

Perception of Coarticulated Tones in Taiwan Mandarin and Taiwan Southern Min



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Background

Beijing Mandarin (BM) has been found to make use of normalization to deal with tonal coarticulation (TC)-induced tone variations [1, 2]:

The same surface tone is:

- perceived as **lower** when preceded by a **higher** tone offset.
- perceived as **higher** when preceded by a **lower** tone offset.

Therefore, a route from production to perception under TC is found for BM:

TC → target tone mistaken as another tone under TC-induced variations → retrieve the target through normalization.

However, two conditions may lead to different routes:

- Magnitude of TC.
- Different perceptual mechanisms.

Taiwan Mandarin (TM) & Taiwan Southern Min (TSM) as test cases

Factor 1 Possibility of tonal confusion (the larger the tone inventory, the more likely the confusion):

Tone inventory sizes:

- TM: 4 (55, 21, 51, 35)
- TSM: 7 (55, 33, 21, 51, 35, 54, 32)

→ TSM has a **higher** possibility of tonal confusion.

Factor 2 Recoverability of target tones:

Table 1. Mapping between intended target tones and coarticulated tones in TM (top) and TSM (bottom). The top row lists the coarticulated (surface) tones. Based on the carry-over and anticipatory effects, the intended target tones can be identified through normalization and filled in the corresponding cells. Impossible mappings between target and coarticulated tones are left blank. The apostrophes indicate that tone sandhi is applied.

TM	55	35	21(4)	51
Carry-over	Raising Lowering	T2 (35) T1 (55)	T4 (51)	T3 (21(4))
Anticipatory	Raising Lowering	T4 (51) T3 (21(4))	T2 (35)	T1 (55)
TSM	55	35	21	51
Carry-over	Raising Lowering	T5 (35) T7 (33)	T1 (55)	T3 (21) T7 (33)
Anticipatory	Raising Lowering	T3' (51) T1' (33)	T1' (33)	T7' (21) T2' (55)

→ TSM has a **lower** recoverability of target tones, due to the many-to-one mapping.

Two possibilities:

- TSM may have weaker TC to avoid TC-induced tone variations ← disfavored by previous studies [3]
- TSM may have weaker normalization for TC due to the lower recoverability, and may make use of **other** perceptual mechanisms. ← focus of the present study

Another possible mechanism: Tone acceptance ranges

In this study, we propose a novel mechanism to deal with TC-induced tone variations: tone acceptance ranges.

