The handle [http://hdl.handle.net/1887/37609](http://hdl.handle.net/1887/37609) holds various files of this Leiden University dissertation.

**Author:** Qian Li  
**Title:** The production and perception of tonal variation: evidence from Tianjin Mandarin  
**Issue Date:** 2016-02-10
CHAPTER 2 LANGUAGE DESCRIPTION OF TIANJIN MANDARIN

2.1 Introduction

Tianjin Mandarin is a member of the northern Mandarin Chinese family. The dialect is spoken in the urban areas of the Tianjin Municipality in People’s Republic of China. The city is only about 100 kilometers away from Beijing. While the old variety of Tianjin Mandarin has been reported to differ from Beijing Mandarin in its lack of post-alveolar consonants, the dialect spoken by the younger generation shows basically identical segmental structure to Beijing Mandarin (as also noted in Wee et al., 2005). What differentiates the two dialects is primarily their tonal system. For ease of comparison, the present description on consonants and vowels used the illustrating words from the description of Standard Chinese in Lee & Zee (2003) as much as possible, with deviations mainly due to a different view we have adopted to transcribe the sound system. The sound files illustrated in the present description were produced by a male speaker who was born in the 1980s in Nankai District of Tianjin, one of the oldest districts of Tianjin. The dialect spoken there is regarded as most representative by local people.

2.2 Consonants

There are 25 consonants in Tianjin Mandarin, as shown in Table 2.1. Words illustrating the consonants are shown in Table 2.2 in which most of the syllables have Tone 1, others have Tone 2 or Tone 4. Lexical tones here are marked with a superscript. (See section 2.5 in this chapter for more details on lexical tones and tone sandhi in Tianjin Mandarin.)

Table 2.1 Overview of consonantal phonemes and their place and manner of articulation.

<table>
<thead>
<tr>
<th></th>
<th>Bilabial</th>
<th>Labiodental</th>
<th>Denti-alveolar</th>
<th>Post-alveolar</th>
<th>Alveolo-palatal</th>
<th>Velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plosive</td>
<td>p pʰ</td>
<td>t tʰ</td>
<td></td>
<td></td>
<td></td>
<td>k kʰ</td>
</tr>
<tr>
<td>Affricate</td>
<td>ts tsʰ</td>
<td>tf tfʰ</td>
<td>te teʰ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal</td>
<td>m</td>
<td>n</td>
<td></td>
<td></td>
<td></td>
<td>η</td>
</tr>
<tr>
<td>Fricative</td>
<td>f</td>
<td>s</td>
<td>j</td>
<td>ε</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Approximant</td>
<td>w</td>
<td></td>
<td>j</td>
<td>j η</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral Approximant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>l</td>
<td></td>
</tr>
</tbody>
</table>

1 A version of this chapter has been submitted for publication as: Qian Li & Yiya Chen. (under revision). Tianjin Mandarin – Illustration of IPA. Journal of the International Phonetic Association.
2.2.1 Plosive

Plosives in Tianjin Mandarin differentiate three different places of articulation: bilabial /p/, /pʰ/ as in /pe¹/ ‘eight’ and /pʰe²/ ‘to climb’, danti-alveolar /t, tʰ/ as in /te¹/ ‘to build’ and /tʰe¹/ ‘he/she’, and velar /k, kʰ/ as in /ky¹/ ‘song’ and /kʰy¹/ ‘subject’. They are contrastive in aspiration; aspirated plosives have longer VOT than their unaspirated counterparts. The contrast holds for all places of articulation, as shown in Table 2.3. Averaged across different places of articulation, the mean VOT for aspirated plosives in our dataset is 102 ms while that for unaspirated plosives is only 23 ms. Furthermore, velar plosives have significantly longer VOT than bilabial and denti-alveolar plosives as revealed by a post-hoc Tukey HSD test (velar vs. bilabial: Diff.=20ms, p-adj.<0.001; velar vs. denti-alveolar: Diff.=10ms, p-adj.<0.001), while the bilabial and denti-alveolar plosives are not significantly different.

