

Perception of Coarticulated Tones in Taiwan Mandarin and Taiwan Southern Min



Po-Hsuan Huang¹ Chenhao Chiu^{1, 2}

¹Graduate Institute of Linguistics, National Taiwan University
²Neurobiology and Cognitive Science Center, National Taiwan University

Abstract

Lexical tones in tone languages have been found to coarticulate with ambient tones, and speakers are observed to normalize for such coarticulation (i.e., tonal coarticulation (TC)). Beijing Mandarin (BM) is one of the examples. In languages with larger tone inventories, however, the recoverability of the target tones is lower, and a faithful comprehension of coarticulated tones based solely on normalization may be less likely. In this study, the perception of coarticulated tones in Taiwan Mandarin (TM) and Taiwan Southern Min (TSM) is investigated. It was revealed that compared with Taiwan Mandarin, Taiwan Southern Min tones induced much less normalizing effects. Crucially, Taiwan Southern Min was found to have stricter tone boundaries than Taiwan Mandarin, presumably allowing for effective tone perception under tonal coarticulation despite the larger tone inventory and a lower degree of normalization. This study sheds light on the perception strategies of coarticulated tones in languages with tone inventories of different sizes and the nature of tonal coarticulation.

Background

BM has been found to make use of normalization to deal with TC-induced tone variations [1, 2]:

The same target 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:

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

However, two aspects may lead to different routes:

- Magnitude of TC.
- Different perceptual mechanisms.

TM & TSM as test cases

Factor 1 Possibility of tonal confusion:

Tone inventory sizes:

- TM: 4
- TSM: 7

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

Factor 2 Recoverability of target tones:

	55	35	21(4)	51
Carry-over	Raising Lowering	T2 (35)	T1 (55)	T4(51)
Anticipatory	Raising Lowering	T4 (51)	T3 (21(4))	T2 (35)

Table 1. Mapping between intended target tones and coarticulated tones in Taiwan Mandarin. 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.

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

Table 2. Mapping between intended target tones and coarticulated tones in Taiwan Southern Min. 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.

→ TSM has a **lower** recoverability of target tones.

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 w/ TC-induced tone variations: tone acceptance ranges.

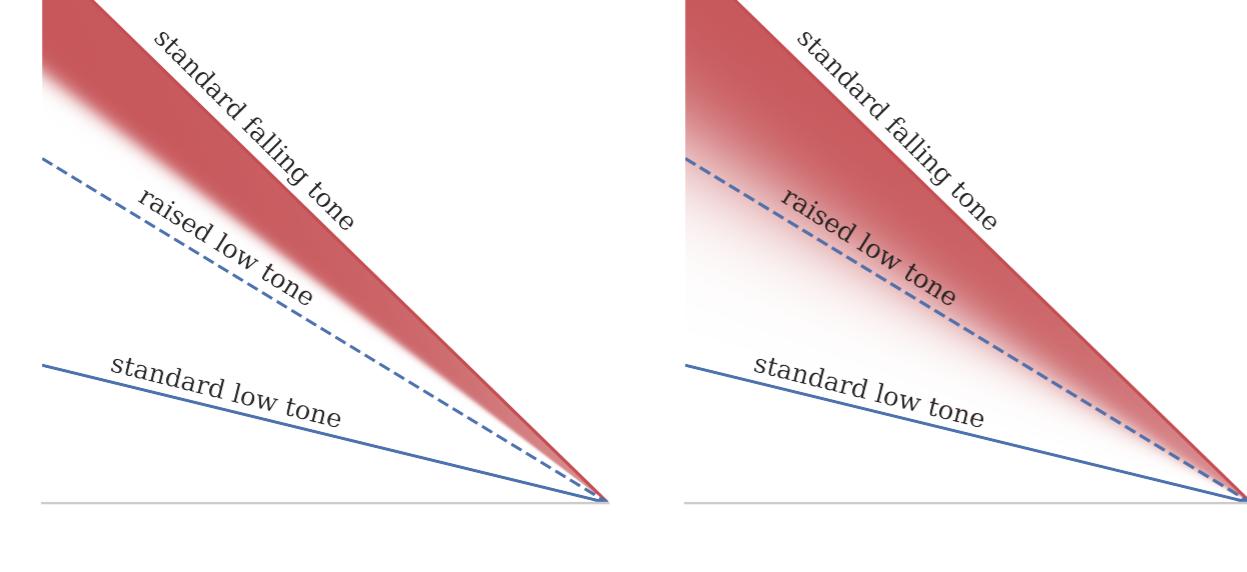


Figure 1. An illustration of narrower (left) and wider (right) tone acceptance ranges of a falling tone. The red areas indicate the acceptance ranges. The darkness of the redness indicates the probability of acceptance.

Under the same degree of Tc-induced tone variations, a raised low tone may be

- in a language w/ wider acceptance ranges: accepted as a falling tone → retrieve the target tone through normalization
- in a language w/ narrower acceptance ranges: still perceived as a low tone → weaker normalization induced

Research questions

- Does TSM have weaker normalization for TC than TM?
- Does TSM have narrower tone acceptance ranges than TM?

