

## Abstract

This study investigates and compares tonal coarticulation in Taiwan Mandarin and Taiwan Southern Min, two Sinitic languages with different sizes of tone inventory. Crucially, this study seeks to inquire whether tonal coarticulation is a universal constraint applied to all tone languages, or can be voluntarily controlled. Intuitively, languages with a larger number of tones may attempt to avoid tonal coarticulation as these languages are associated with higher possibilities of tonal confusion in tonal coarticulation. Alternatively, a lack of such avoidance would suggest such coarticulation is likely involuntary, and may be applied universally. Our results pointed to the second postulation. No differences of magnitude were found between coarticulation in the two languages. Another finding revealed that, both Taiwan Mandarin and Taiwan Southern Min demonstrated more symmetric distributions. Our results therefore suggest that while tonal coarticulation is likely a universal constraint, it may also be subject to language-specific factors, thus leading to the different distributions attested cross-linguistically.

## Background

Tone languages are found to have tonal coarticulation in continuous speech, where a lexical tone changes its F0 values in presence of a preceding or following tone.

### Distribution of tonal coarticulation

Two kinds of coarticulatory effects are categorized:

- Carry-over: Effects from preceding syllables, typologically stronger and assimilatory.
- Anticipatory: Effects from following syllables, typologically weaker and dissimilatory.

	Magnitude	Direction
Carry-over	Strong	Assimilatory
Anticipatory	Weak	Dissimilatory

- Asymmetric distribution is found typologically.
  - Such typological distribution is found in languages including Beijing Mandarin, Cantonese, Thai, and Vietnamese [1].
  - Some inconsistent results, however, have been found in languages like Taiwan Southern Min and Malaysian Hokkien, where the two languages were found to have more symmetric distributions (i.e., both carry-over and anticipatory effects being assimilatory) [1, 2].
- Leads to the debate of:  
Tonal coarticulation: is a universal constraint ↔ varies across languages.

### The nature of tonal coarticulation

**Stance 1** Tone variation under coarticulation is likely caused by articulatory constraints (e.g., [3]).

**Stance 2** Such variation may be manipulatable (e.g., [4])

### Tone inventories in Taiwan Mandarin & Taiwan Southern Min

	Number of tones	Possibility of perceptual confusion
Taiwan Mandarin	4	Low
Taiwan Southern Min	7	High

→ A comparison between Taiwan Mandarin and Taiwan Southern Min is a good testing ground for the two stances.

### Research questions

- How is tonal coarticulation manifested in TM and TSM, given that they have different sizes of tone inventory?
- Is tonal coarticulation universally applicable or language-specific?

## Methods

A production experiment was conducted to examine tonal coarticulation in Taiwan Mandarin and Taiwan Southern Min. The experiment quantified both carry-over and anticipatory effects in disyllabic words.

### Participants & stimuli

#### Participants

- 25 Taiwanese college students (15 females; 20–27 y.o., mean=22.64)
  - 14 Taiwan Mandarin monolingual
  - 11 Taiwan-Mandarin-Taiwan-Southern-Min bilingual

#### Stimuli

- One disyllabic word was chosen for each of the tone combinations
  - Taiwan Mandarin: 16 (4 tones×4 tones)
  - Taiwan Southern Min: 25 (5 tones×5 tones, with the two check tones excluded)
- 10 repetitions

### Pitch extraction

**Step 1** F0 values extracted using Praat [5], with the time step set at 0.01s.

**Step 2** F0 values divided into 11 proportions.

**Step 3** Mean of the F0 values in each proportion calculated.

**Step 4** Mean F0 values converted to z-transformed semitones for between-subject comparisons.

### Analyses

**Step 1** Pitch onsets and offsets calculated as the first and last of the 11 time points from each tone production.

**Step 2** Realized tones after sandhi labeled with a five-level scale.

**Step 3** F0 values fitted through linear mixed effect models (LMM).

In this study, a positive coefficient is regarded as indicator of assimilatory effects, whereas a negative one is regarded as indicator of dissimilatory effects.

## Results

Significant coarticulatory effects were found for both carry-over (Figure 1) and anticipatory (Figure 2) effects (all  $p$ 's<.001\*\*\*), and no differences of magnitudes of coarticulatory effects between Taiwan Mandarin and Taiwan Southern Min were found, be it carry-over or anticipatory ( $p$ =.31 and  $p$ =.65, respectively).