### Table 2.2 Words illustrating consonants.

<table>
<thead>
<tr>
<th></th>
<th>pe¹</th>
<th>t</th>
<th>te¹</th>
<th>tʃ́</th>
<th>tʃʰe¹</th>
<th>k</th>
<th>ky¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>‘eight’</td>
<td>‘to build’</td>
<td>‘residue’</td>
<td>‘sand’</td>
<td>‘subject’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pʰ</td>
<td>‘to climb’</td>
<td>‘be/she’</td>
<td>‘to insert’</td>
<td>‘to circle’</td>
<td>‘to raise’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>‘mother’</td>
<td>‘to build’</td>
<td>‘to add’</td>
<td>‘to add’</td>
<td>‘to add’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>‘to send’</td>
<td>‘to wipe’</td>
<td>‘to build’</td>
<td>‘to add’</td>
<td>‘to drink’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>w</td>
<td>‘frog’</td>
<td>‘to include’</td>
<td>‘to add’</td>
<td>‘to add’</td>
<td>‘to drink’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l</td>
<td>‘to pull’</td>
<td>‘to pull’</td>
<td>‘to pull’</td>
<td>‘to pull’</td>
<td>‘to pull’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bilabial</th>
<th>Denti-alveolar</th>
<th>Velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>unaspirated</td>
<td>aspirated</td>
<td>unaspirated</td>
</tr>
<tr>
<td>Mean</td>
<td>16 ms</td>
<td>91 ms</td>
</tr>
<tr>
<td>SD</td>
<td>6 ms</td>
<td>16 ms</td>
</tr>
<tr>
<td>N</td>
<td>121</td>
<td>188</td>
</tr>
</tbody>
</table>

2.2.2 VOT of unaspirated vs. aspirated plosives in three different places of articulation, based on all plosive consonants in a dataset of 3935 monosyllables.
2.2.2 Affricate

Affricates in Tianjin Mandarin display the same two-way distinction in aspiration as plosives. They have three places of articulation: denti-alveolar /ts, tsʰ/ as in /tse₁/ ‘to circle’ and /tsʰv₁/ ‘to wipe’, post-alveolar /tʃ, tʃʰ/ as in /tʃi₁/ ‘residue’ and /tʃʰi₁/ ‘to insert’, as well as alveolo-palatal /tɕ, tɕʰ/ as in /tɕi₁/ ‘to add’ and /tɕʰi₁/ ‘to nip off’.

The denti-alveolar affricates are produced with the tip of the tongue behind the lower front teeth and the tongue blade against the alveolar ridge. The post-alveolar affricates are pronounced with the tongue tip raised against the post-alveolar region. The alveolo-palatal affricates are pronounced with the tongue tip down behind the lower front teeth and with the dorsum of the tongue against the area between the alveolar ridge and the hard palate.

The alveolo-palatal consonants in Tianjin Mandarin are obligatorily followed by an alveolo-palatal glide before the following vowel if the consonant is not followed by a high vowel, such as in /tɕi₁/ ‘to add’, /tɕʰi₁/ ‘to nip off’ and /ɕi₁/ ‘shrimp’. Figure 2.1 shows the spectrogram of /tɕi₁/ ‘to add’, where we see a transition (glide /j/) between the consonant /tɕ/ and the vowel /i/, taking up about ¼ of the total rhyme length. The F1 of the glide starts with a low value (around 500Hz) and gradually increases up to 850Hz as that of the vowel /i/; the F2 of the glide starts around 2000Hz and ends with 1500Hz. The F1 and F2 values of the glide onset therefore resemble that of a front high vowel. Glides in such contexts have been traditionally considered part of the rhyme and transcribed as a vowel (see, e.g., Lee & Zee, 2003 for the transcript of the same syllables in Standard Chinese as /tɕi¹/, /tɕʰi¹/ and /ɕi¹/, respectively). In line with Duanmu (2000) and Lin (2007), we treat them as glides which constitute part of the onset, so as to avoid the ill-motivated idiosyncratic feature of Tianjin Mandarin as having triphthongs.

![Figure 2.1](image-url) The spectrogram of a /tɕi₁/ syllable.

It is important to note the difference between Tianjin Mandarin and Shanghai Chinese. Chen and Gussenhoven (in press) have argued that the transition between an alveolo-palatal affricate and its following vowel in Shanghai Chinese is phonetic and predictable from the context, and should not be treated phonemically as /j/. For comparison between the two dialects, we have plotted the spectrograms of three
segmentally comparable monomorphemic words /təʊ¹/ ‘knife’, /tjaʊ¹/ ‘to hold in the mouth’, and /tejəʊ¹/ ‘to teach’ as those in Figure 2.2 in Chen and Gussenhoven (in press). Different from the observation in Shanghai Chinese where the transition between the alveolo-palatal consonant and the vowel is rather brief, here we see that in Tianjin Mandarin, there is a clear glide-like transition in /tejəʊ¹/ (right in Figure 2.2), which is similar to that in /tjaʊ¹/ (middle in Figure 2.2) where there is a real glide, and different from that in /taʊ¹/ (left in Figure 2.2) where there is only subtle phonetic coarticulation.

Figure 2.2 The spectrograms of /taʊ¹/, /tjaʊ¹/ and /tejəʊ¹/. Dashed frames indicate the transitions.

