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The Effect of Word Frequency and Neighbourhood Density on Tone Merge

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Abstract

This study investigates the effect of word frequency and neighbourhood density on lexical tone merging in Dalian Mandarin (a Chinese dialect) with acoustic data from 60 participants. We quantitatively analysed the tonal F0 contours with both functional data analysis and linear-mixed effects modelling to reveal the effects of word frequency and neighbourhood density on tonal contrast neutralization.

Results show that Tone 1 and Tone 4 are near-mergers in Dalian Mandarin. Word frequency and neighbourhood density show no effect on tonal duration, but do affect the concave and convex of F0 curves and the slope of F0's velocity profile, which confirms their role in the tone merging process.

Background

Lexical tone merging, a process of sound change, is a tonal contrast neutralization phenomenon that has been investigated through word production in various languages (e.g., Mok et al., 2013). Dalian Mandarin has four lexical tones: falling (Tone 1), rising (Tone 2), dipping (Tone 3) and falling (Tone 4). Whether the two falling tones (Tone 1 and Tone 4) have been merged or not is still under discussion (e.g., Gao, 2007; Liu, 2009).

Various factors have been proposed to affect contrast neutralization, such as word frequency (e.g., Mok et al., 2013). However, it is not clear how languages may differ in the effect of word frequency on potential tone mergers. Neighbourhood density has also been reported to affect neutralization (e.g., Ernestus & Baayen, 2006); however the effect of neighbourhood density on tone merging has not been studied yet.

Methodology

- 1. Participants:** 60 native speakers of Dalian Mandarin: 20 middle-aged (mean: 50; SD: 3.6) and 30 young speakers (mean: 22; SD: 3.6).
- 2. Stimuli:** 90 monosyllabic words. Three conditions: high neighbourhood density with high word frequency (HDHF), high neighbourhood density with low word frequency (HDLF) and low neighbourhood density with high word frequency (LDHF).
- 3. Statistics:** Linear-mixed effects modelling and functional data analysis (Gubian et al., 2015).
- 4. Measurement:** Duration, F0 curve and F0's velocity profile.

Research Questions

1. Are Tone 1 and Tone 4 in Dalian Mandarin completely merged?
2. Do word frequency and neighbourhood density affect the tone merging process?

