Perception and Production of Tone Sandhi in Jino: An Acoustic Study

Zen Tiger

University of Oxford, UK

Abstract:

This study explores the perception and production of tone sandhi in Jino, a tonal language spoken in southwestern China, through an acoustic lens. Tone sandhi, the phenomenon where tones undergo changes based on their phonological context, is an integral feature of many tonal languages. Jino, with its rich tonal system, exhibits complex tone sandhi patterns that play a crucial role in both the lexical and syntactic structure of the language. This paper investigates how Jino speakers produce and perceive tone sandhi in various contexts, utilizing both acoustic measurements and perceptual experiments. Data were collected from native Jino speakers in natural speech conditions, and acoustic analysis was performed using Praat software to measure key features such as pitch contours, duration, and intensity. This study offers new insights into the interplay between perception and production in tonal languages, contributing to the broader understanding of tone sandhi and its phonetic and cognitive mechanisms.

Keywords: Jino language, tone sandhi, perception, production, acoustic analysis, pitch contours, tonal variation

I. Introduction:

Tone sandhi refers to the modification of tones in a language based on their phonological environment. In many tonal languages, tone sandhi occurs as a natural part of speech, where tones change to fit the prosodic and syntactic contexts in which they appear. Jino, a member of the Sino-Tibetan language family spoken in southwestern China, exhibits a rich tonal system characterized by a range of pitch contours[1]. The language has several lexical tones, and tone

sandhi plays a significant role in its phonological system, influencing both meaning and syntactic structure. Understanding tone sandhi in Jino is important because it provides insights into the dynamic and context-sensitive nature of tonal systems. Tone sandhi is not just a random alteration but is governed by specific rules based on syntactic structures, stress, and speech rate. In Jino, certain high tones neutralize to mid tones in fast speech or when occurring in specific syntactic positions, such as within a phrase or clause boundary. Additionally, tone sandhi can affect tone patterns at the level of individual words, influencing how speakers produce and perceive tones in connected speech[2]. One key aspect of tone sandhi in Jino is its interaction with syntactic structures. For example, syllables in phrase-final positions are often less likely to undergo sandhi, as these positions tend to be more prominent and stress-bearing. In contrast, syllables in non-final positions, especially when adjacent to other tones, are more likely to experience tonal shifts. This suggests that tone sandhi in Jino, like in many other tonal languages, interacts with prosodic features such as stress and intonation. In addition to syntactic structure, speech rate also influences the production of tone sandhi in Jino[3]. Faster speech tends to compress tonal distinctions, leading to the neutralization of contrasts between high and mid tones. Conversely, slower speech preserves these tonal distinctions more clearly, highlighting the dynamic relationship between tone, speech rate, and perception. The perception of tone sandhi is similarly context-dependent. Native speakers of Jino are adept at detecting tonal shifts, particularly when they occur in predictable environments, such as when high tones shift to mid tones in connected speech. However, the perception of tone sandhi can be affected by factors such as the clarity of the pitch contour, the presence of stress, and the syntactic role of the syllables in question. This study aims to investigate both the production and perception of tone sandhi in Jino. By employing acoustic analysis to examine pitch contours, syllable duration, and intensity, and combining this with perceptual experiments to assess how well speakers detect tonal variations in different contexts, the research provides a comprehensive view of how tone sandhi operates in Jino[4]. The findings will not only contribute to the phonetic understanding of Jino's tonal system but also offer insights into how tonal variation is processed by speakers of tonal languages.

II. Acoustic Analysis of Tone Sandhi in Jino: Production Data

The production of tone sandhi in Jino is characterized by significant tonal variation depending on the phonological context, including syntactic position, speech rate, and prosodic prominence[5]. To examine how tone sandhi is produced, we conducted acoustic analysis on speech samples from 12 native Jino speakers (6 males, 6 females). These participants were asked to produce sentences containing target words with different tonal environments, including both isolated words and words embedded in phrases. The data collection included two distinct speech rate conditions: one in which participants were instructed to speak slowly and another in which they were encouraged to speak more rapidly[6]. Using Praat, a widely used software for phonetic analysis, we extracted fundamental frequency (F0) contours, syllable durations, and intensity measurements from the recordings. These parameters were crucial for understanding the pitch variations and the neutralization processes involved in tone sandhi. For each target syllable, we tracked the F0 contour across different speech rate conditions, focusing on high, mid, and low tones to observe how they interacted with neighboring syllables. One of the primary findings of the acoustic analysis was that high tones often neutralized to mid tones in fast speech, particularly when the syllable occurred in the middle of a phrase[7]. This neutralization effect was more pronounced in connected speech, where rapid articulation compressed the pitch range, leading to less distinguishable tonal contrasts. In contrast, in slow speech, high tones maintained their distinct pitch contours, demonstrating that speech rate plays a significant role in the production of tone sandhi. Additionally, the analysis revealed that syllables in phrase-final positions exhibited more stable tonal contours. This finding suggests that final position syllables, which tend to be more prominent in speech, are less likely to undergo tonal shifts compared to syllables within the body of the phrase[8]. In particular, high tones at the end of a phrase were more likely to retain their pitch and not undergo the neutralization observed in other contexts. The syllable duration data further supported the claim that tone sandhi is influenced by speech rate. In fast speech, syllables involved in tone sandhi were significantly shorter in duration, which correlated with a more compressed pitch range. Conversely, in slow speech, syllables were longer, allowing for greater differentiation in pitch and tonal contrast. This study also found that tone sandhi in Jino is sensitive to the syntactic structure of the sentence. For example, syllables in initial positions or those within focused constituents maintained their original tonal

contours, while syllables in non-prominent positions, such as in the middle of a phrase or following a pause, were more likely to undergo tonal shifts[9].