It is worth noting that alveolo-palatals /tɕ/, /tɕʰ/ and /ɕ/ can directly occur only before the high front vowels /i/ and /y/ (and their corresponding glides /j/, /ɥ/), and are therefore in complementary distribution with the denti-alveolars /ts/, /tsʰ/, /s/, the post-alveolars /tʃ/, /tʃʰ/, /ɕ/, as well as the velars /k/, /kʰ/ and /x/. Their phonemic status has been under some debates, which we will not pursue further here but refer interested readers to Lin (2014) for further details.

2.2.3 Nasal

The nasal series in Tianjin Mandarin contain three different places of articulation: bilabial /m/ as in /mɐ¹/ ‘mother’, denti-alveolar /n/ as in /nɐ⁴/ ‘to include’, and velar /ŋ/ as in /ɑŋ²/ ‘to raise’.

2.2.4 Fricative

Fricatives in Tianjin Mandarin differentiate five different places of articulation: labiodental /f/ as in /fɐ¹/ ‘to send’, denti-alveolar /s/ as in /sɐ¹/ ‘to cast’, post-alveolar /ʃ/ as in /ʃɐ¹/ ‘sand’, alveolo-palatal /ɕ/ as in /ɕɐ¹/ ‘shrimp’, and velar /x/ as in /xɐ¹/ ‘to drink’, which alternates with the uvular fricative /χ/ when followed by a non-high vowel as in /xaa²/ ([χaː]) ‘child’ and /xaʊ³/ ([χaʊ³]) ‘good’.
2.2.5 Approximant

Tianjin Mandarin has four central approximants /w, ɹ, j,ɥ/ as in /wu¹/ ‘frog’, /rɔn²/ ‘person’, /jw¹/ ‘duck’ and /喹e¹/ ‘to restrict’, which mainly differ in their places of articulation, and one lateral approximant /l/ as in /la¹/ ‘to pull’. Among them, /w/, /j/ and /ɥ/ can serve as part of a complex onset. /j/ and /ɥ/ are mostly in complementary distribution except for one context; before the vowel /e/, they are contrastive as in /ne¹/ ‘to pinch’ vs. /nɥe⁴/ ‘to abuse’, /teje¹/ ‘to connect’ vs. /te喹e²/ ‘to feel’, /teʰje¹/ ‘to cut’ vs. /teʰ喹e¹/ ‘to lack’, and /ceje¹/ ‘to rest’ vs. /ce喹e¹/ ‘boots’.

2.2.6 Syllabic consonant

As in Beijing Mandarin, Tianjin Mandarin has two syllabic consonants: the denti-alveolar /צ/ (as in /tsz³/ ‘son’) and post-alveolar /ɹ/ (as in /tʃz³/ ‘paper’). They are homorganic with the preceding onset. /צ/ follows denti-alveolar obstruents /ts, tsʰ, s/ (as in /tsz³/ ‘son’, /tsʰצ³/ ‘word’, /sz¹/ ‘to think’), while /ɹ/ only following post-alveolar obstruents /tʃ, tʃʰ, ʃ/ (as in /tʃz³/ ‘paper’, /tʃʰצ²/ ‘to eat’, /צ¹/ ‘poem’). In addition, /ɹ/ can occur by itself as in /ɹ⁴/ ‘the sun’. For further details of their acoustic and articulatory realizations, readers are referred to Lee and Zee (2014) and Lee-Kim (2014). While our transcriptions are in line with Chao (1948), it is important to note that the literature witnesses quite some debates in both the phonemic status and notation of the two sounds (see also review in Lee-Lim, 2014). Traditionally, Sinologists refer to them as “apical vowels” (e.g., Karlgren, 1915-1926). They have also been referred to as “fricative vowels” in Ladefoged and Maddieson (1996), syllabic approximant /ɹ/ in Lee and Zee (2003, 2014), and syllabic dental approximant /צ/ and retroflex approximants /ɻ/, respectively in Lee-Kim (2014).

2.3 Vowels

Vowels in Tianjin Mandarin consist of eight monophthongs and four diphthongs. Like consonants, vowels in Tianjin Mandarin are identical to those in Beijing Mandarin. However, our transcription adopted here is different from that in Lee and Zee (2003), mainly due to different treatments (i.e., vowel vs. glide) of the so-called “onglide” and the notations that we chose for the diphthongs. Words with denti-alveolar onset consonants were used to reduce contextual influence from the preceding consonant.

2.3.1 Monophthongs

The eight monophthongs in Tianjin Mandarin as well as their respective allophones are illustrated in Table 2.4. Vowels produced in different contexts are treated as phonemes due to their clearly different vowel qualities although they are not contrastive and can be treated as allophones (e.g., Lin, 2007) or contextual variation as in Lee and Zee (2013).
Table 2.4 Words illustrating monophthongs.