Experiment 1: Magnitude of normalization for TC

Two experiments were conducted to examine 1) the magnitude of normalization for TC and 2) tone acceptance ranges in TM & TSM.

Methods

Participants & stimuli

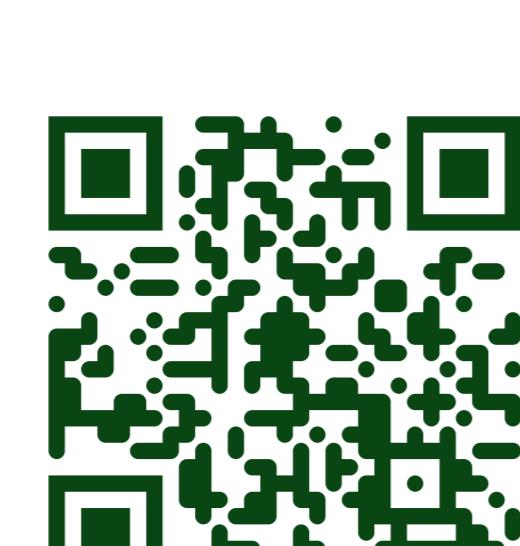
Participants

- 25 Taiwanese college students (15 females; 20–27 y.o., mean=21.93)
 - 15 Taiwan Mandarin monolingual
 - 28 Taiwan-Mandarin-Taiwan-Southern-Min bilingual (11 advanced; 17 intermediate)

Stimuli

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

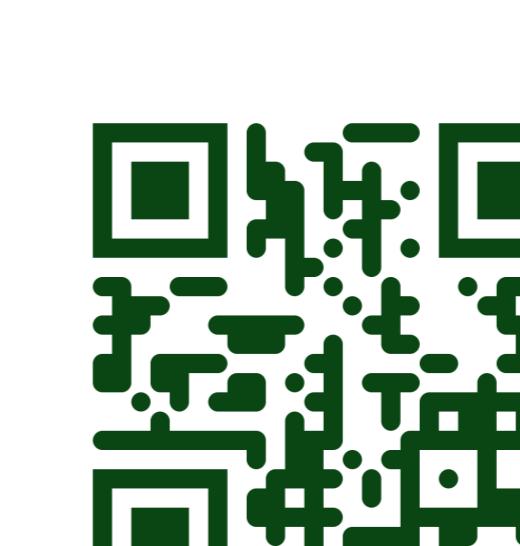
- TM version: 10 levels×3 tones (55, 51, 35)
- TSM version: 10 levels×4 tones (55, 51, 33, 21)



Our lab



This paper



Authors' websites

Procedure

- A fixation for 1s → an ear and the auditory stimulus presented → 0.4s inter-stimuli interval → Two target words presented
- 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

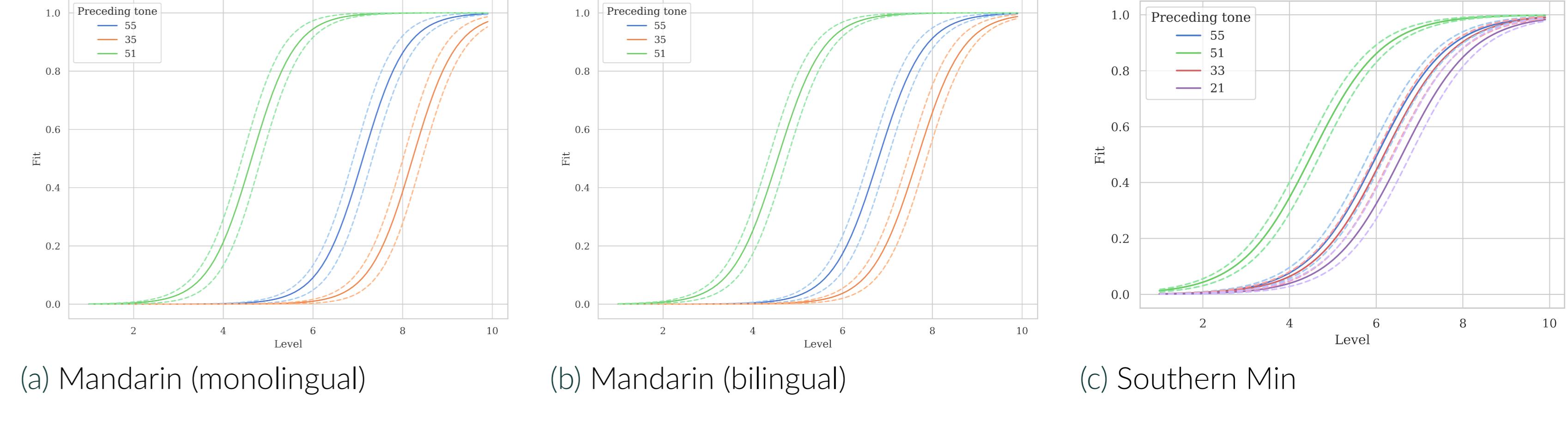


Figure 2. Logistic regression fits of falling tone response across different preceding tones.

