Reduction in Dali Nisu tone change-in-progress

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Abstract

In this paper, reduction as a key mechanism in diachronic tone change is illustrated through an apparent-time study of tone changes-in-progress in Dali Nisu, a Tibeto-Burman minority language spoken in southwest China. 26 native speakers of Dali Nisu (11 female, 15 male) participate in a tonal production experiment. Linear mixed effects modelling results show that three reduction changes are in progress: 1) high level tone lowering, 2) low rising tone flattening, and 3) low falling tone flattening. As a result of (1) and (3), overall tonal range is decreasing. Voicing of syllable-initial consonants interact with the reduction changes: the magnitude of the reduction effect seen among younger, more educated speakers depends on voicing of the initial consonant. This case study provides a snapshot of tone change-in-progress, showing that tonal reduction is an important mechanism shaping tone change in syllable-tone languages.

Index Terms: tone change, reduction, coarticulation, apparent time, change-in-progress

1. Introduction

Understanding of the mechanisms underlying tonogenesis, the birth of tone, has advanced considerably since Haudricourt's seminal work [1]. However, tonogenetic mechanisms of segment-pitch and phonation-pitch transphonologization cannot fully account for the complex development of tonal systems, especially in East and Southeast Asia. Most studies of tone change look to language contact, perceptual (dis)similarity, and segment/phonation interactions with pitch to explain tone change, e.g., [2]-[4]. This paper argues that tonal coarticulation and reduction are also important mechanisms shaping the directionality of tone change in syllable-tone languages (i.e., in which a single tone maps onto a single syllable). Segmental and tonal coarticulatory effects on tonal onsets tend to extend rightward through the syllable (resulting in "wave pattern" changes); pitch movements in the tonal offset tend to reduce in magnitude and duration ("line pattern" changes). This coarticulatory path to tone change [5] results in a cyclical directionality: low level > falling > high level or rising-falling > rising > low level or falling-rising (see Figure 1). Another significant line pattern change is reduction of level tones to mid. Both wave and line patterns of directionality, among others, were first discovered by Zhu [6], though described in different terms; the mechanisms behind these patterns were first described in [7]-[9].

Cross-linguistically, assimilatory carry-over effects show greater magnitude and duration than anticipatory effects [10]-[11]; the dominance of rightward assimilation pushes tonal onsets and tonal offsets to show complementary behavior in diachronic change. The differential behavior of tonal onsets and offsets follows Beddor's [5] coarticulatory path to sound change, in which the temporal extent of the coarticulatory effect and source vary inversely: as the effect increases, the source decreases. Coarticulatory effects, which most strongly affect tonal onsets, tend to become extended and enhanced over time (wave pattern). For example, a low tonal offset's depression of a following syllable's high tonal onset creates a rising trajectory, which may then become phonologized as part of the tonal target. Diachronic tone splits are usually explained via segment-pitch transphonologization, for example the "voiced-low" principle, i.e., voiced initial consonants depress pitch [4]. This paper's findings suggest that segment-pitch coarticulation does not operate independently from tonal coarticulation and reduction, but rather interacts with them in interesting ways.

A recent typological review [12] examines what types of phonetic tone change occur most often in syllable-tone languages. Studies with two methodological approaches are included: 1) apparent-time studies and 2) across-time studies, that is, analyses of tonal systems that compare their findings with previous (usually decades ago) analyses of the same dialect. The database comprises a total of 58 studies on 52 syllable-tone language varieties from the Sinitic, Tai-Kadai, Hmong-Mien, and Tibeto-Burman language groups, with 51 apparent-time studies and 7 across-time comparative studies. 112 occurrences of tone change in the review are categorized into 34 types of change (e.g., "low level > mid level"). Figure 1 summarizes the most commonly occurring tone changes, representing 91 change occurrences (88% of the 112 occurrences). Red lines represent line pattern changes (reduction), while black lines represent wave pattern changes (extension and enhancement of tonal coarticulatory effects).

The cross-linguistic review of ongoing tone change reveals a dominant, though not absolute, directionality cycle in which low > falling > high > rising > low, etc. (Figure 1). The gradual diachronic changes in pitch trajectory result in a repeating transverse wave that at times flattens out to level. Wave pattern and line pattern changes occur with roughly the same frequency (wave changes account for 52% of the changes reported and reduction for 36%). Even studies that point to language contact [2] or segment-pitch coarticulation [13] as motivating forces report changes that follow these patterns. Conversely, changes that were not conditioned by segments also show wave and line pattern changes. This suggests that segment-pitch coarticulation may in fact play a subsidiary role in tone change, with tonal coarticulation and reduction playing the more dominant role in influencing directionality of change.