<table>
<thead>
<tr>
<th>Open Syllable</th>
<th>Closed Syllable before coda /n/</th>
<th>Closed Syllable before coda /ŋ/</th>
</tr>
</thead>
<tbody>
<tr>
<td>i ti¹</td>
<td>ln² ‘forest’</td>
<td>ln³ ‘zero’</td>
</tr>
<tr>
<td>y ly²</td>
<td>tevn¹ ‘army’</td>
<td>tevn¹ ‘army’</td>
</tr>
<tr>
<td>e tje¹</td>
<td>tjen¹ ‘bump’</td>
<td>tjn¹ ‘bump’</td>
</tr>
<tr>
<td>o to</td>
<td>possessive marker</td>
<td>un¹ ‘when’</td>
</tr>
<tr>
<td>y tyn²</td>
<td>‘to build’</td>
<td>’to get’</td>
</tr>
<tr>
<td>e tu¹</td>
<td>‘metropolis’</td>
<td>‘more’</td>
</tr>
<tr>
<td>o two¹</td>
<td>‘army’</td>
<td>‘east’</td>
</tr>
</tbody>
</table>

Figure 2.3a shows the mean F1 and F2 values of 50 samples for each monophthong produced in open syllables by measuring the vowel midpoint. /ə/ is not included in Figure 2.3a because open syllables with /ə/ can only occur as neutral-tone syllables which cannot be produced in isolation. (See section 5.3 in this chapter for more details.) Monophthongs occurring in closed syllables with denti-alveolar and velar nasal coda are plotted in Figure 2.3b.

![Figure 2.3 F1 and F2 values of monophthongs produced in open syllables (a) and their respective allophones in closed syllables (b).](image)

There are three front high vowels in Tianjin Mandarin. /i/ and /y/ (as in /ti¹/ ‘low’ and /ly²/ ‘donkey’) are front close vowels contrasting only in the rounding of the lips. In closed syllables, /i/ and /y/ are realized as their lax counterparts /ɪ/ as in /ln²/ ‘forest’ and /ln³/ ‘zero’ and /y/ as in /tevn¹/ ‘army’, respectively. When these two high front vowels are followed by nasal codas, an offglide [ə] is inserted as the articulation of the vowel transits to the vocal configuration for the following coda, which is illustrated in Figure 2.4 where the spectrogram of the syllable /tʰn¹/ ([tʰn¹]) ‘to listen’ in Tianjin Mandarin is plotted against that of the syllable /snh/ ‘sing’ in American English (Ladefoged, 1999). In the latter, there is a clear and sharp acoustic boundary between the vowel and the nasal codas without the presence of a transitional schwa.

/e/ is a front close-mid vowel, which can occur in open syllables; while in closed syllables, we only observe the front open-mid vowel /ɛ/. In both syllable types, a
preceding glide (i.e., /j/, /ɥ/, /w/) is obligatory as in /tje¹/ ‘dad’ and /tjen¹/ ‘bump’. Furthermore, in closed syllables, /ɛ/ only occurs before the denti-alveolar nasal coda /n/.

a. /tʰɛ¹/  

b. /sɪŋ/

**Figure 2.4** Spectrogram comparison of the syllable /tʰɛ¹/ in Tianjin Mandarin (a) vs. the syllable /sɪŋ/ in American English (b).

The central vowel /ə/ , commonly known as schwa, can occur in open syllables with only neutral tone as in /tə/ possessive marker or closed syllables with both nasal coda /n/ and /ŋ/ (as in /tan²/ ‘to drag’ and /təŋ¹/ ‘lamp’). As can be seen from Figure 2.3b, in closed syllables, the realization of /ə/ is slightly influenced by different following nasal codas due to their closure gestures at different places of articulation. Before the alveolar nasal coda /n/, /ə/ is slightly more frontal than that before the velar nasal codas /ŋ/.

/ɜ/ is a mid low vowel, which is transcribed as the cardinal /a/ in Lee and Zee (2003). /ɜ/ can occur in open syllables as in /tɜ¹/ ‘to build’. In closed syllables, /ɜ/ is realized differently according to different nasal codas, as the front low /a/ before denti-alveolar nasal coda /n/ (as in /tan¹/ ‘single’) and as the back low /a/ before velar nasal coda /ŋ/ (as in /təŋ¹/ ‘when’). Lee and Zee (2003) treat the three variants in Beijing Mandarin as the same phoneme. We would like to highlight their salient differences in the vowel quality and opted to transcribe them as three different phonemes.

/ʊ/ is a back close vowel. It can occur in open syllables as in /tʊ¹/ ‘metropolis’; in closed syllables before the velar nasal coda /ŋ/, it is realized as its lax counterpart /ʊ/ as in /tʊŋ¹/ ‘east’.

Both /ɤ/ and /o/ are back close-mid vowels differing in the lip shapes as in /tɤ²/ ‘to get’ and /təʊ¹/ ‘more’ where an onglide /w/ is obligatory before /o/.

