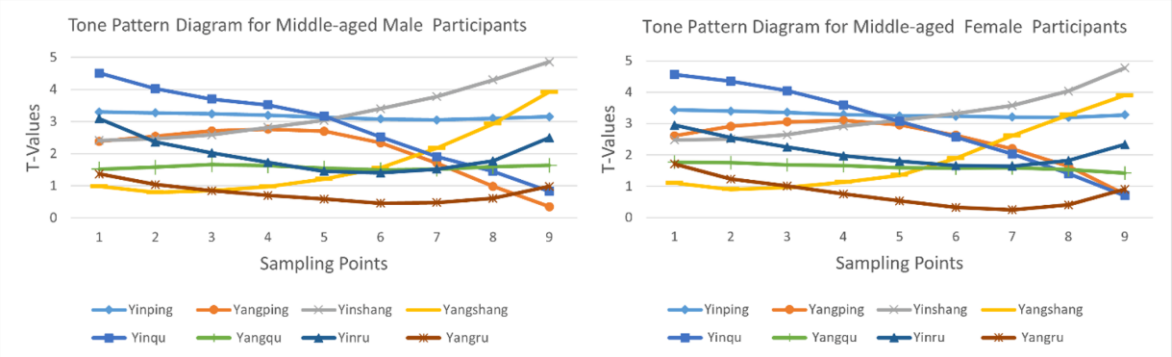

Figure 2: Tone Pattern Diagram for Middle-aged Male and Female Participants.

DOI: 10.54254/2753-7064/63/20242562

Figure 2 depicts the tone pattern diagrams for middle-aged male and female participants.

Yinping: The curve initially dips slightly, followed by a minor rise. The overall change is less than 1 and remains within scale 4. The tone is perceived as a level tone and is transcribed as 44.

Yangping: The curve forms a convex shape, beginning within scale 3 and ending within scale 1. For the male group, the rise is less than 1, with the inflection point located within scale 3, transcribed as 331. For the female group, although the inflection point lies within scale 4, the rise is still less than 1, and it is also transcribed as 331.

Yinshang: The curve shows an overall rise, with a smaller increase in the first half and a larger one in the second half. It starts within scale 3 and ends within scale 5, transcribed as 35.

Yangshang: The curve initially dips slightly before rising, with the rise starting small and becoming larger towards the end. It begins within the intersection of scales 1 and 2, and ends within scale 4, with a fall of less than 1. The tone is perceived as a rising tone and is transcribed as 14.

Yinqu: The curve shows an overall descent, with a smaller decline in the first half and a larger one in the second half. It starts within scale 5 and ends within scale 1, transcribed as 51.

Yangqu: The curve remains flat within scale 2 and is transcribed as 22.

Yinru: The curve forms a concave shape, starting within scale 3, with the inflection point in scale 2, and ending within scale 3, transcribed as 323.

Yangru: The curve also forms a concave shape, starting within scale 2, with the inflection point and the endpoint located within scale 1. The rise is less than 1, and the final rise in tone is perceptually non-essential, transcribed as 21.

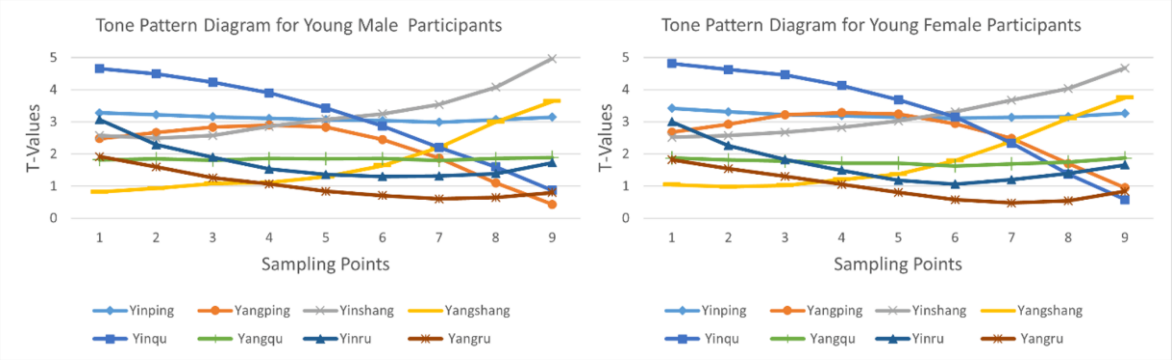

Figure 3: Tone Pattern Diagram for Young Male and Female Participants.