→ TSM had smaller magnitudes of normalization for TC than TM.

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 were used.
- 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

- A fixation for 1s → an ear and the auditory stimulus presented → 0.4s inter-stimuli interval → A circle (accepted) & a cross (not accepted) presented
- 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

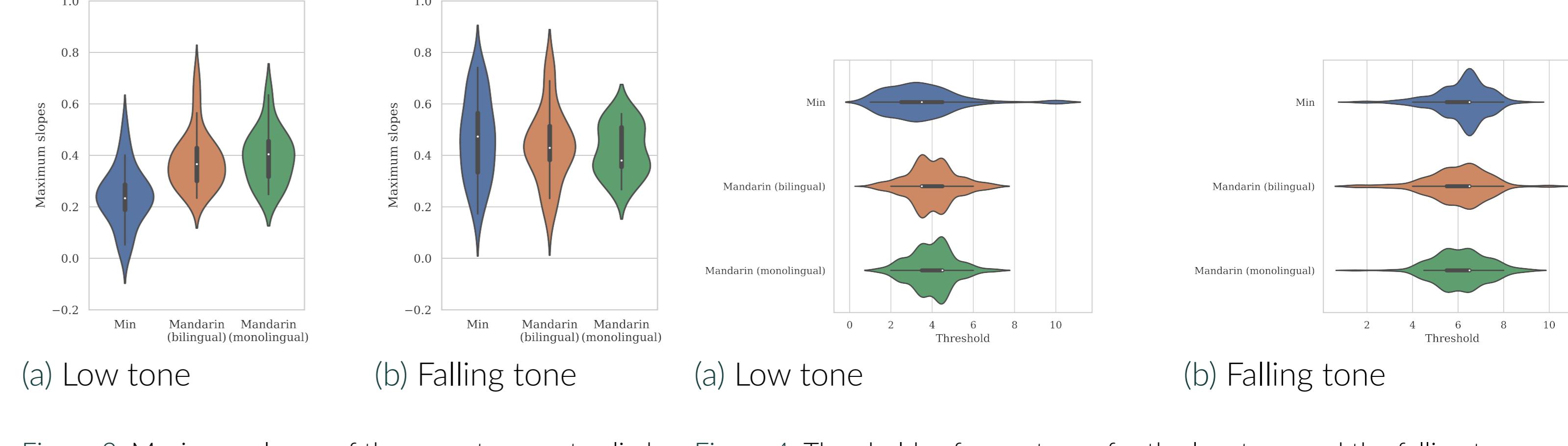


Figure 3. Maximum slopes of the acceptance rate climbs for the low tone and the falling tone for advanced speakers.

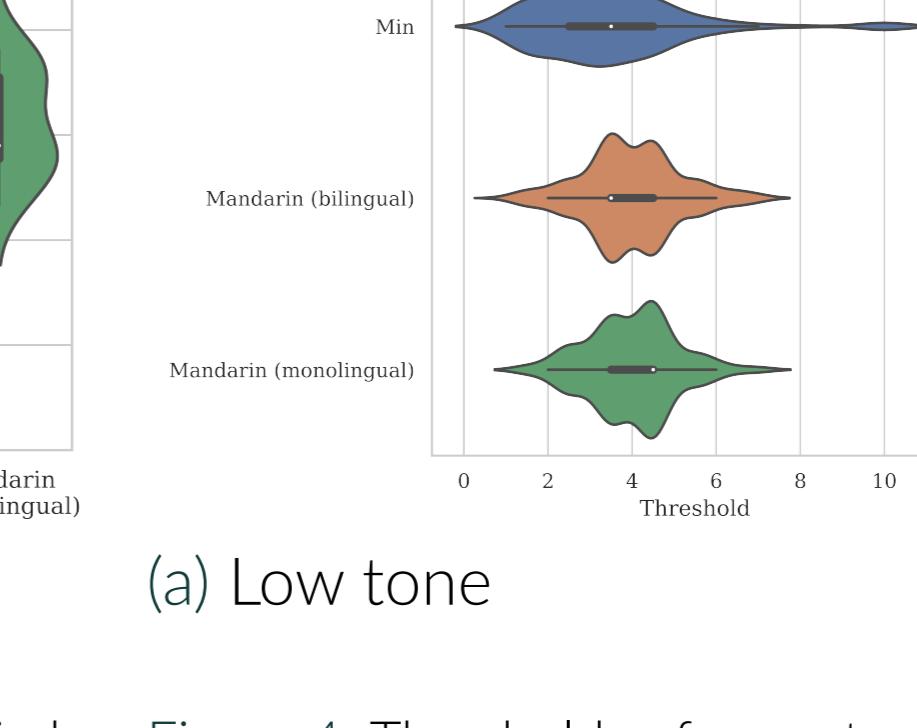


Figure 4. Thresholds of acceptance for the low tone and the falling tone.

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

Table 3. Summary of the results of Exp.2.

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 w/ 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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- [4] D. J. Finney, *Probit Analysis*, 3rd ed. Cambridge: Cambridge University Press, 1971.