**2.3.2 Diphthongs**

Diphthongs in Tianjin Mandarin can only occur in open syllables, as illustrated in Table 2.5. Figure 2.5 shows the mean F1 and F2 values of 50 samples for each diphthong by measuring the respective midpoint of the two parts in the vowel. Arrows in Figure 2.5 demonstrate the trajectories of the gliding.
Table 2.5  Words illustrating diphthongs.

<table>
<thead>
<tr>
<th></th>
<th>ler²</th>
<th>tae¹</th>
<th>tao¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>ei</td>
<td>‘thunder’</td>
<td>‘dull’</td>
<td>‘knife’</td>
</tr>
<tr>
<td>ae</td>
<td>‘all’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2.5  F1 and F2 values of diphthongs. Gliding trajectories are shown with arrows.

Figure 2.6  Spectrogram comparison of diphthongs /ei/ vs. /æː/ as in syllables /ler²/ ‘thunder’ (a) vs. /lae²/ ‘to come’ (b), respectively.

There are four diphthongs in Tianjin Mandarin, among which /ei, æː/ gliding towards the front (as in /ler²/ ‘thunder’ and /tae¹/ ‘dull’) and /ao, ao/ towards the back (as in /tao¹/ ‘knife’ and /tao¹/ ‘all’). /ei/ and /æː/ are frequently transcribed as /ei/ and /ai/, both gliding towards the same high front target /i/ (e.g., Lee & Zee, 2003; Lin, 2007). However, this is not confirmed by our data. First, we can see from Figure 2.5 that, neither /ei/ or /æː/ really reaches the high front region at the offset part; second, as shown in Figure 2.6, the ending point of /ei/ vs. /æː/ have very different spectrograms especially in
terms of F1 and F2, where the offset part of /et/ shows clearly lower F1 but higher F2 values than that of /æt/. The same differences can also be observed for /æt/ vs. /ət/, where both have been frequently transcribed to glide towards the back high vowel /u/ (e.g., Lee & Zee, 2003; Lin, 2007).

2.3.3 Rhotic vowel and er-hua

There is a rhotic vowel /ə/ in Tianjin Mandarin which is produced as an r-colored schwa, with the tip of tongue up at the end of the vowel. The syllable /ə/ can only occur independently in three syllables: /ə²/ ‘son’, /ə³/ ‘ear’ and /ə⁴/ ‘two’. When /ə/ is produced with neutral tone, it is used as a diminutive suffix.

When adding the suffix /ə/ to a noun, typically, the two syllables are coalesced into one rhoticized syllable in the output form, with the vowel part of the preceding syllable directly rhoticized and only the lexical tone of the preceding syllable is kept, e.g., /nu²/+/ə/→/nu-ə⁴/ ‘there’ (as compared to /nu⁴/ ‘that’). There are also other rhoticizing processes in the following types of syllable structures:

In open syllables, if the vowel is /æ/ only the /a/ part is rhoticized while /ɛ/ is deleted, e.g., /pʰæɛ²/ + /ə²/ → /pʰæ̃ɛ/ ‘badge’ (as compared to /pʰæɛ²/ ‘card’); if the rhyme is /e/ /et/ or syllabic consonants, the entire rhyme part is replaced with /ə/ e.g., /per²/ + /ə²/ → /pə⁴/ ‘very’ (as compared to /per⁴/ ‘double’).

In closed syllables, if the coda is /n/, only the vowel is rhoticized, while the coda is deleted, e.g., /pαn⁴/ + /ə²/ → /pαn⁴/ ‘partner’ (as compared to /pα⁴/ ‘campanion’); if the coda is /ŋ/, the coda is realized with the nasalization of the vowel, and the entire nasalized rhyme is rhoticized, e.g., /xwan²/ + /ə²/ → /xwan²/ ‘yolk’ (as compared to /xwan²/ ‘yellow’). Similar rhoticization processes have been reported in Lee and Zee (2014) for Beijing Mandarin (although the vowels are transcribed differently).

2.4 Syllable structure & phonotactics

The syllable structure in Tianjin Mandarin is (C/G)V(C). C stands for consonants. Except for /ŋ/, all consonants can occur at the initial onset position of a syllable. G stands for glides such as /j/ in /je¹/ ‘duck’, /w/ in /wu¹/ ‘frog’ and /ŋ/ in /qe¹/ ‘to restrict’. V stands for vowels. Coda is optional, and only one nasal consonant (/n/ or /ŋ/) is allowed (as in /tan¹/ ‘single’ or /tan¹/ ‘when’). /n/ is the only consonant that appears both at the beginning and end of a syllable (as in /nu³/ ‘to include’ and /tan¹/ ‘single’). Onsetless syllables are also possible, as in /æe¹/ (‘sad’).