Figure 3 displays the tone pattern diagrams for young male and female participants.

Yinping: The curve shows a slight dip initially, followed by a slight rise. The overall change is less than 1 and remains within scale 4. The tone is perceived as level and is transcribed as 44.

Yangping: The curve forms a convex shape, starting on scale 3 and ending on scale 1. For the male group, the rise is less than 1, with the inflection point located on scale 3, transcribed as 331. In the female group, the inflection point is on scale 4, resulting in a tonal difference, transcribed as 341.

Yinshang: The curve rises overall, with a smaller increase in the first half and a larger one in the second half. It starts within scale 3 and ends on scale 5, transcribed as 35.

Yangshang: For the male group, the curve shows a rise, with a smaller increase in the first half and a larger increase in the second half. It begins on scale 1 and ends on scale 4, transcribed as 14. For the female group, the curve initially dips slightly before rising, with a small rise at first, followed by a larger one. It starts at the intersection of scales 1 and 2 and ends on scale 4, with a dip of less than 1. The tone is perceived as rising, transcribed as 14.

Yinqu: The curve shows an overall decline, with a smaller descent in the first half and a larger descent in the second half. It starts on scale 5 and ends on scale 1, transcribed as 51.

Yangqu: The curve remains flat within scale 2 and is transcribed as 22.

DOI: 10.54254/2753-7064/63/20242562

Yinru: The curve forms a concave shape, starting on scale 3, with both the inflection point and the endpoint located in scale 2. The rise is less than 1, and the final rise is not necessary for perception, transcribed as 32.

Yangru: The curve also forms a concave shape, starting on scale 2, with the inflection point and the endpoint on scale 1. The rise is less than 1, and the final rise is not necessary for perception, transcribed as 21.

Through the acoustic analysis of tones in the Ruian dialect, a complete table of monosyllabic tone values for male and female participants across three generations was obtained (Table 3).

Table 3: Monosyllabic Tone Values of Ruian Dialect.

Group / Tone	Elderly Male	Elderly Female	Middle-aged Male	Middle-aged Female	Young Male	Young Female
Yinping	44	44	44	44	44	44
Yangping	331	341	331	331	331	341
Yinshang	35	35	35	35	35	35
Yangshang	14	14	14	14	14	14
Yinqu	51	51	51	51	51	51
Yangqu	22	22	22	22	22	22
Yinru	323	323	323	323	32	32
Yangru	212	212	21	21	21	21

4. Discussion

4.1. Internal Comparative Analysis

The tone values and contours of Yinping, Yinqu, and Yangqu tones have remained unchanged, indicating a relatively stable pattern within the Ruian dialect.

Yangping, Shangsheng, and Rusheng's tone patterns vary. To assess their tone values further, the duration of these tones was measured. The resulting table of monosyllabic tone durations for Yangping, Shangsheng, and Rusheng across three generations of male and female participants is presented in Table 4.

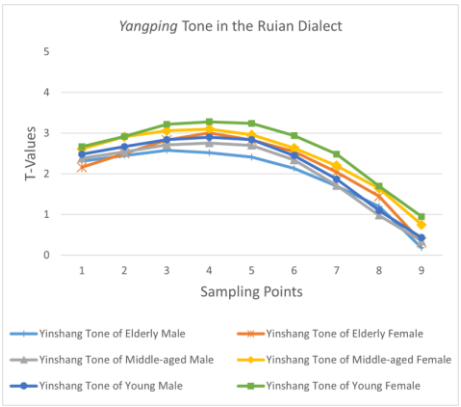

Figure 4: Yangping Tone in the Ruian Dialect.

According to Figure 4, the *Yangping* tone exhibits a convex arch shape. The tone fluctuations in the *Yangping* tone for female participants are more pronounced than for male participants. For male participants, the tone range increases progressively with age. However, no significant differences in

DOI: 10.54254/2753-7064/63/20242562

the duration of the *Yangping* tone were observed between male and female participants. The duration for female participants ranged from 300 to 350 ms, while for male participants, it ranged from 240 to 300 ms. Therefore, the *Yangping* tone for both male and female participants is transcribed as 331.

