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Research Article

# An acoustic study of contextual tonal variation in Tianjin Mandarin

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ABSTRACT

The *f*0 realization of lexical tones is known to vary greatly due to contextual tonal variation processes such as tone sandhi and tonal coarticulation. This study set out to investigate the *f*0 variability induced by these two different sources with well-controlled acoustic data from Tianjin Mandarin. Tianjin Mandarin is known for its complex patterns of tonal variation over disyllabic constituents, as well as for the conflicting directionality of sandhi alternations and possible iterative application of disyllabic sandhi rules over trisyllabic constituents. Previous studies on Tianjin tone sandhi have often been based on impressionistic descriptions of speech produced by speakers of older generations. In this study, we investigated the *f*0 realization of disyllabic and trisyllabic tonal sequences in Tianjin Mandarin produced by younger speakers (born in the 1980s). Through examining *f*0 variation of lexical tones as a function of different following tones, we observed an interesting anticipatory raising effect of the lexical low-falling tone (T1). Furthermore, we confirmed three tonal sequences with tone sandhi changes: (1) two low-falling tones (T1T1), (2) a high-falling tone followed by a low-falling tone (T4T1), and (3) two low-dipping tones (T3T3). These disyllabic tone sandhi patterns, however, were not consistently observed within trisyllabic sequences, as claimed in the literature. Specifically, while T3T3 showed sandhi application regardless of its position within a trisyllabic sequence, T1T1 and T4T1 sequences showed sandhi changes only when they were right aligned. Last but not least, no tonal neutralization was observed over any of the sandhi processes. Rather, we argue that T3T3 is a near-merger sandhi case, while T1T1 and T4T1 can be classified as no-merger sandhi sequences.



## 1. Introduction

It is known that the *f*0 realization of lexical tones varies extensively in connected speech. At a global level, *f*0 can vary due to the overall discourse prosody in which the tone-bearing lexical item is produced. At a more local level, the *f*0 realization of a lexical tone can be further affected by its neighboring tones (see e.g., Chen, 2012 for a review). One well-noted local contextual effect is tone sandhi, which is often described as the phonological change of lexical tones (Chen, 2000; also see Zhang, 2010 for a review). Another local contextual effect is tonal coarticulation, which is traditionally defined as phonetically minor *f*0 adjustments to preceding or following tones (see Xu, 2001 for a review). Both processes cause changes in the *f*0 realization of a lexical tone, so that the resulting *f*0 contour may deviate to varying degrees from the canonical *f*0 shape of the tone produced in isolation. While there has been general agreement on the difference between tonal coarticulation and tone sandhi to account for contextual tonal variation, there is little consensus or research effort on how exactly or whether the wide range of *f*0 deviations can be categorized as a function of these two distinct processes.

In this study, we aimed to address this issue through directly comparing these two types of tonal variation. Our empirical base is Tianjin Mandarin, a Northern Mandarin dialect spoken in the urban areas of Tianjin, a metropolis in northern China. Tianjin Mandarin presents an interesting test case on tonal variation, further understanding of which will shed light on how different tonal variation processes intertwine to determine the *f*0 realization of lexical tones. The dialect is known for its complex tone sandhi patterns over disyllabic constituents. Over trisyllabic constituents, some tone sandhi rules have been argued to apply only to the leftmost two syllables, while others only to the rightmost two syllables, regardless of the morpho-syntactic structures. Furthermore, some sandhi

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rules are claimed to apply iteratively, i.e., over derived contexts of the first round of sandhi application. These two properties are together known as the "paradox" in Tianjin tone sandhi (e.g., Chen, 2000).

It is important to note that although tonal variation in Tianjin Mandarin has been extensively studied, most were based on impressionistic data. In a recent acoustic study, Zhang and Liu (2011) examined tonal coarticulation of disyllabic items but did not compare them to the previously claimed tone sandhi patterns. This makes it impossible to evaluate directly how tonal variation due to different sources may differ. Furthermore, despite the potentially significant implications of the Tianjin Mandarin tone sandhi "paradox" on our theoretical modeling of tonal variation, no experimental work has been done on trisyllabic tone sandhi in Tianjin Mandarin. Pilot results in Li and Chen (2012) raised serious doubts on the tonal variation patterns of trisyllabic sequences reported in the literature (Chen, 2000 and references therein).