In addition, there are some co-occurrence restrictions of consonants and vowels in Tianjin Mandarin:

1) Alveolo-palatals /te, teʰ, e/ can only occur before front high vowels /i, y/ (as in /tei¹/ ‘chicken’, /teʰi¹/ ‘seven’, /ei¹/ ‘west’, /tey¹/ ‘to live’, /teʰy¹/ ‘maggot’, /ey¹/ ‘needs’), or their corresponding glides /j, u/ (as in /teje¹/ ‘to connect’, /teʰje¹/ ‘to cut’, /eje¹/ ‘to rest’, /teqe²/ ‘to feel’, /teʰqe¹/ ‘to lack’, /qe¹/ ‘beats’).
2) Complementary to 1), front high vowels /i, y/ and the corresponding glides /j, ɥ/ cannot follow denti-alveolar /ts, tsʰ, s/, post-alveolar /tʃ, tʃʰ, ū/, or velar /k, kʰ, x/; however, /y/ and /ɥ/ can follow denti-alveolar /n, l/ (as in /ny/ 'woman', /ly²/ 'donkey', /nɥe⁴/ 'to abuse', /lɥe⁴/ 'to omit').

3) Mid-close vowels /e, o/ have to co-occur with glides /j, w/, respectively, as in /tje¹/ 'dad', /two¹/ 'more'; back mid-close vowel /x/ cannot follow labial consonants /p, pʰ, m, f/.

4) Glide /w/ cannot be followed by front vowels while /ɥ/ only followed by front vowels (as in /ɥe¹/ 'to restrict'). /j/, however, can be followed by front, central and back vowels as in /ji¹/ 'one', /ja¹/ 'duck', /jan¹/ 'central'.

2.5 Tones

Tianjin Mandarin differs from Beijing Mandarin mainly in the tonal system. It has a different tonal inventory. Moreover, when tones are combined, Tianjin Mandarin exhibits a complex pattern of tonal variability, different from that in Beijing Mandarin.

2.5.1 Lexical tones in isolation

There are four lexical tones in Tianjin Mandarin. Different f0 values have been proposed to describe the tonal contours (e.g. Li & Liu, 1985; Shi, 1986; Wee et al., 2005). Figure 2.7 shows the f0 contours of the four lexical tones elicited in isolation with obstruent onsets. Each tonal contour was obtained by averaging across 50 samples produced by the same male speaker. The f0 values were normalized so that it can be interpreted into the five-scale pitch system using the T-normalization method developed by Shi (1986). Here the intervals 0-1, 1-2, 2-3, 3-4, and 4-5 correspond to 1–5 in Chao (1920)’s pitch annotation system, respectively.

As illustrated in Figure 2.7, Tone 1 (hereafter referred to as T1) is a low-falling tone, of which pitch contour falls from the mid to the lower end of the speaker’s pitch range, as in /laʊ¹/ 'to dredge up'. Tone 2 (T2) is a high-rising tone, whose pitch contour rises from the mid to the upper end of the pitch range, as in /laʊ²/ 'hard-working'. Tone 3 (T3) is a 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, as in /laʊ³/ 'old'. Tone 4 (T4) is a high-falling tone which falls from the upper end to the mid of the pitch range, as in /laʊ⁴/ 'to flood'. It is noticeable that T1 and T4 show very comparable falling f0 patterns but in different registers. T1 was realized in a lower register while T4 in a relatively higher one. Adopting the pitch range scale in Chao (1920), T1 can be transcribed as /31/, T2 as /45/, T3 as /213/, T4 as /53/.
Figure 2.7 Lexical tones in isolation. Lines stand for the mean. Gray areas stand for ±1 standard error of mean. Tone 1 (T1) is illustrated with black line and dark gray area; Tone 2 (T2) with white line and dark gray area; Tone 3 (T3) with black line and light gray area; Tone 4 (T4) with white line and light gray area. Normalized time.

It can be noted that, the lexical tones of Tianjin Mandarin are different from that of Beijing Mandarin except for the dipping tone T3. In Beijing Mandarin, T1 is a high level tone. Contrastingly, there is no level tone in Tianjin Mandarin. More importantly, register, among other acoustic cues, seems to play an important role in falling tone discrimination in Tianjin Mandarin, which is not normally found in Beijing Mandarin.

2.5.2 Tone variability in connected speech

When lexical tones are produced in connected speech, the f0 realization is usually varied either phonetically due to tonal coarticulation or phonologically due to tone sandhi.