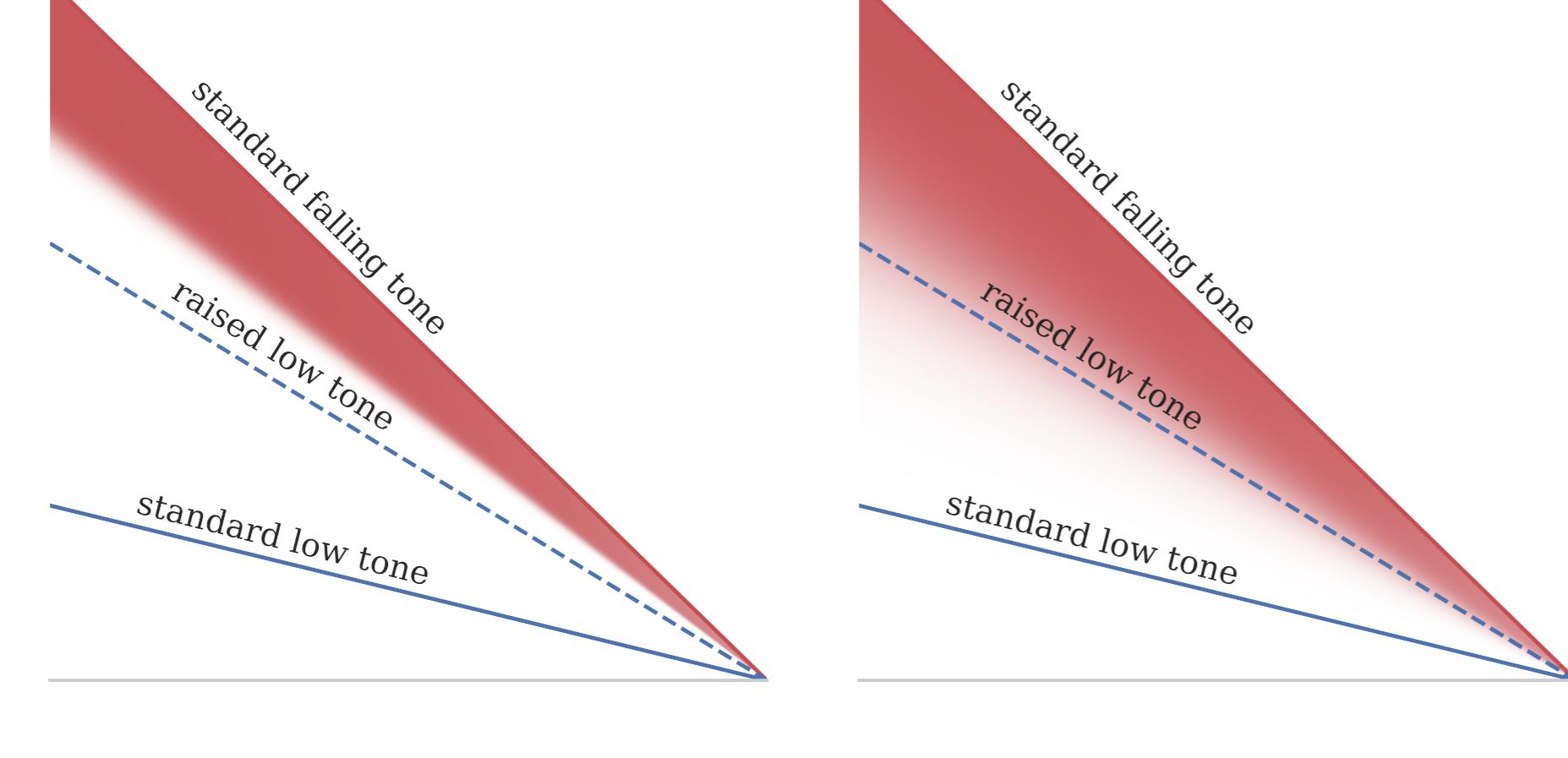


Figure 1. Illustration of narrower (left) and wider (right) tone acceptance ranges of a falling tone. The red areas indicate the acceptance ranges. The darkness of the redness indicates the probability of acceptance.

Under the same degree of TC-induced tone variations, a raised low tone

- in a language w/ a wide acceptance range: may be accepted as a falling tone → retrieve the target tone through normalization.
- in a language w/ a narrow acceptance range: may be still perceived as a low tone → weaker normalization induced.

Research questions

- Does TSM have weaker normalization for TC than TM? (factor 1 → exp. 1)
- Does TSM have narrower tone acceptance ranges than TM? (factor 2 → exp. 2)

Experiment 1: Magnitude of normalization for TC

Methods

Participants & stimuli

Participants

- 43 Taiwanese college students (25 females; 20–27 y.o., mean=21.93)
 - 15 TM monolingual+28 TM-TSM bilingual (11 advanced; 17 intermediate)

Stimuli

Low-to-falling tone continua preceded by lexical tones w/ different levels of tone offsets in minimal pairs.