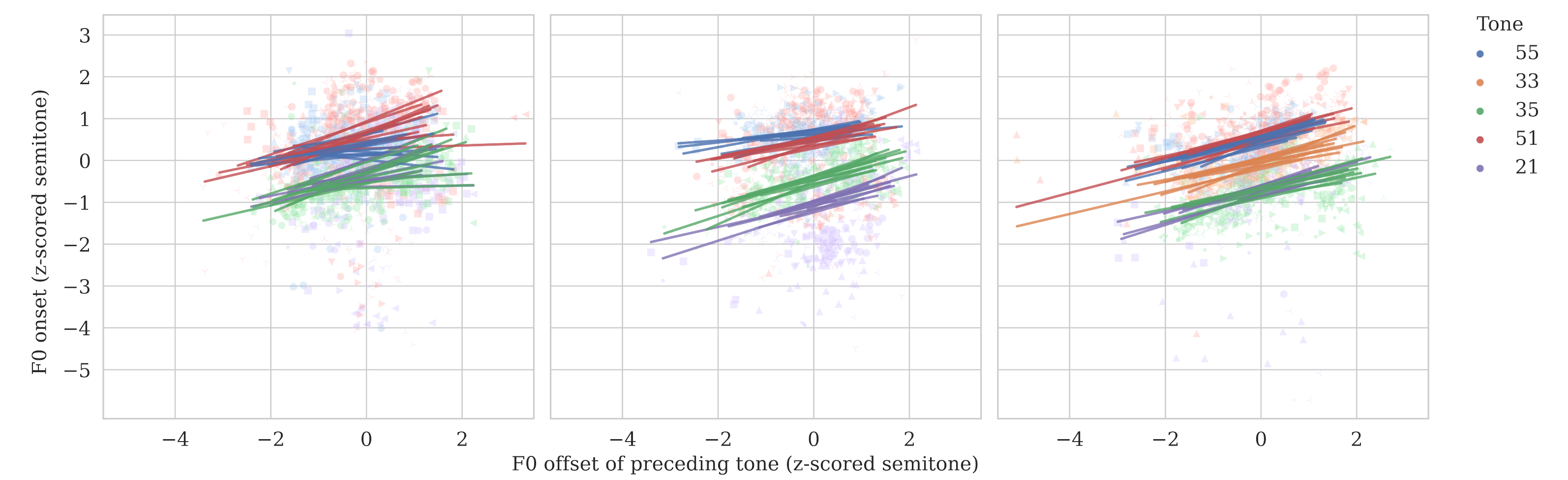


Figure 1. Results of fitted LMM models of tone onsets and offsets in carryover position (left: Taiwan Mandarin (monolingual); middle: Taiwan Mandarin (bilingual); right: Taiwan Southern Min).

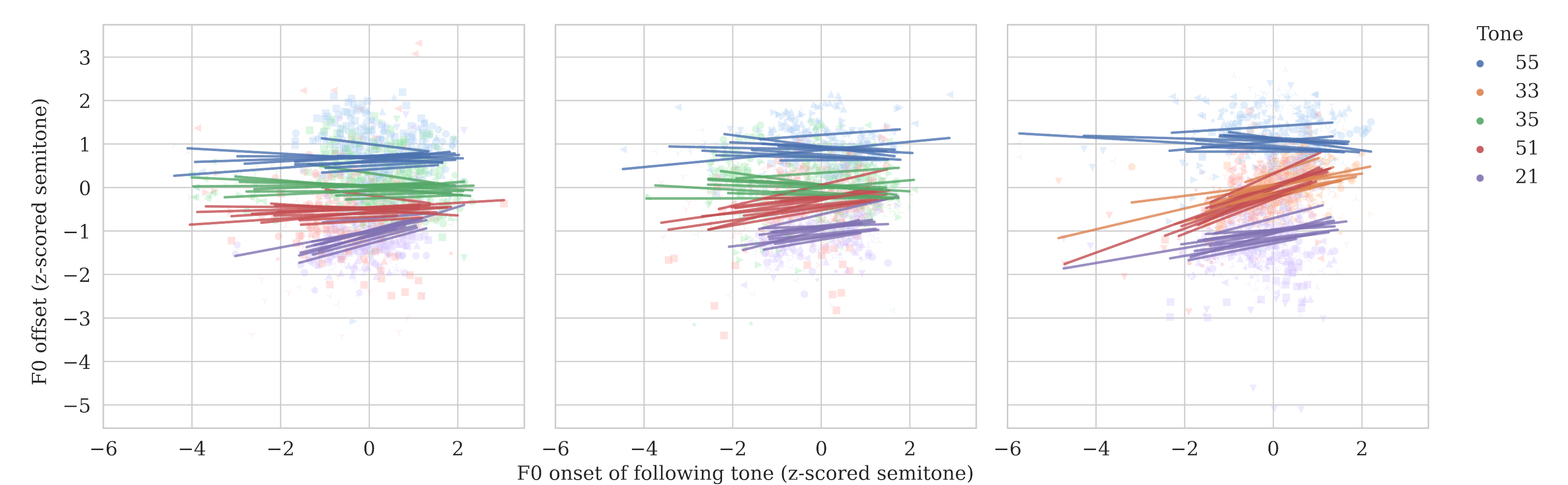


Figure 2. Results of fitted LMM models of tone onsets and offsets in anticipatory position (left: Taiwan Mandarin (monolingual); middle: Taiwan Mandarin (bilingual); right: Taiwan Southern Min).