2.5.2.1 Tonal coarticulation

Tonal coarticulation in Tianjin Mandarin is bi-directional, including left-to-right carryover effect and right-to-left anticipatory effect. Similar to Beijing Mandarin and most other East-Asian tonal languages, carryover effect in Tianjin Mandarin is assimilatory in nature, while anticipatory effect is dissimilatory. Carryover effect tends to be greater than anticipatory effect both in terms of the magnitude and the temporal extent. In Tianjin Mandarin, carryover effect can be observed in all tonal contexts except when the second tone is the low falling T1, while anticipatory effect is only triggered by low tones (i.e., T1 and T3). Figure 2.8 illustrates the two coarticulatory effects in Tianjin Mandarin. Each tonal contour was obtained by averaging across 12 samples produced by the male speaker. For more details on tonal coarticulation in Tianjin Mandarin, readers are referred to Zhang and Liu (2011) as well as Li and Chen (2016).

As shown in Figure 2.8a, the f0 of a tone can be realized differently due to different preceding tones: when T2 is preceded by a high tone such as T4 (as in /tei\textsuperscript{4} m\textsuperscript{ou}\textsuperscript{2}/...
‘stratagem’), the onset $f_0$ realization of the second T2 is clearly higher than that following a low tone such as T1 (as in /kweɪ mwo/ ‘scale’). In Figure 2.8b, the anticipatory effect is shown as the first tone is realized differently due to different second tones: when T2 is followed by a low tone such as T1 (as in /paɛ mɑʊ/ ‘white cat’), the offset $f_0$ realization of the first T2 shows faster rate of $f_0$ rising than that before a high tone as T4 (as in /tiʃmɑʊ mɪ/ ‘dense’).

In Figure 2.8, the anticipatory effect is shown as the first tone is realized differently due to different second tones: when T2 is followed by a low tone such as T1 (as in /paɛ mɑʊ/ ‘white cat’), the offset $f_0$ realization of the first T2 shows faster rate of $f_0$ rising than that before a high tone as T4 (as in /tiʃmɑʊ mɪ/ ‘dense’).

Figure 2.8 $f_0$ realization of T2 when connected with a high tone (T4) vs. a low tone (T1). T2 as the second tone in a, T2 as the first tone in b. Normalized time.

2.5.2.2 Tone sandhi

Previous impressionistic studies have reported multiple disyllabic tone sandhi rules in Tianjin Mandarin (e.g., Li & Liu, 1985; Hung, 1987; Tan, 1987; Zhang, 1987; Chen, 2000; Wang, 2002; Wee et al., 2005; Hyman, 2007). Three patterns have been confirmed with experimental data: T1T1, T3T3, T4T1 (Li & Chen, 2016), with no complete neutralization with their respective targeted outputs as proposed in the rules (see also Zhang & Liu, 2011 for similar observations). Figure 2.9 shows the $f_0$ contours of the three tone sandhi patterns. Each tonal contour was obtained by averaging across 12 samples produced by the male speaker.

Figure 2.9 $f_0$ realization of three tone sandhi patterns in Tianjin Mandarin. Normalized time.
It can be seen from Figure 2.9 that in all the three tonal combinations, the first tone was realized with a drastically different contour from its canonical form (compared to their respective contours in Figure 2.7). In T1T1 (Figure 2.9a), the first T1 is not a low falling tone any more as its canonical form. Instead, the offset of the tone was raised to a great extent, as in /teji₁ mao₁/ ‘domestic cat’. In T3T3 (Figure 2.9b), the first T3 was realized with a rising contour, which is different from the dipping contour of T3 in isolation, as in /wu³ ny³/ ‘dancing girl’. In T4T1 (Figure 2.9c), the first tone shows a high rising f0, as in /xao⁴ me¹/ ‘stepmother’. It is again very different from the high falling contour when the tone was pronounced in isolation. Among the three tone sandhi sequences, T3T3 is near-merged with its so-called sandhi output T2T3 (as in /tʰwo² njao³/ ‘ostrich’), while T1T1 and T4T1 are not merged with any tonal sequence, as claimed as T3T1 (as in /nae³ me¹/ ‘nanny’) and T2T1 (as in /pae² mao¹/ ‘white cat’) in the literature.

When these bisyllabic constituents occur in trisyllabic sequences, tone sandhi does not consistently apply as reported in the literature (e.g., Li & Liu, 1985; Chen, 2000; Ma, 2005; Wee et al., 2005). Instead, only T3T3 was found to apply sandhi changes consistently and regardless of its alignment in the trisyllabic sequences, as illustrated with an example in Figure 2.10. In both T3T3T2 (as in /xwo³ pe³ teje²/ ‘torch festival’) and T2T3T3 (as in /xwe³ pja³ teja³/ ‘Marble Pillar Award’) sequences, the first T3 was realized with a rising f0 contour as found in the disyllabic data (Figure 2.9b), indicating the application of tone sandhi in both contexts.