- TM version: 3 tones (55, 51, 35)×10 levels
- TSM version: 4 tones (55, 51, 33, 21)×10 levels

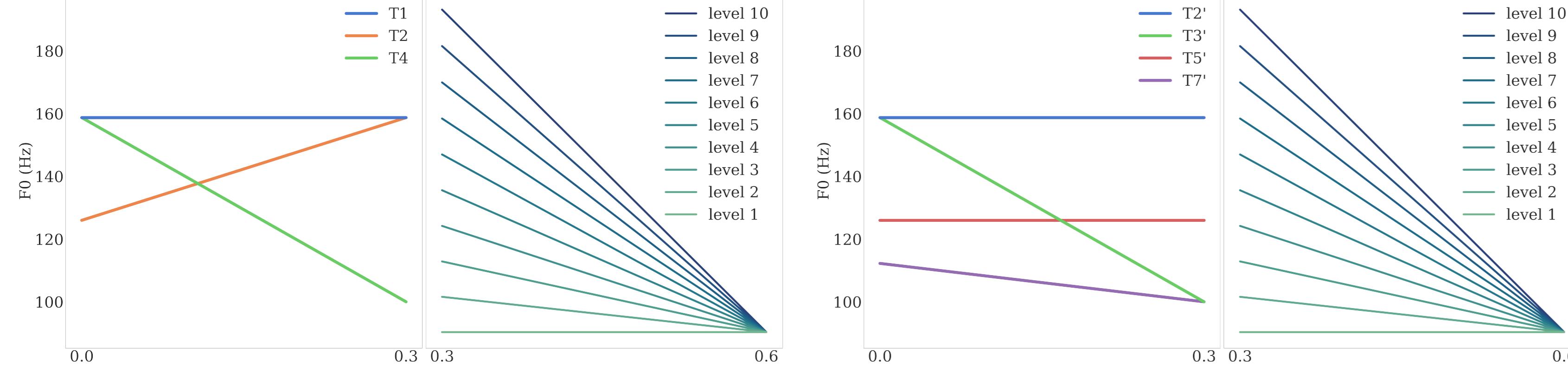


Figure 2. Illustration of synthesized tone contours (left: TM; right: TSM).

Procedure

- Fixation (1s) → auditory stimulus (.6s) → inter-stimuli interval (.4s) → target alternatives
- 5 repetitions for each combination

Analyses

- The participants' responses were converted into 0 (low tone response) and 1 (falling tone response).
- The responses were then fitted through mixed-effect logistic regression models.

Results

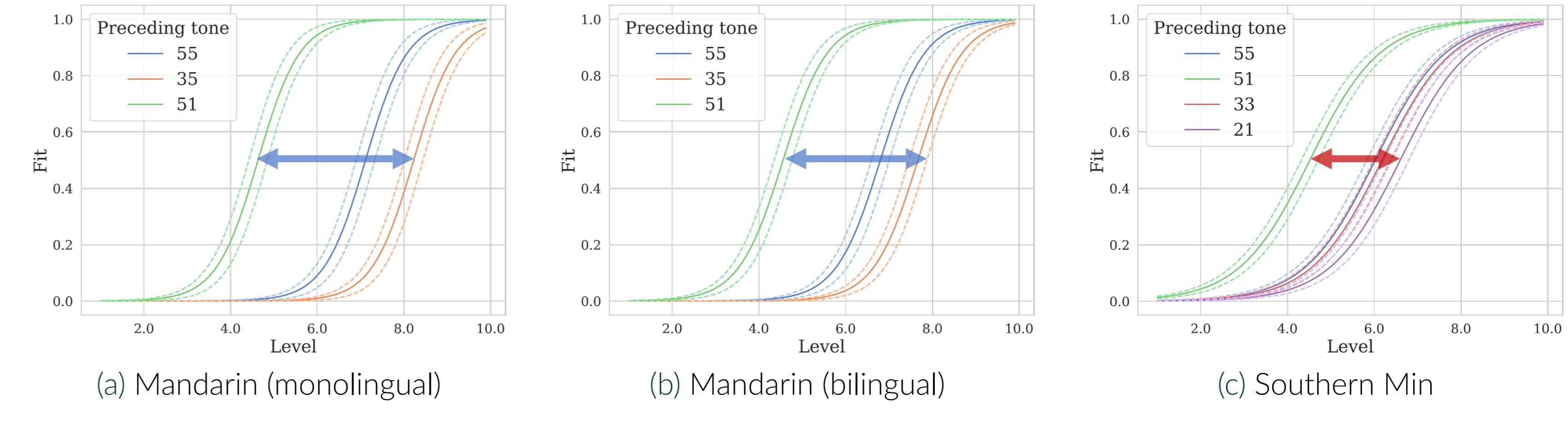


Figure 3. Logistic regression fits of falling tone response across different preceding tones.