III. Perception of Tone Sandhi in Jino: A Cognitive Perspective

While the production of tone sandhi has been the primary focus of this study, the perceptual aspect of tone sandhi is equally important for understanding how Jino speakers process tonal variation in natural speech[10]. To investigate the perception of tone sandhi, we conducted a series of perceptual experiments with the same group of native Jino speakers. The goal of these experiments was to assess how well speakers can identify tonal shifts in different syntactic and prosodic contexts, particularly those that involve tone sandhi. The perceptual tasks included both forced-choice identification tasks and discrimination tasks. In the forced-choice task, participants were presented with pairs of stimuli, one of which contained a tonal shift (i.e., tone sandhi) and the other which did not. The speakers were asked to identify whether the stimuli were the same or different in terms of tone[11]. In the discrimination task, participants listened to minimal pairs of words or sentences that differed only in terms of tone sandhi and were asked to judge whether the tone sandhi was present or absent. The results of the perceptual experiments showed that native Jino speakers are highly sensitive to tone sandhi, especially when the tonal shifts occur in predictable syntactic and prosodic contexts. Speakers were able to correctly identify tone sandhi in phrase-medial positions and in fast speech conditions where tonal neutralization typically occurs[12]. However, the ability to perceive tone sandhi was somewhat less accurate in less predictable contexts, such as when tonal shifts occurred in final positions or in slower speech conditions where tonal contrasts were clearer. Interestingly, the perception of tone sandhi was influenced by syntactic structure. When tone sandhi occurred in non-prominent positions (e.g., in the middle of a sentence or within a subordinate clause), it was more difficult for participants to detect the tonal change[13]. In contrast, when tone sandhi occurred in stressed or prominent positions (e.g., at the beginning or end of a sentence), speakers were more accurate in identifying the tonal shift. This finding underscores the role of prosodic prominence and syntactic position in both the production and perception of tone sandhi. The results also suggest that Jino speakers rely heavily on pitch contour cues to identify tone sandhi. When pitch contours were disrupted or

unclear due to reduced speech rate or other factors, the perception of tone sandhi decreased. This highlights the close relationship between the production and perception of tonal variation and the importance of clear pitch cues for accurate tonal identification[12].

Conclusion:

This study provides valuable insights into both the production and perception of tone sandhi in Jino, shedding light on the acoustic mechanisms behind tonal shifts and their perceptual processing. The findings indicate that tone sandhi in Jino is influenced by a variety of factors, including speech rate, syntactic structure, and prosodic prominence. In terms of production, speakers exhibit tonal neutralization in fast speech, with high tones shifting to mid tones in specific syntactic positions, particularly within phrases. In contrast, slower speech preserves more distinct tonal contours, especially in phrase-final and stressed positions. This research contributes to the broader understanding of tone sandhi processes and offers valuable insights for further studies on the phonetic and cognitive aspects of tonal systems in Sino-Tibetan languages. Future research could expand on these findings by exploring tone sandhi in other dialects of Jino or related languages and examining how these processes differ across various speech communities.

References:

- [1] Z. Xiaoyu, "Acoustic experimental study on the tone sandhi of the Jino language," *Linguistics of the Tibeto-Burman Area*, vol. 47, no. 2, pp. 254-283, 2024.
- [2] N. Hayashi, "The historical development of Youle Jino," *Senri ethnological studies,* 2009.
- [3] H. Andersen, "Sandhi and prosody: reconstruction and typology," *Sandhi phenomena in the languages of Europe,* pp. 231-248, 1986.
- [4] E. Zee and I. Maddieson, "Tones and tone sandhi in Shanghai: Phonetic evidence and phonological analysis," *UCLA working papers in phonetics,* vol. 45, no. 1, pp. 93-129, 1979.
- [5] N. HAYASHI, "A Sketch of Buyuan Jino Tones and Their Development," *神戸市外国語大学外国学研究*, vol. 83, pp. 21-36, 2012.
- [6] M. Y. Chen, *Tone sandhi: Patterns across Chinese dialects*. Cambridge University Press, 2000.
- [7] 林範彦 and ハヤシノリヒコ, "The Historical Development of Youle Jino," *Senri Ethnological Studies*, vol. 75, pp. 255-280, 2009.
- [8] J. Zhang and Y. Lai, "Testing the role of phonetic knowledge in Mandarin tone sandhi," *Phonology*, vol. 27, no. 1, pp. 153-201, 2010.

- [9] N. HAYASHI, "A Sketch of the Buyuan Jino Case-Marking System," *神戸外大論叢*, vol. 68, no. 2, pp. 181-202, 2018.
- [10] N. Hayashi, "Youle Jino adjectives and their semantic mapping," *神戸外大論叢*, vol. 64, no. 3, pp. 9-22, 2014.
- [11] Z. Qin, "The second-language productivity of two Mandarin tone sandhi patterns," *Speech Communication*, vol. 138, pp. 98-109, 2022.
- [12] N. Hayashi, "Origins of Jino Fricatives," *Bulletin of Chinese Linguistics,* vol. 8, pp. 61-77, 2015.
- [13] J. Zhang, Y. Lai, and C. Sailor, "Modeling Taiwanese speakers' knowledge of tone sandhi in reduplication," *Lingua*, vol. 121, no. 2, pp. 181-206, 2011.