By contrast, the patterns T1T1 and T4T1 can only be applied when the patterns are right aligned in the trisyllabic sequences, as shown with an example for T1T1 in Figure 2.11. In T2T1T1 (Figure 2.11b) where the T1T1 sequence is right-aligned as in /xon² tan¹ teʰy¹/ ‘red light district’, the middle T1 was realized with a rising f0 contour comparable to that in Figure 2.9a, suggesting the application of tone sandhi in this case. When T1T1 is left-aligned (Figure 2.11a) as in /kon¹ Jian¹ tey²/ ‘Trade and Industry Bureau’, tone sandhi does not apply since the first T1 was realized with a falling contour, just like its canonical form as in Figure 2.7. For further details, see Li and Chen (2012a, 2016).

Figure 2.10 f0 realization of trisyllabic sequences when T3T3 is left-aligned (a. T3T3T2) vs. right-aligned (b. T2T3T3). Normalized time.
2.5.3 Neutral tone

As in Beijing Mandarin, neutral tone also exists in Tianjin Mandarin. The neutral tone syllables are those that do not surface with any of the lexical tones. As these syllables always occur in the prosodically weak positions like in Beijing Mandarin (Chen & Xu, 2006), they are usually produced with acoustic reduction in the segmental aspects, where the onset consonant of the neutral tone syllable is sometimes voiced, and the vowel might be centralized or even deleted. For example, in the word /kɤ1 kɤ/ ‘elder brother’, in which the second syllable is a neutral tone syllable, its onset consonant is often voiced, and the vowel can be reduced to a schwa, as in [kɤ1 ga]. Suprasegmentally, neutral tone syllables are usually produced with short duration (typically about half of the duration for a lexical tone syllable); and their \( f_0 \) realization also exhibits much variability (Wang, 2002).

Neutral tone syllables in Tianjin Mandarin never occur independently; instead, they always follow a lexical tone syllable in a disyllabic lexical item. Typical neutral tone syllables include grammatical morphemes (e.g., possessive marker /təə/ in A), the second syllable of a disyllabic lexical item (e.g., /li/ in B), and the final syllable of a reduplicated form (e.g., /kɤ/ in C).

A.  /wo3 təə/  ‘mine’  
B.  /pwo1 li/  ‘glass’  
C.  /kɤ1 kɤ/  ‘elder brother’

Like in Beijing Mandarin, \( f_0 \) realization of neutral tone in Tianjin is much influenced by the preceding lexical tones, due to its prosodic weak position. A stable mid low tonal target can be observed, but only when given enough time as in Chen and Xu (2006).

Previous studies observe special rising neutral tone realization when it is followed by the low falling T1 (Wang, 2002; Li & Chen, 2011) for example in /pʰe1 tɻɔ mɤ1/ ‘carrying Mom on the back’, as illustrated in Figure 2.12. Each tonal contour was obtained by averaging across 6 samples produced by the male speaker.

However, the rising neutral tone realization is due to the general raising effect of T1 upon its preceding tones (Li & Chen, 2012b; cf. Wang, 2002). When there are multiple...
neutral tone embedded as shown in Figure 2.13a, the neutral tone first aims to realize its own mid-low tonal target by the end of the second neutral tone, as in the example sentence /tʰė ʃwȯ mė mė mə̇ mė nȧ ʃi lȧ nė kȯ eʃeṅ tė jəu̇ 2/. ‘He said mothers’ cats messed up that cotton ball.’ The raising could only be observed over the very last neutral-tone syllable. Importantly, the rising effect can be blocked by a major prosodic boundary as in Figure 2.13b, as in the example sentence /tʰu̇ ʃwȯ mė mė mə̇ tȯ tsə̇ jə̇ 1 tė ʃu̇ lȧ saṅ pȧ kə̇ waė 4 tė jəṅ 2/. ‘He said mothers’ had increased by 300 yuan.’

![Figure 2.12](image)

**Figure 2.12** $f_0$ realization of one neutral tone (N) embedded between two T1s. Normalized Time.

**a. No Major Boundary**

![Figure 2.13a](image)

**b. With Major Boundary**

![Figure 2.13b](image)

**Figure 2.13** $f_0$ realization of three neutral tones (N1N2N3) embedded between two T1s without (a) or with (b) a major prosodic boundary following the neutral tone sequence. Normalized Time.

### 2.6 Transcription of recorded passage ‘north wind and the sun’

This passage is transcribed phonemically based on the symbols described in the consonant and vowel part. Tones are marked with numbers instead of tonal values. Tones undergoing sandhi changes are marked with the number of the original tone with brackets. Neutral tone syllables are not marked with tone numbers.
有一天，

北风和太阳正在说谁的本事大。

正好有个穿斗篷的人走过来。

他俩说，谁能能让那个人脱掉斗篷。

就算谁厉害。

那个人就把斗篷裹得越紧。

北风没辙，只好放弃。

接着，太阳晒得热烘烘的，

那个人立马把斗篷脱掉了。

然后，北风只能认输。