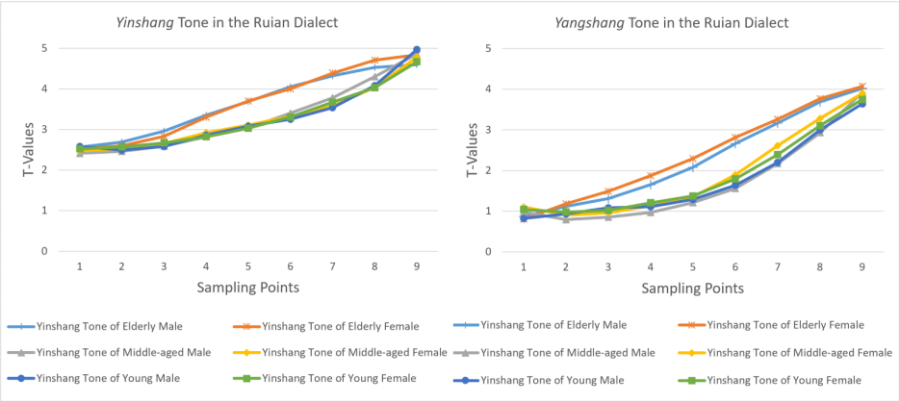

Figure 5: Yinshang Tone and Yangshang Tone in the Ruian Dialect.

From the *Shangsheng* tones in Figure 5, it can be seen that the tone values and contours for *Yinshang* and *Yangshang* have not changed. However, the contour shape varies with age. The elderly group displays a smooth rising curve, while both the middle-aged and young groups show a gradual rise followed by a faster ascent. The duration of the *Yinshang* tone ranges from 250 to 290 ms, and the *Yangshang* tone ranges from 280 to 310 ms. There were no significant differences in duration for the *Shangsheng* tones, thus *Yinshang* is transcribed as 35 and *Yangshang* as 14.

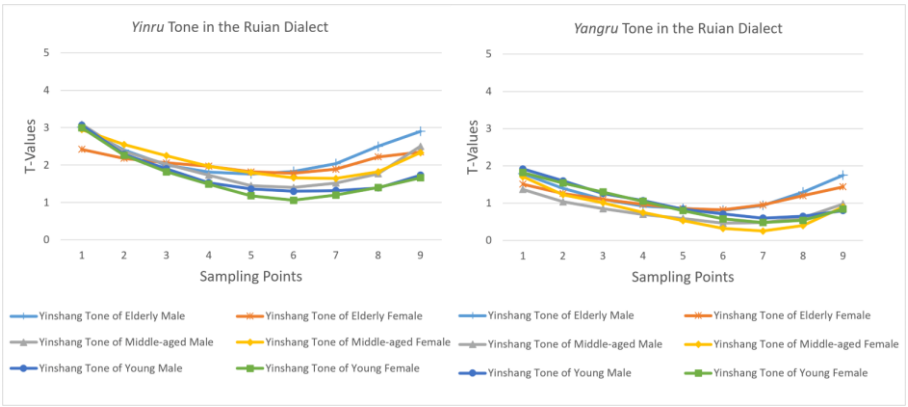

Figure 6: Yinru Tone and Yangru Tone in the Ruian Dialect.

From the tone curves in Figure 6, *Rusheng* tone exhibits a convex arch shape. As age decreases, the tone fluctuations also become smaller. The duration of *Rusheng* tone for young male participants ranges from 230 to 250 ms, while for young female participants, it ranges from 310 to 340 ms, shorter than that of elderly and middle-aged participants. The tone curves for young male and female participants largely overlap, leading to the transcription of *Yinru* and *Yangru* tones in the elderly and middle-aged groups as rising-falling tones, with tone values of 323 and 212, respectively. In the younger group, these tones have shifted to falling tones, with tone values of 32 for *Yinru* and 21 for *Yangru*. The characteristic of the upturning of the tonic tail is more obvious in the elderly, which is consistent with Zhu Xiaonong's observation [10]. However, this study shows that the young people's glottal stop is not obvious, and the phenomenon of glottal stop weakening occurs, which is in the evolvement of vanishing of tail vowels in entering tone.