Tones in unstressed or post-focus syllables, the most likely place for reduction to occur, tend to have lower mean pitch, flatter pitch contours, and shorter duration [14]-[15]. Zhang

10.21437/TAL.2018-10

[16] finds that contour tones usually have longer duration and thus gravitate toward domain-final syllables; de Lacy [17] posits that low prominence and low pitch tend to attract each other. Non-final non-heads, therefore, tend to introduce tonetic variants that are flatter and lower. In fast and/or reduced speech, tonal range is often narrower than in careful speech [18]. Diachronically, this contextual variation can result in 1) contour reduction [7] (mostly through reducing the pitch movement in the tonal offset) and 2) level tones' convergence on mid. In Figure 1, the mid level tone appears relatively inert, an attractive target for other tones but reluctant to move itself. As mid requires minimal articulatory effort, a low level tone raising to mid level (attested in Guangzhou Cantonese [19]) could be considered a form of reduction, even though it involves the overall raising of pitch.

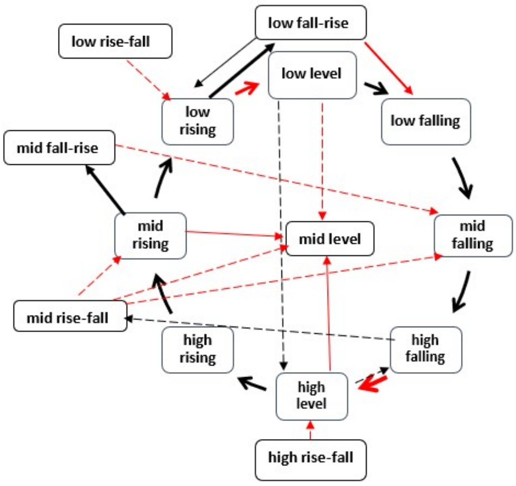

Figure 1: *Commonly occurring tone changes. Red represents line pattern changes. Thicker lines represent more frequently reported changes. Adapted from [12].*

Another evident pattern in Figure 1 is the tendency for pitch movements in tonal offsets to reduce to zero. Tonal reduction includes reducing the magnitude and/or *duration* of the pitch movement used to approximate a tonal target. As coarticulatory effects extend later and later in the syllable, pitch movements in offsets get pushed right off the end of the syllable. Sometimes, especially in rapid speech, pitch articulators are unable to execute a pitch movement by the end of the syllable, creating tonetic variants without the offset movement realized [20]. For example, the rise of a low rising tone may not be completed by the end of the syllable, creating a variant more like low level. Since native speakers of syllable-tone languages are conditioned to expect the entire tone, including the pitch movement of the offset, to map onto a single syllable [21], they may be biased to eventually select the offset-less variant as the exemplar.

This paper further illustrates the effects of the reduction mechanism in diachronic tone change through an apparent-time study of tone change in Dali Nisu, a Yi minority language spoken in Yunnan, China. The apparent-time study on Dali Nisu shows four changes-in-progress that are most reasonably explained by reduction: 1) high level tone lowering, 2) low rising tone flattening, 3) low falling tone flattening, and 4) as a result of the above changes, tonal range is decreasing.

2. Apparent-time study of Dali Nisu tone change-in-progress

Dali Nisu is a previously undocumented Ngwi (Loloish, Tibeto-Burman) language spoken in Dali Prefecture, Yunnan Province, China. There are approximately 20,000 speakers; however, Nisu linguistic vitality is threatened: urbanization among young speakers is leading to increasing bilingualism in Chinese and less use of Nisu in daily life. In Dali Nisu, each syllable is specified for one of four tone categories: high level (55), mid level (33), low falling (21) and low rising (13). The purpose of this study is to test four hypotheses about reduction changes in Nisu: 1) the high level tone (Tone 55) is lowering, 2) the low rising tone (Tone 13) is flattening, 3) the low falling tone (Tone 21) is also flattening, and 4) the overall tonal range is decreasing. These changes are occurring as a function of age and/or other social factors such as gender and education.