Results

1. Duration: No significant difference in duration between Tone 1 and Tone 4 regardless of stimulus conditions.

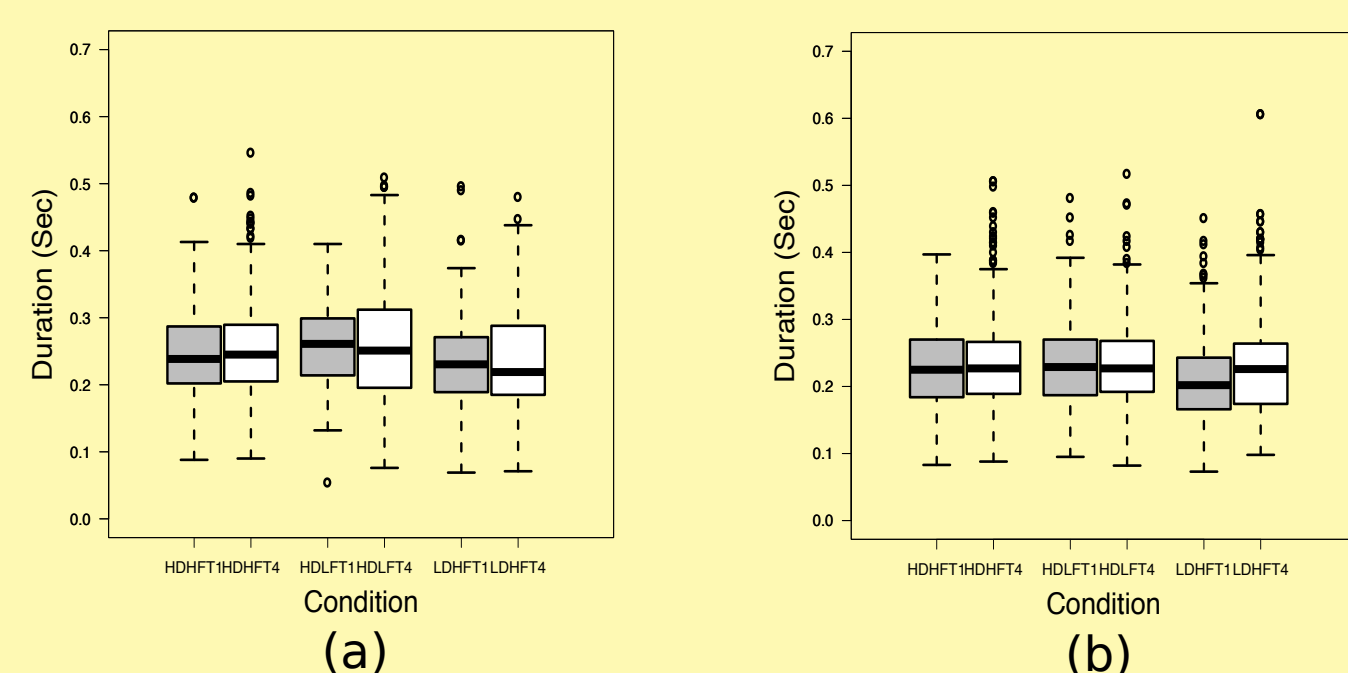


Figure 1: Duration of Tone 1 and Tone 4 produced by (a) middle-aged speakers and (b) young speakers in three conditions (HDHF, HDLF and LDHF).

2. F0 curves and F0's velocity profile: Results of middle-aged and young speakers were similar. We only showed results from young speakers below for illustration.

F0 curve and F0's velocity profile (i.e. the speed of the two falling tones) were analysed using functional t-test and Functional Principle Component Analysis (FPCA) in Functional Data Analysis. They were further tested with linear-mixed effects modelling (Baayen, 2008).

2.1 F0 curves: Tone 1 and Tone 4 are not completely merged across word frequency and neighbourhood density conditions.

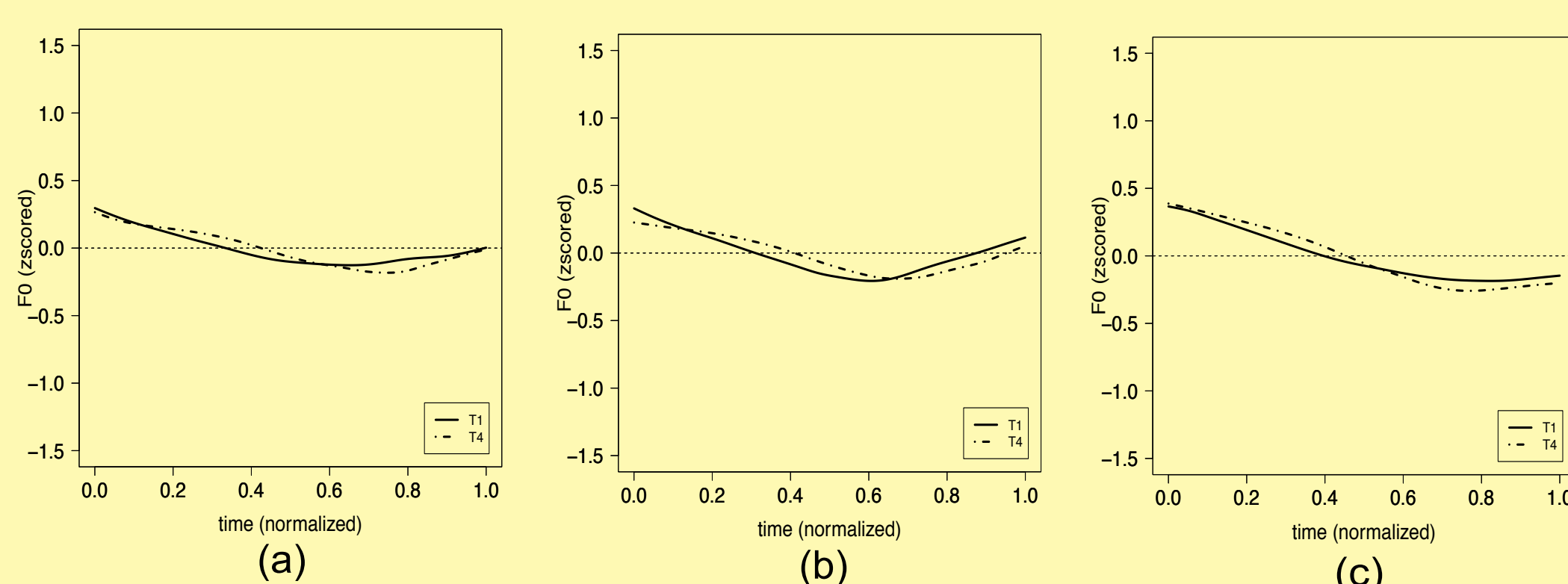


Figure 2: The average of the (normalised) F0 curves for Tone 1 and Tone 4 in three conditions (a: HDHF; b: HDLF; c: LDHF) by young speakers.

Table 1: Summary of linear-mixed effects modelling for F0 curves between Tone 1 and Tone 4 of young speakers.