→ TSM had smaller magnitudes (red arrow) of normalization for TC than TM (blue arrows).

Experiment 2: Tone acceptance ranges

Methods

Participants & stimuli

Participants

The same participants as Exp. 1 were recruited.

Stimuli

- Word-non-word continua w/ a high-level tone + a low-to-high continua.
- The second syllable went from a standard low tone to a standard falling tone from level 1 to level 10.
- 10 words chosen:
 - 55+21: 5 (more like a non-word on level 1; more like a word on level 10)
 - 55+51: 5 (more like a word on level 1; more like a non-word on level 10)

Procedure

- Fixation (1s) → auditory stimulus (.6s) → inter-stimuli interval (.4s) → a circle (accepted) & a cross (not accepted)
- 10 repetitions for each combination

Analyses

- Steepness of acceptance climbs:** determined as the maximum of the slopes between the response rate of each of the 10 levels.
- Threshold of acceptance:** determined w/ probit analysis [4].
- t-tests used to examine statistical significance.

Results

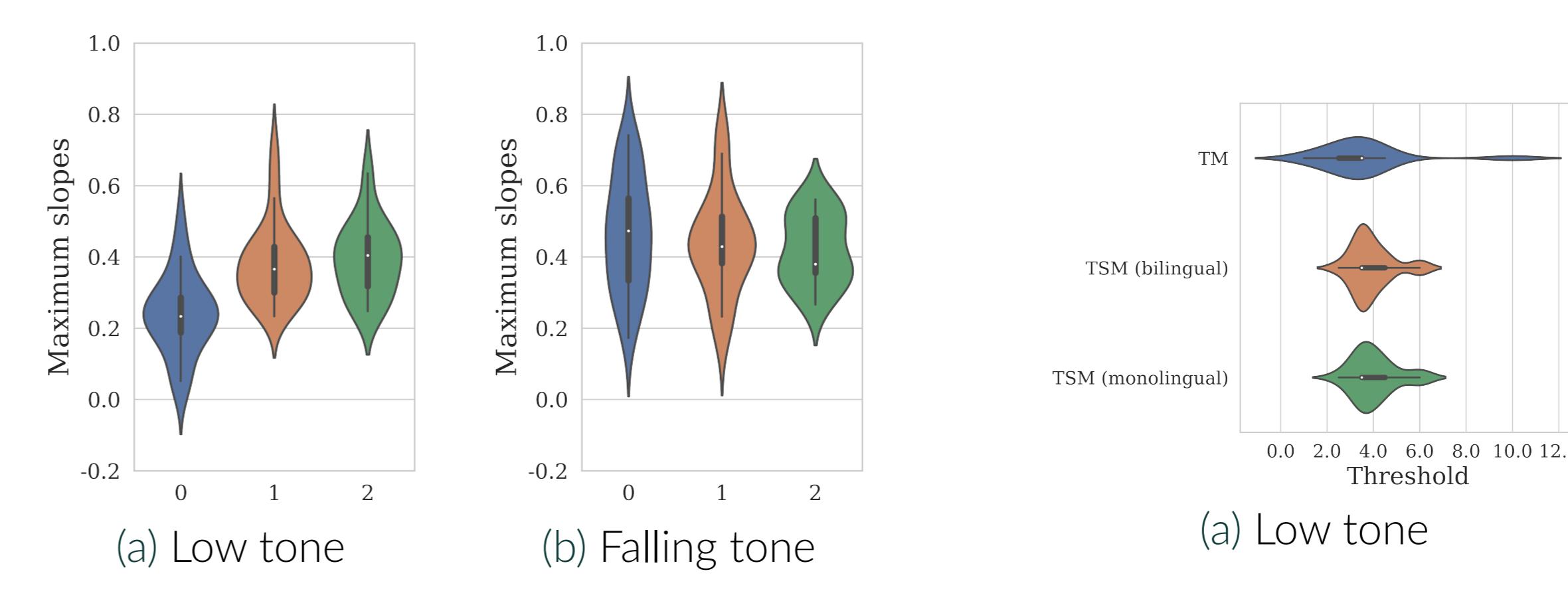


Figure 4. Maximum slopes of the acceptance rate climbs for the low tone and the falling tone for advanced speakers.

(a) Low tone

(b) Falling tone

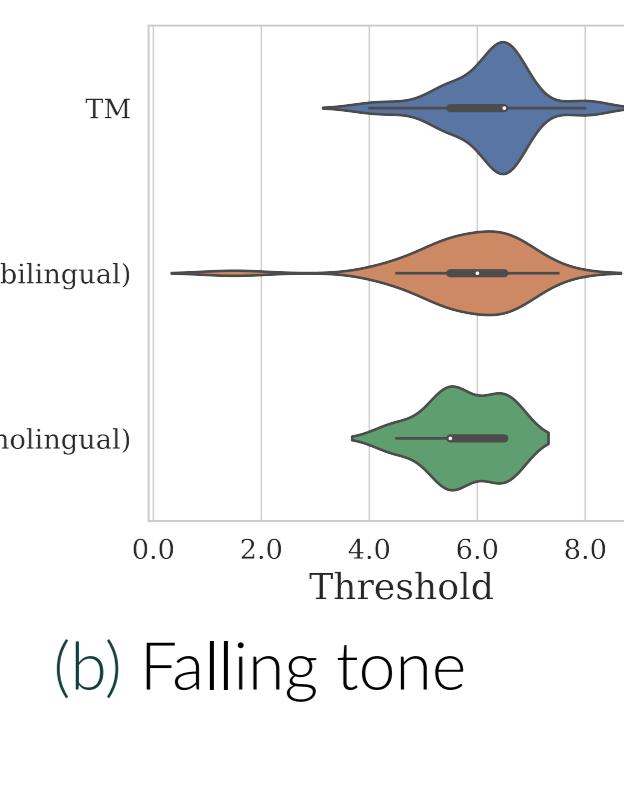


Figure 5. Thresholds of acceptance for the low tone and the falling tone.