2.1. Material and Procedures

Data was gathered during two field trips in January 2016 and August 2016 to Tuanjie District, Dali Bai Autonomous Prefecture, Yunnan Province, China. 26 native Nisu speakers, 11 female and 15 male, took part in a production experiment. Subjects' ages range from 16 to 85 years, with an average age of 38.3 years and median age of 30 years. Education levels range from 0 to 16 years, with males having an average of 9.9 years and females an average of 6.9. Nisu speakers' access to education has dramatically improved in the last decades; only speakers younger than 40 years old attend more than 9 years of school. Education in this area is conducted entirely in Standard Mandarin (SM), never in Dali Nisu. Years of education therefore approximate intensity of exposure to SM.

The production task consisted of pronouncing 66 Nisu words three times in citation form and three times in a carrier phrase. 63 of the words were monosyllabic and 3 were disyllabic; voiced, voiceless unaspirated and voiceless aspirated initial consonants were elicited in equal proportions, to uncover possible effects of initial voicing on pitch. Number of words for each tone category were fairly evenly distributed (18 high level words, 17 mid level, 10 low falling, and 21 low rising).

Subjects were recorded in their own homes using a Sony Linear PCM recorder (PCM-M10) at a sample rate of 48.00 kHz. Subjects were asked to give the Nisu word when prompted in Chinese; all subjects had listening ability in Standard Mandarin and were able to complete this task easily. The first author annotated all three citation forms, leaving carrier phrase forms for later investigation. For each token, the tone bearing unit (the vowel) was manually segmented in Praat [22]. F0 was then extracted using a Praat script [23] that measured F0 at 10 millisecond intervals. Tokens were normalized for duration on a 200-point relative time scale, normalized for pitch with speaker mean pitch as the baseline, and converted to logarithmic semitones using R [24]. A total of 4,187 tone tokens were extracted, normalized and analyzed.

We test Hypotheses 1, 2 and 3 through linear mixed effects (LME) modelling using Rbrul [25], with Age, Education level, Gender, and Initial consonant voicing (voiced or voiceless) as fixed factors, and Speaker and Word as random factors. Interactions between factors are also tested, and any significant interactions are reported. For Hypothesis 1 (high level tone is lowering), Tone 55 peak is the dependent variable. For Hypothesis 2 (low rising tone flattening) and Hypothesis 3 (low falling tone flattening), pitch excursion is the dependent variable, defined as difference between the tonal onset (= semitone value at Time 1) and the tonal offset (=semitone value at Time 200). For Hypothesis 4 (tonal range decreasing), we define tonal range as the average of Tone 55 minus the average of Tone 21 for each speaker and use multiple regression modelling.

2.2. Results

The cross-generational differences in tone systems are illustrated through comparison of Figure 2, tone system of an 85 year old male speaker, and Figure 3, tone system of an 18 year old male speaker.

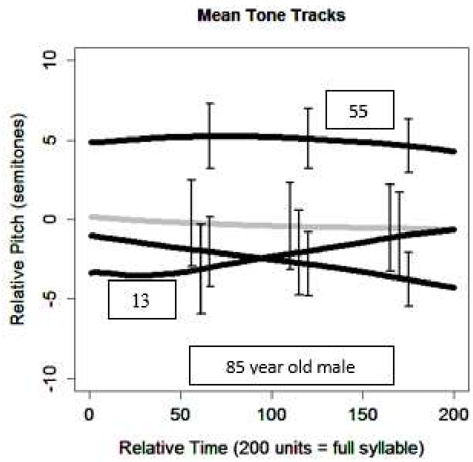

Figure 2: *Mean tone tracks for 85 year old male.*

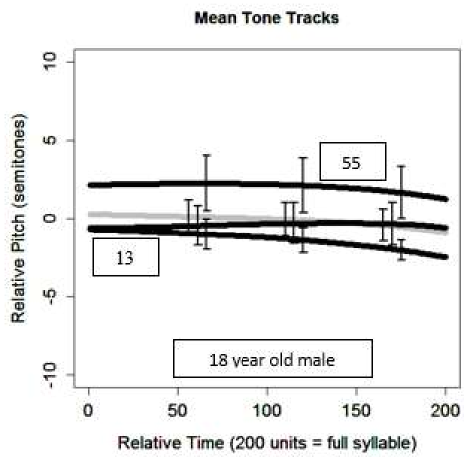

Figure 3: *Mean tone tracks for 18 year old male.*

In the younger speaker's tone system, Tone 55 is significantly lower, even partially overlapping with Tone 33, the mid level tone (Hypothesis 1). The younger speaker's Tone 13 trajectory has less pitch excursion than the older speaker (Hypothesis 2), and his Tone 21 trajectory also shows less excursion (Hypothesis 3). As a result of the above changes, the tonal range is decreasing (Hypothesis 4).