DOI: 10.54254/2753-7064/63/20242562

Table 4: Monosyllabic Tone Durations in the Ruian Dialect (ms).

	Yangping	Yinshang	Yangshang	Yinru	Yangru
Elderly Male	248	271	292	376	362
Elderly Female	334	258	287	425	422
Middle-aged Male	289	267	286	314	277
Middle-aged Female	312	286	309	369	326
Young Male	297	276	281	244	236
Young Female	327	269	297	332	313

In this dialect, the tone patterns for *Pingsheng*, *Shangsheng*, and *Qusheng* are generally consistent across participants. However, there are clear age-related differences in the *Rusheng* tones, with the younger generation shifting from complex contour tones to falling tones. Therefore, when selecting participants, it is crucial to distinguish between older and newer variants of the dialect to obtain a comprehensive understanding of its tonal system.

4.2. Comparative Analysis with Previous Studies

A comparison between this acoustic analysis of the Ruian dialect and previous research (Table 3) reveals notable differences in both tone values and tone contours.

The Yinping tone (44) corresponds with Zhang and Xu's findings and is similar to the 55 tone documented by Chen.

The Yangping tone (331) shows a significant deviation from the previously recorded value of 31. The tone contour in this study exhibits a convex arch. Based on the tone duration and native speaker perception, it is classified as a level-falling tone (331).

The Yinshang tone (35) and the Yangqu tone (22) align closely with earlier records.

The Yangshang tone (14) is similar to Zhang's 24 and Xu's 34, but it differs considerably from Chen's 214. In this study, no significant contour pattern was observed for the Yangshang tone.

The Yinqu tone (51) is closer to Zhang's 42, while it differs from Chen and Xu's recordings of 53.

The Yinru tone (323) and Yangru tone (212) for elderly and middle-aged participants align with the values recorded by Zhang and Xu, and are comparable to Chen's Yinru (434) and Yangru (323). This study revealed that the younger generation's Rusheng has shifted from rising-falling tones to falling tones, with the Yinru tone now having a value of 32 and the Yangru tone a value of 21.

It is important to emphasize that differences in survey locations and participants can significantly influence the description of tonal patterns. The survey in A Study of the Phonology of the Ruian Dialect was conducted solely in Chengguan Town, while Zhejiang Dialect Resource Collection: Ruian covered not only Chengguan Town but also several suburban villages, including Lingxia, Zhou'ao, Dongyong, and Baiyanqiao. The participants in both studies were divided into two age groups: middle-aged adults (35–59 years) and elderly individuals (60 years and above). However, Ruian Dialect Pronunciation Dictionary does not specify its survey locations or the demographics of its participants, making it difficult to account for the potential influence of regional and speaker variation on the tonal descriptions. This lack of clarity may result in misinterpretations when comparing findings across studies.

5. Conclusion

It is generally accepted that the Ruian dialect contains eight tonal categories. However, discrepancies in the tone values of Yinping, Yinqu, Shangsheng, and Rusheng have been observed across various studies. Additionally, there are significant differences in the tone value and contour of Yangshang.

DOI: 10.54254/2753-7064/63/20242562

Chen described Yangshang as a rising-falling tone with a tonal value of 214, whereas Zhang and Xu classify it as a falling tone with values of 24 and 13, respectively. The reliance on traditional "auditory transcription" methods and the limited number of participants in previous research likely contributed to these variations, introducing potential bias and making it difficult to capture the tonal system of the Ruian dialect fully. Based on sociolinguistic and acoustic study methods, this study analyzes the tonal patterns of male and female participants across three generations, providing a more comprehensive depiction of the Ruian dialect's tonal system. The study identifies eight distinct tonal categories in the Ruian dialect: Yinping, Yangping, Yinshang, Yangshang, Yinqu, Yangqu, Yinru, and Yangru. The tone values for Yinping (44), Yinqu (51), and Yangqu (22) show consistency across age and gender groups, indicating stability in these tones. The Yangping tone exhibits a convex shape, with a greater tone variation observed in female participants than males. For male participants, the tone variation increases progressively with age. However, due to the lack of significant differences in tone duration between genders, the Yangping tone is uniformly classified as a level-falling tone (331). For Yinshang (35) and Yangshang (14), the tone rise is gradual in the first half and more pronounced in the second half for middle-aged and younger participants. However, these variations do not differ significantly from those of the elderly participants in terms of tone values.