Table 2. Summary of the results of Exp.2.

Target tone	Language	Steepness	Threshold
Low tone	TM	Steeper	No difference
	TSM	Less steep	
Falling tone	TM	Less steep (for advanced speakers)	Stricter (marginal significance)
	TSM	Steeper (for advanced speakers)	Less strict (marginal significance)

Discussion

Magnitude of normalization for TC

Our results supported the prediction that the lower recoverability of target tones in TSM led to less reliance on normalization for TC.

Tone acceptance ranges

On the other hand, TSM may make use of narrower tone acceptance ranges to block out coarticulated tones, reducing the probability of confusing them with other lexical tones.

Conclusions

Overall, this study investigated the perception of coarticulated tones in Taiwan Mandarin and Taiwan Southern Min. Two different perceptual strategies were found. Taiwan Mandarin, like Beijing Mandarin, made use of normalization to cope with TC-induced tone variations. On the other hand, Taiwan Southern Min had weaker normalization, but narrower tone acceptance ranges, which presumably could help reduce the probability of confusing a coarticulated tone with another lexical tone.

References

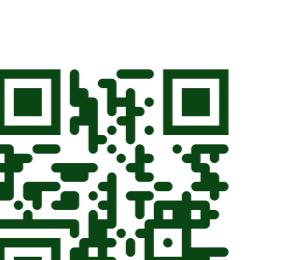
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