The results in Table 2 show that Tone 55's peak is indeed lowering among younger speakers; R^2 fixed = 0.116, R^2 random=.495. Age is the strongest predictor: for each +1 year increase in age, there is an increase of +0.0342 semitones. Education and Voicing interact: higher education levels predict peak lowering in syllables with voiceless initials (but not voiced). Figure 4 is the scatterplot of Tone 55 peak for all tokens versus Age. Syllables with voiced and voiceless initials are plotted separately to illustrate that Voicing does not interact with Age for Tone 55 (unlike Tones 13 and 21).

Table 1: *Linear mixed effects modeling results for Tone 55 peak. Significance codes: '***' = < 0.001; '**' = < 0.01 '*' = < 0.05 ; ' ' = > 0.05.*

Factor	Coefficient	Significance
Age	0.0342	p=0.00306**
Education*Voicing: +1:*voiceless*	-0.0279	p=0.00423**

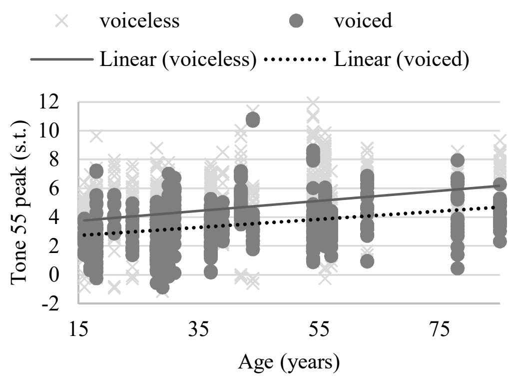

Figure 4: *Scatterplot with regression lines for Tone 55 peak versus Age in syllables with voiced or voiceless initial consonants.*

In Table 3, LME results show that only the interaction of Age and Initial Consonant Voicing is significant in Tone 13 excursion (R^2 fixed=0.114, random=0.376). We perform separate LME modelling on voiced-initial syllables versus voiceless, shown in Table 3. With voiced initials, every +1 year of Age predicts an increase of +0.0382 semitones in pitch excursion (R^2 fixed=0.201, random=0.328). With voiceless initials, Age has a smaller and less significant effect (R^2 fixed=0.074, R^2 random=0.376). Figure 5 gives the scatterplot for all tokens, with voiced and voiceless plotted separately to illustrate the interaction.

Table 2: *Linear mixed effects modeling results for Tone 13 pitch excursion.*

Condition	Factor	Coefficient	Significance
Both types	Age*Voicing: *+1: voiced*	0.00776	p=0.0014**
Voiced	Age	0.0382	0.000641***
Voiceless	Age	0.0249	0.0152*

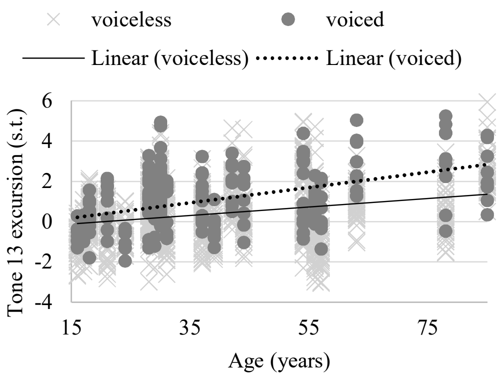

Figure 5: *Scatterplot with regression lines of Tone 13 pitch excursion versus Age in syllables with voiced or voiceless initial consonants.*

In Table 4, LME results show Tone 21 is also flattening: the difference between onset and offset is decreasing with decreasing age, but the effect only occurs in syllables with voiceless consonants; R^2 = 0.142, R^2 random= 0.290. We separately conduct LME modelling on voiced and voiceless initial syllables. For the voiced condition, there is no evidence of ongoing change (R^2 fixed=0.00659, R^2 random=0.330). But with voiceless initials, for every +1 year of Age there is a predicted increase of 0.0394 s.t. (R^2 fixed=0.174, R^2 random=0.338). Voiceless-initial syllables show a mean excursion of 3.79 semitones, but voiced-initial have a mean of only 2.823 semitones. Figure 6 gives the scatterplot and regression lines for Tone 21 pitch excursion versus Age, with voiced and voiceless initial syllables plotted separately to illustrate the interaction effect.

