Cross-dialectal perspective on the form and meaning relation: the case of Tone 3 sandhi

Yuxin Lu, Yu-Hsiang Tseng, R. Harald Baayen
University of Tübingen, Germany

https://doi.org/10.36505/TheLinguisticProceedings/2025/16/01/018/000678

Abstract

This study investigates the tonal realization of Tone 3 sandhi in spontaneous speech of Beijing and Taiwan Mandarin, focusing on whether it is influenced by word-specific and semantic factors. Using corpus data and Generalized Additive Mixed Models, we found complete neutralization between T2–T3 and T3–T3 tone patterns in both varieties. Nevertheless, words exhibited distinct "pitch signatures," with some showing similar pitch contours across varieties and others notable differences. Computational modeling using the Discriminative Lexicon Model further revealed that tonal contours can be predicted from contextual meaning with above-chance accuracy. These results suggest that tone realization is shaped not only by phonological structure but also by word-specific semantics and collocational preferences.

Keywords: tone 3 sandhi, GAMMs, form-meaning relation, word-specific tonal realization.

Introduction

Tone 3 sandhi is a phonological process that a Tone 3 becomes Tone 2 when it is followed by another Tone 3. In a recent study by Lu et al. (2025), disyllables with T3-T3 tone patterns were found to be completely neutralized with T2-T3 in spontaneous speech of Taiwan Mandarin. More importantly, words' meaning emerged as an important predictor of tonal realizations. The finding that semantics co-determines pitch realizations has also been found for two-syllable words with other tone patterns in Taiwan Mandarin (Chuang et al., 2025; Lu et al., 2025b). However, little is known about this in other varieties of Mandarin beyond Taiwan Mandarin.

The current study investigates how Tone 3 sandhi is realized in spontaneous speech, in both Beijing Mandarin and Taiwan Mandarin. Three main questions are addressed. First, does word-specific tonal realization also occur in Beijing Mandarin? Second, does Tone 3 sandhi also show complete neutralization in spoken Beijing Mandarin, as in Taiwan Mandarin? Third, if so, can the observed pitch contours be predicted from their meaning in context with above-chance accuracy?

Proceedings Phonetics 2025 Hong Kong: 16th International Conference on Linguistic Research and Applications

Data

The data of Beijing Mandarin come from the Beijing Corpus (Ruan et al., 2018), and the data of Taiwan Mandarin come from the Taiwan Mandarin Spontaneous Speech Corpus (Fon, 2004). Both datasets consist of naturally occurring conversational speech in unstructured interviews. F0 value was estimated over the entire syllables since the focus of the current study is on how pitch is realized on whole onomasiological words. Subsequently, we selected tokens with T2-T3 and T3-T3 tone patterns from both corpora (see Table 1). For more details on data selection, see Lu et al. (2025).

Table 1. Overview of tokens and word types in two datasets.

Place	Tone pattern	Tokens	Word types
Beijing	T2-T3	1291	23
Beijing	T3-T3	1096	34
Taiwan	T2-T3	1828	30
Taiwan	T3-T3	1239	33

Tonal realizations

We made use of Generalized Additive Mixed Models (Wood, 2017) to model pitch contours as a function of *normalized time, tone pattern, neighouring tones, gender, duration, word position, speaker,* and lastly, *word*. Two separate models were fitted to the data of Beijing and Taiwan Mandarin respectively. The GAMM analysis shows that there was no clear evidence for the difference in pitch contours between T2-T3 and T3-T3 for neither Beijing nor Taiwan Mandarin. Consistent with Lu et al. (2025), this suggests that T3-T3 is completely neutralized in both spoken Beijing and Taiwan Mandarin.

However, when we did not control for the effect of *word*, the tone sandhi in our data also appeared incomplete. This highlights the importance of word-level effects, namely, the words with the same tone patterns had their own "pitch signature". As shown in Figure 1, some words showed similar pitch contours across varieties, while others exhibited notable differences. These word-specific components were driven by word's semantics and collocational preferences. For example, 还有 (hai2you3, 'still have') was typically preceded by PAUSE and 然后 (*ran2hou4*, 'then') in both varieties. However, 可以 (*ke3yi3*, 'can'), which shows different pitch contours especially in the beginning of the syllable, was mostly preceded by PAUSE, 也 (*ye3*, 'also'), and 你 (*ni3*, 'you') in Beijing Mandarin, but mostly by PAUSE in Taiwan Mandarin.