The specific goal of this study therefore was to collect data from a well-controlled acoustic experiment and investigate (1) how lexical tones are realized with varying *f*0 contours in disyllabic domains without pre-exclusion of any tonal sequence claimed to involve tone sandhi processes; and (2) whether disyllabic tone sandhi alternations can be observed in trisyllabic constituents, with particular focus upon the issue of directionality and iterativity of sandhi application. By doing so, we hope to arrive at a better understanding of tonal realization in Tianjin Mandarin, which, in turn, would help to further refine a general theory of tonal variation.

### 1.1. Lexical tones of Tianjin Mandarin in isolation

Although Tianjin Mandarin has a very similar segmental structure to Standard Chinese, the dialect differs significantly from Standard Chinese in terms of the tonal system (Han, 1993; Wee, Yan, & Chen, 2005). There are four lexical tones in Tianjin Mandarin. Fig. 1 illustrates the *f*0 realization of the four lexical tones elicited in isolation. All *f*0 contours were plotted based on 50 samples with different segmental structures for each tone, produced by a male native speaker in his 20s at the time of recording (born in 1983). *f*0 contours were time-normalized by taking 20 points in the rhyme part of each syllable with equal time interval. The *f*0 values were normalized by converting them to speaker-specific *z*-scores (Rose, 1987) with the formula: $z=\frac{f0_x - f0_{mean}}{f0_{SD}}$. ($f0_x$: the observed *f*0 value in Hz; $f0_{mean}$: the mean *f*0 value of the speaker in Hz; $f0_{SD}$: the standard deviation of *f*0 value of the speaker in Hz.)

As can be seen from Fig. 1, Tone 1 is a low-register falling tone, with a pitch contour that falls from the middle to the lower end of the speaker's pitch range. Tone 2 is a high-register rising tone, whose pitch contour rises from the middle to the upper end of the pitch range. Tone 3 is a low-register dipping tone, which falls slightly from the lower pitch range, stays at the bottom and then rises to the mid pitch range of the speaker. Tone 4 is a high-register falling tone which falls from the upper end to the mid pitch range.

Table 1 summarizes the annotations adopted in different studies. Strictly speaking, no annotation system listed in Table 1 accurately reflects the *f*0 contours plotted in Fig. 1. This discrepancy is in part an indication of the considerable variation in lexical tone production that exists both within and across speakers of the same generation as well as across speakers of different generations. Despite the variability, the basic *f*0 patterns of the four lexical tones are rather consistent at a more abstract level.

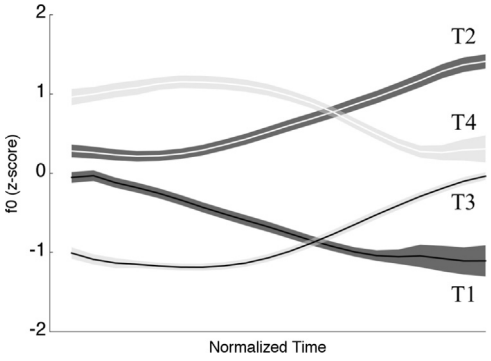


**Fig. 1.** Four lexical tones in Tianjin Mandarin produced in isolation (with normalized time). Lines stand for the mean. Gray areas stand for ±1 standard error of the mean.

**Table 1**
Transcriptions of the four lexical tones in Tianjin Mandarin in different studies.

| T1 | T2 | T3 | T4 | |
|---|---|---|---|---|
| L | H | R(LH) | F(HL) | For e.g., Chen (2000), Wee et al. (2005), Hyman (2007) |
| LL | HH | LH | HL | For e.g., Wang and Jiang (1997); Wang (2002); Ma (2005) |
| 21 | 45 | 213 | 53 | For e.g., Li and Liu (1985), Hung (1987), Tan (1987), Zhang (1987) and Han (1993) |
| 211 | 455 | 113 | 553 | For e.g., Shi (1986) |
| 41 | 34 | 12 | 52 | For e.g., Zhang and Liu (2011) |