Table 4: *Linear mixed effects modeling results for Tone 21 pitch excursion.*

R^2	Factor	Coefficient	Significance
Both types	Age*Voicing: *+1: voiceless*	0.0149	p=0.0000000 0144***
Voiced	Age	0.00744	0.437
Voiceless	Age	0.0394	0.000715***

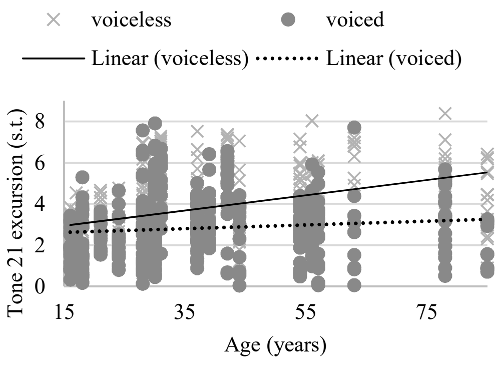

Figure 6: *Scatterplot and regression lines for Tone 21 pitch excursion versus Age in syllables with voiced or voiceless initial consonants.*

Finally, we test if tonal range is shrinking among young speakers. This is not an independent result, but rather the result of Tone 55 lowering and Tone 21 flattening. Age, gender, and education are the predictive factors in the multiple regression model. Our hypothesis is supported: age is the only significant factor (p = 0.00997), with R^2 = 0.230. For each +1 year of age, the range increases by 0.0494 semitones. Across our sample (16-85 years), the model estimates a total difference in tonal range of 3.41 semitones, which constitutes over half the mean tonal range of 5.85 semitones.

2.3. Discussion

Regression modelling results lead to rejection of the null hypotheses and suggest that Dali Nisu is undergoing the following line pattern changes-in-progress: 1) Tone 55 is lowering, 2) Tone 13 is flattening, 3) Tone 21 is flattening, and 4) therefore, overall tonal range is shrinking. For Tone 55 peak lowering, the effect of Education is contingent on voicing of the initial, with greater effect on voiceless-initial syllables. An Education effect suggests that contact with Standard Mandarin may be an indirect influence on Tone 55 lowering, since all schooling is conducted in SM. Significant interactions between Age and Voicing in Tone 13 and Tone 21 show that the magnitude of change depends on the voicing of the initial consonant: for the low rising tone, the change is occurring in voiced-initial syllables, but for the low falling tone, change is occurring in voiceless-initial syllables. In both cases, the condition that shows a larger mean excursion is decreasing with decreasing age. That is, the effect of initial consonants that resulted in increased pitch excursion in older generations no longer has the same effect among younger speakers. Each of the above changes reflects reduction in the magnitude of the pitch movement as speakers approximate tonal targets.

3. Conclusions

Tone change is complex and unpredictable, but not random or inexplicable., The changes described here, though striking, are by no means unique; low rise flattening has been documented in Chinese dialects such as Changsha [26] and Suzhou [27], and high level lowering has been found in Yueyang (Hunan) [28]. This paper demonstrates that reduction, an important mechanism of segmental sound change, is also influential in shaping tone change directionality. The changes in Dali Nisu show that the voicing of initial consonants interact with ongoing reduction changes. Reduction of pitch excursion in the low falling and low rising tones show similar patterns: the condition that formerly engendered the greatest excursion is the one that now shows the strongest reduction effect among younger speakers. This demonstrates the interplay between segmental coarticulation and reduction in tone change, a promising avenue of inquiry that deserves further attention.

4. Acknowledgements

The authors would like to thank the Dali Nisu speakers who participated in the experiment, especially to the host and teacher Yanfei Shi and her family.

5. References

[1] A.-G. Haudricourt, "De l'origine des tons en vietnamien," *Journal asiatique*, vol. 242, pp. 69–82, 1954.

[2] T. L-Thongkum, "Tone change and language contact: a case study of Mien-Yao and Thai," in *Southeast Asian Linguistics Studies In Honor of Vichin Panupong*, A. S. Abramson, Ed. Bangkok: Chulalongkorn University Press, 1997, pp. 153–160.

[3] M. X. Ming 明茂修, and X.C. Zhang 张显成, "试论汉语方言的调值格局及其演变机制 [The patterns and evolution mechanism of tone value of Chinese dialects]," 西南大学学报（社会科学版）[*Journal of Southwest University (Social Sciences Edition)*], vol. 41, pp. 145–192, 2015.

[4] A. S. Abramson and D. Erickson, "Tone splits and voicing shifts in Thai: phonetic plausibility," in *Pan-Asiatic Linguistics: Proceedings of the Third International Symposium on Languages and Linguistics, vol. 1*, Chulalongkorn University, Bangkok, 1992, pp. 1–16.