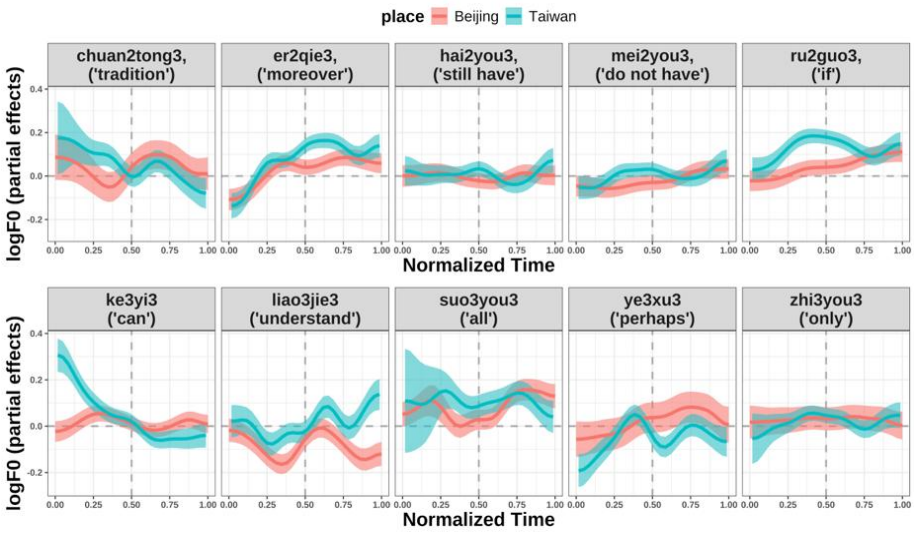

Figure 1. A selection of predicted pitch contours of words, estimated by factor smooth for word. In every panel, pitch contours are color-coded by place.

Computational modelling

To deepen our understanding of how pitch contours may be driven by semantics, we obtained semantic vectors presented by 896-dimensional contextualized embeddings from the Qwen-2.5 large language model. Furthermore, we made use of the Discriminative Lexicon Model (DLM, Heitmeier et al., 2025), a computational model focusing on the relationship between form and meaning. DLM was able to predict the pitch contours of word tokens from their meanings with the mean accuracy of 29.69% for Beijing data and 29.21% for Taiwan data (premuation baseline 10.30% and 10.44%). However, when we permuted the semantic vectors between Beijing and Taiwan Mandarin, the model's mean prediction accuracy dropped to 26.65% and 26.71% respectively.

Conclusion

The present study examined the pitch contours of T2–T3 and T3–T3 sequences in both Beijing and Taiwan Mandarin, and further investigated whether tonal contours could be predicted from words' meanings in context. First, we successfully replicated the findings of complete neutralization and word-specific tonal realizations in Taiwan Mandarin, originally reported by Lu et al. (2025a), using a slightly different dataset. Second, we extended these findings to Beijing Mandarin, showing that the word effect is robust across varieties. Third, we demonstrated that computational modelling can predict tonal contours from contextual

meaning with above-chance accuracy, suggesting a complex and nuanced interaction between tonal realization and semantics.

Note

1. The Hanyu Pinyin annotation of disyllables undergoing tone sandhi still follows the citation tones of each syllable in isolation for the ease of understanding, for example, *有点* is annotated as *you3dian3*.

References

Chuang, Y.-Y., Bell, M. J., Tseng, Y.-H., Baayen, R. H. 2025. Word-specific tonal realizations in Mandarin. Accepted for publication in Language. arXiv:2405.07006v2.

Heitmeier, M., Chuang, Y.-Y., Baayen, R. H. 2025. The Discriminative Lexicon: Theory and implementation in the Julia package JudiLing. Cambridge University Press. in press.

Lu, Y., Chuang, Y.-Y., Baayen, R. H. 2025. Form and meaning co-determine the realization of tone in Taiwan Mandarin spontaneous speech: the case of Tone 3 sandhi. arXiv preprint arXiv:2408.15747. Under Revision for Journal of Chinese Linguistics.

Lu, Y., Chuang, Y.-Y., Baayen, R. H. 2025. The realization of tones in spontaneous spoken Taiwan Mandarin: a corpus-based survey and theory-driven computational modeling. arXiv preprint arXiv:2503.23163. Accepted for publication in Corpus Linguistics and Linguistic Theory.

Ruan, F., Song, Q., Li, K., Hao, Y. 2018. Definition of corpus, scripts, standards and specifications of environment/speaker coverage for Mandarin languages. Technical report, Beijing Haitian Ruisheng Science Technology Ltd.

Wood, S. N. 2017. Generalized additive models: an introduction with R. CRC press.