The Rusheng for elderly and middle-aged participants displays a rising-falling pattern, with tone values of 323 and 212, respectively. Among younger participants, these tones have shifted to falling tones, with Yinru valued at 32 and Yangru at 21. This research employs acoustic and sociolinguistic methods to provide an objective analysis of the tonal system of the Ruian dialect, offering a detailed depiction of its tonal system. By adopting a sociolinguistic approach, the study also explores the potential for documenting dialectal variations and provides valuable data for future research on the tonal system of the Ruian dialect.

References

[1] *Ruian City People's Government Website [EB/OL]. (2020-08-21) [2024-08-05]. https://www.ruian.gov.cn/art/2020/08/21/art-1229230397-54752451.html*

[2] *Yan Yiming. Southern Zhejiang Ou Dialect [M]. Shanghai: East China Normal University Press, 2000.*

[3] *Compiled by Zhang Yongkai and the Office of Cultural Heritage Protection and Management of Ruian City. Dictionary of Ruian Dialect Pronunciations [M]. Shanghai: Shanghai Academy of Social Sciences Press, 2004.*

[4] *Chen Haifang. A Study on the Phonetics of Ruian Dialect [D]. Zhejiang University, 2008.*

[5] *Xu Lili. Zhejiang Dialect Resource Collection: Ruian [M]. Hangzhou: Zhejiang University Press, 2019.*

[6] *Zhang Jingwei. Empirical Analysis of Synchrony Sound Change Paths: A Sociophonetic Study of Tone Variation in Wu Dialect [J]. Language Science, 2019, 18(06):581-595.*

[7] *Xu Yun, Huang Caiyu, Wang Yan. Research and Analysis of Mono-Syllablic Tones in Changzhou Dialect [J]. Journal of Changzhou Institute of Technology (Social Sciences Edition), 2019.*

[8] *Institute of Linguistics, Chinese Academy of Social Sciences. Dialect Investigation Word List (Revised Edition) [M]. Beijing: Commercial Press, 1981.*

[9] *Shi Feng. Tone Analysis of Two-Syllable Words in Tianjin Dialect [J]. Language Research, 1986.*

[10] *Zhu Xiaonong, Jiao Lei, Yan Zhicheng. Three ways of Rusheng sound change [J]. Studies of the Chinese Language, 2008.*

Appendix

Appendix 1: Participants

Male Participants			Female Participants		
No.	Age	Residence	No.	Age	Residence
M1	89	Yuhai Street	F1	78	Dongshan Street
M2	80	Dongshan Street	F2	71	Yuhai Street
M3	74	Anyang Street	F3	68	Jinhu Street

DOI: 10.54254/2753-7064/63/20242562

Appendix 1: (continued)

M4	72	Yuhai Street	F4	68	Anyang Street
M5	64	Yuhai Street	F5	62	Anyang Street
M6	61	Yuhai Street	F6	61	Yuhai Street
M7	56	Yuhai Street	F7	58	Yuhai Street
M8	47	Yuhai Street	F8	54	Anyang Street
M9	46	Yuhai Street	F9	47	Anyang Street
M10	46	Dongshan Street	F10	46	Yuhai Street
M11	45	Yuhai Street	F11	43	Yuhai Street
M12	45	Anyang Street	F12	42	Yuhai Street
M13	44	Anyang Street	F13	41	Yuhai Street
M14	40	Anyang Street	F14	40	Dongshan Street
M15	38	Yuhai Street	F15	39	Yuhai Street
M16	31	Jinhu Street	F16	33	Jinhu Street
M17	29	Jinhu Street	F17	28	Anyang Street
M18	27	Yuhai Street	F18	27	Yuhai Street
M19	27	Anyang Street	F19	26	Yuhai Street
M20	26	Yuhai Street	F20	24	Anyang Street
M21	23	Jinhu Street	F21	21	Jinhu Street
M22	23	Yuhai Street	F22	20	Anyang Street
M23	21	Dongshan Street	F23	19	Jinhu Street