[5] P. S. Beddor, "A coarticulatory path to sound change," *Language*, vol. 85, no. 4, pp. 785–821, 2009.

[6] X. N. Zhu 朱晓农. "演化比较法：如何进行声调演化的研究? [The evolutionary comparative method: How to conduct studies of tonal evolution?]," 语言科学[*Linguistic Science*], in press 2018. doi: 10.7509/j.linsci.201703.031242.

[7] P. Pittayaporn, "Directionality of tone change," in *Proceedings of the 16th International Congress of Phonetic Sciences (ICPhS XVI)*, J. Trouvain and W. J. Barry, Eds. Saarbrücken, Germany: Saarland University, 2007, pp. 1421–1424.

[8] L. Carroll, "A diachronic chain shift in the sandhi tones of Jinhua Wu," presented at the Linguistics Student Association Colloquium, San Diego State University, 2010.

[9] C. Yang, "The sine wave pattern in tonal evolution," presented at the 9th International Conference in Evolutionary Linguistics, Yunnan Minzu University, 2017.

[10] Y. Xu, "Contextual tonal variations in Mandarin," *Journal of Phonetics*, no. 25, pp. 61–83, 1997.

[11] J. Zhang and J. Liu, "Tone sandhi and tonal coarticulation in Tianjin Chinese," *Phonetica*, pp. 161–191, 2011.

[12] C. Yang. "Wave and line: coarticulation and reduction in diachronic tone change." under review.

[13] C. Yang, J. N. Stanford, and Z. Yang, "A sociotonetic study of Lalo tone split in progress," *Asia-Pacific Language Variation and Change*, vol. 1, pp. 52–77, 2015.

[14] Y. Chen and C. Gussenhoven, "Emphasis and tonal implementation in Standard Chinese," *Journal of Phonetics*, vol. 36, pp. 724–746, 2008.

[15] L. Wang, B. Wang, and Y. Xu, "Prosodic encoding and perception of focus in Tibetan (Anduo Dialect)," presented at the Speech Prosody Sixth International Conference, Shanghai, China, 2012.

[16] J. Zhang, "The role of contrast-specific and language-specific phonetics in contour tone distribution," in *Phonetically Based Phonology*, B. Hayes, R. Kirchner, and D. Steriade, Eds. Cambridge: Cambridge University Press, 2004, pp. 157–190.

[17] P. de Lacy, "The interaction of tone and stress in Optimality Theory," *Phonology*, vol. 19, no. 1, pp. 1–32, 2002.

[18] R. Coto Salano, "Tonal reduction and literacy in Me̱'pha̱a Vááthá," PhD dissertation, University of Arizona, Tucson, 2017.

[19] J. Ou, "Tone merger in Guangzhou Cantonese," MA thesis, The Hong Kong Polytechnic University, Hong Kong, 2012.

[20] Y. Xu, "Fundamental frequency peak delay in Mandarin," *Phonetica*, vol. 58, pp. 26–52, 2001.

[21] Y. Xu, "Timing and coordination in tone and intonation—An articulatory-functional perspective," *Lingua*, no. 119, pp. 906–927, 2009.

[22] P. Boersma and D. Weenick, "Praat: doing phonetics by computer. Version 6.0.30," 2017.

[23] J. N. Stanford, "Procedure for extracting tones from Praat to txt file, normalizing in R, exporting to Excel," 2011.

[24] R Core Team, *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing, 2017.

[25] D. E. Johnson, "Getting off the GoldVarb standard: Introducing Rbrul for mixed-effects variable rule analysis," *Language and Linguistics Compass*, vol. 3, pp. 359–383, 2009.

[26] N. Xiang 向柠 and F. Shi 石锋, "长沙话单字调的声学实验与统计分析 [Experimental and statistical analysis of tones in Changsha dialect]," *语言研究 [Linguistics Study]*, vol. 27, pp. 53–58, 2007.

[27] X. M. Bei 贝先明, "苏州话阴阳调类的分组统计差异[The difference of statistical analysis between Yin tones and Yang tones in Suzhou dialect]. *湖州职业技术学院学报*[*Journal of Huzhou Vocational and Technological College*], pp. 44–48, 2011.

[28] W. He 何薇, "湖南省新派岳阳市方言语音及其社会变异研究 [The phonetic study and social changing of the new Yueyang dialect in Hunan Province]," MA thesis, Hunan Normal University, 2007.