Conditions	HDHF	HDLF	LDHF
slope of F0 curve	no significance		
turning point of F0 curve	***	***	***

***: $p < 0.001$

2.2 F0's velocity profile: Tone 1 and Tone 4 are not completely merged in F0' velocity profile.

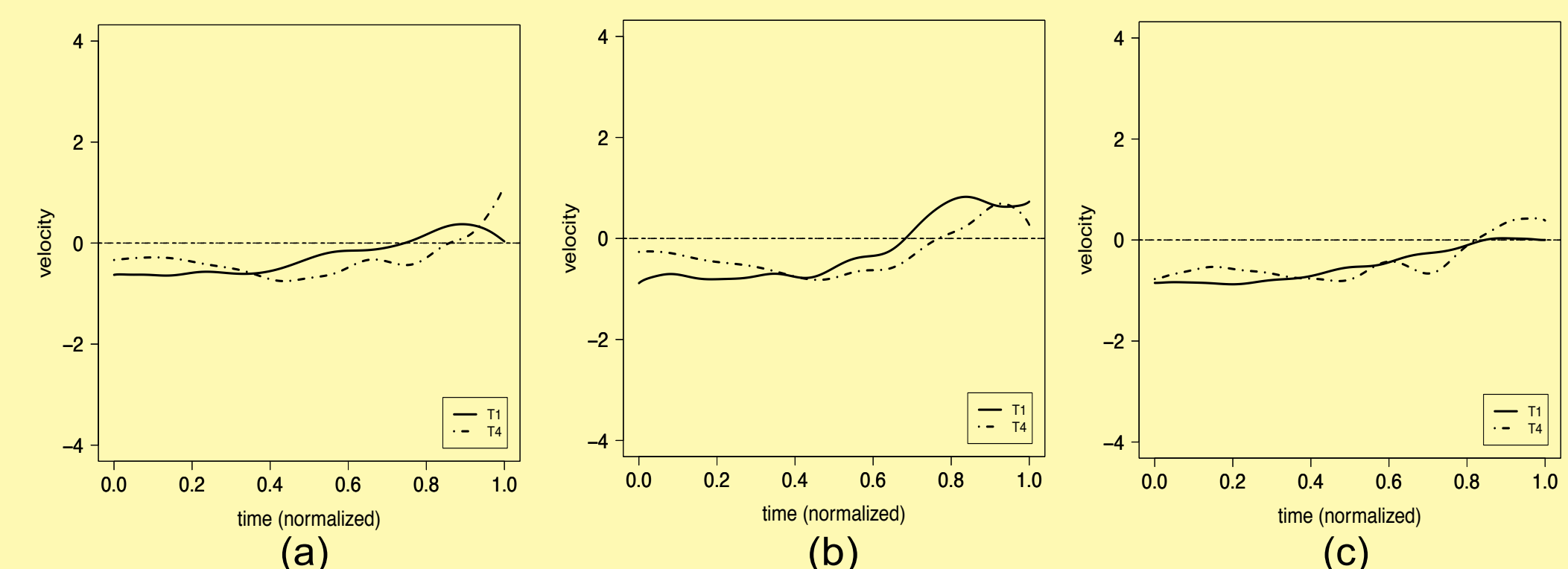


Figure 3: The average of the (normalised) F0's velocity profile for Tone 1 and Tone 4 in three conditions (a: HDHF; b: HDLF; c: LDHF) by young speakers.

Table 2: Summary of linear-mixed effects modelling for F0's velocity profile between Tone 1 and Tone 4 of young speakers.

Conditions	HDHF	HDLF	LDHF
slope of F0's velocity profile	*	*	n.s.
turning point of F0's velocity profile	*	n.s.	n.s.

*: $p < 0.05$; n.s.: no significance

Summary

F0 curves:

1. No significant difference in F0 curves' slope in any of the three conditions.
2. Significant differences in the F0 curves' turning point across conditions.

F0's velocity profile:

1. Significant differences in the slope of F0's velocity profile for words with high neighbourhood density regardless of word frequency conditions.
2. Significant differences in the turning point of F0's velocity profile only for words with high neighbourhood density and high word frequency.
3. Neighbourhood density plays a more important role regardless of word frequency in the contrast maintenance between Tone 1 and Tone 4.

References

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Conclusion

1. In Dalian Mandarin, Tone 1 and Tone 4 are not completely merged. There are no differences in duration regardless of stimulus conditions; however, there is incomplete neutralization in F0.
 2. Both word frequency and neighbourhood density play a role in the contrast maintenance of Tone 1 and Tone 4 in F0 curves and F0's velocity profile.
- Implication:** Our results showed that both word frequency and neighbourhood density should be taken into consideration in the investigation of the tone merging processes.