### Distribution of tonal coarticulation in Taiwan Mandarin and Taiwan Southern Min

Contra previous findings in Beijing Mandarin, Taiwan Mandarin had more symmetric distribution, with both carry-over and anticipatory effects being assimilatory. This result is similar to that of Taiwan Southern Min, as summarized in Table 1. In addition, no differences were found between the Mandarin results of monolingual and bilingual speakers ( $p$ =.92 and  $p$ =.19, carry-over and anticipatory, respectively).

	Magnitude	Direction
Carry-over	Stronger	Assimilatory
Anticipatory	Weaker	

Table 1. Distribution of tonal coarticulation in Taiwan Mandarin and Taiwan Southern Min

## Discussion

### Tonal coarticulation as an involuntary universal constraint

The results in our study seem to support the view of [3] and others, which suggests that tonal coarticulation is likely to a large extent involuntary.

Taiwan Southern Min:

has higher possibility of confusing tones + still possesses comparable magnitude of tonal coarticulation as languages with smaller tone inventories

→ Such variation is likely not entirely voluntary.

**Effect of language-specific traits on tonal coarticulation:** asymmetry in Beijing Mandarin vs. symmetry in Taiwan Mandarin

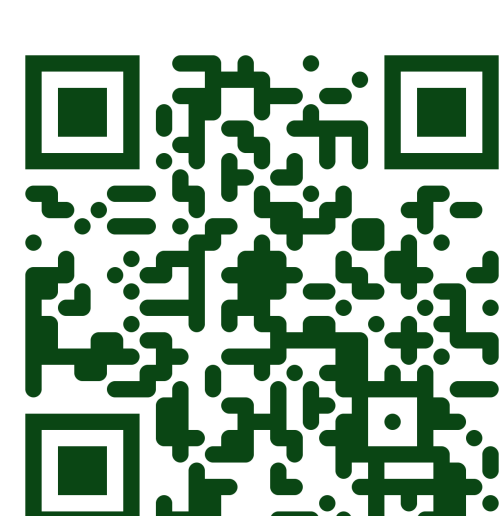
Possible explanation: Taiwan Mandarin may be influenced by Taiwan Southern Min, whose interaction with Taiwan Mandarin is attested frequently (e.g., [6]), resulting in the more symmetric distribution of tonal coarticulation attested.

## Conclusions

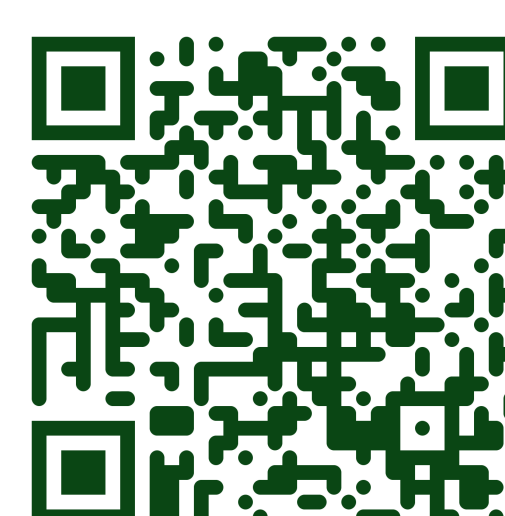
Overall, this study investigated tonal coarticulation in Taiwan Mandarin and Taiwan Southern Min, finding that both languages, despite the large size difference of tone inventory, had similar degree of coarticulation. This study is the first to investigate tonal coarticulation in Taiwan Mandarin, and to quantitatively compare coarticulated tones in two languages with different sizes of tone inventory. We hope to provide novel perspectives concerning the nature of coarticulation and tone variation.

## References

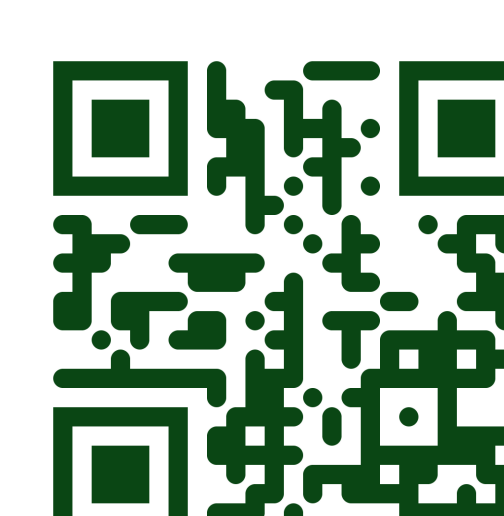
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