The Phonology of Incomplete Tone Merger in Dalian

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Liu, Te-hsin

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1. Introduction

The thesis of tone merger in northern Chinese dialects was first proposed by Wang (1982), and further developed by Lien (1986), the migration of IIb (Yangshang) into III (Qu) being a common characteristic. The present work aims to provide an update on the current state of tone merger in northern Chinese, with a special focus on Dalian, which is a less well-known Mandarin dialect spoken in Liaoning province in Northeast China.

According to Song (1963), four lexical tones are observed in citation form, i.e. 312, 34, 213 and 53 (henceforth Old Dalian). Our first-hand data obtained from a young female speaker of Dalian (henceforth Modern Dalian) suggests an inventory of three lexical tones, i.e. 51, 35 and 213. The lexical tone 312 in Old Dalian, derived from Ia (Yinping), is merging with 51, derived from III (Qu), in the modern system. This variation across decades is consistent with dialects spoken in the neighboring Shandong province, where a reduced tonal inventory of three tones is becoming more and more frequent.

However, the tone merger in Modern Dalian is incomplete. A slight phonetic difference can be observed between these two falling contours: both of them have similar F0 values, but the falling contour derived from Ia (Yinping) has a longer duration compared with the falling contour derived from III (Qu). Nevertheless, the speaker judges the contours to be the same. Similar cases of near mergers, where speakers consistently report that two classes of sounds are “the same”, yet consistently differentiate them in production, are largely reported in the literature. Labov, Yaeger and Steiner (1972), for example, observe that speakers differentiate words like source and sauce in production, but report no distinction between them in perception. Other varieties of English exhibit as well parallel cases of near mergers, such as fool and full in Albuquerque (Di Paolo 1988), too vs. toe and beer vs. bear in Norwich (Trudgill 1974), line vs. loin in Essex (Labov 1971, Nunberg 1980), and meat vs. mate in Belfast (Harris 1985, Milroy and Harris 1980).

A question arises as a consequence of the tone merger in progress in tone sandhi. How will the merged tone behave during phonological processes? The tone patterns in disyllabic sequences in Modern Dalian suggest that the falling contour, derived from Ia and merging into III, should be analyzed as underlyingly /312/, i.e. the lexical tone in the sixties. However, the current citation form of
Ia, /51/, competes with /312/, such that an exception can be found in tone sandhi. The above facts attest that sound change is not lexically abrupt, and could take a long period of time to complete its course (Wang 1969).

The paper is organized as follows. The thesis of tone merger proposed by Wang (1982), as well as the mechanism of tone merger in northern Chinese, will be presented in Section 2. Section 3 highlights the tone system of Dalian. Some of the dialects in Shandong province experiencing tone merger will be discussed as well. Section 4 presents tone sandhi patterns in disyllabic sequences. A phonological analysis couched within Optimality Theory (Prince & Smolensky 1993) will be proposed to account for the apparently complex sandhi rules in Modern Dalian. Concluding remarks will appear in Section 5.

2. Preamble

2.1 Geographical distribution of linguistic patterns and historical evolution of Sinitic languages

Four tonal categories, referred to by their traditional nomenclature as Ping (I), Shang (II), Qu (III) and Ru (IV), have been firmly established since Middle Chinese (approximately from AD 600 to 900), as reflected in the rhyming dictionary Qieyun (Lu Fayen, AD 601). In Middle Chinese the register of a tone can be predicted from the laryngeal state of its onset: a word with a voiceless onset will take a high-register tone whereas a word with a voiced onset will receive a low-register tone. At a later stage, with the loss of contrast between voiced and voiceless consonants, pitch height originally induced by this contrast is phonologized; an 8-tone system is born.

Northern Chinese dialects generally have fewer lexical tones compared with southern Chinese dialects. Haudricourt & Hagège (1978) attribute this tonal impoverishment to the contact of the northern variety with non-tonal languages such as Mongolian in the 14th century and Manchu in the 17th century. Subsequently, the northern variety lost some of its tones obtained after tone split. And since the influence of Mongolians and Manchus did not reach the south of China, southern Chinese dialects preserve better characteristics of Old Chinese. Accordingly, the geographical distribution of linguistic patterns is a good reflection of their historical development in Sinitic languages. For example, in Xiamen, a southern Min dialect, speakers use [tiŋ²¹³]鼎, a three-legged ancient Chinese cooking vessel, to designate "pot"; in Shanghai and in Beijing (Mandarin Chinese), speaker use respectively [hwɔ⁵¹]镬 and [kwɔ⁵⁵]鍋 to name the same utensil. The geographical distribution [tiŋ²¹³]鼎 (south China) → [hwɔ⁵¹]镬 (central China) → [kwɔ⁵⁵]鍋 (north China) exactly mirrors the evolution of the word usage from Ancient Chinese, Middle Chinese to Modern Chinese. With respect to consonant systems, most southern dialects, such as Cantonese, still preserve final stops of Ancient Chinese –p, –t and –k while these codas are reduced to a glottal stop in most Wu dialects. Beijing

The correlation between voicing distinction of initial consonant and register was noted by Maspéron (1912) and Karlgren (1926) for Vietnamese and Chinese respectively, and was later extended to other East and Southeast Asian languages by Haudricourt (1954, 1961), Matisoff (1973) and Haudricourt & Hagège (1978). With respect to other tonal languages, Hyman (1973 a, b) and Hyman & Schuh (1974) also note a similar synchronic correlation between consonant types and F0 in African tonal languages, even if it did not give rise to tonal split.
Mandarin is more innovative since, if the two final nasals –ŋ and –n are considered part of the nucleus, it is virtually an open syllable language. Back in tones, most southern dialects have seven, eight or nine lexical tones (nine tones in Cantonese, seven tones in Xiamen), whereas northern dialects have only three or four lexical tones (4 tones in Beijing Mandarin and in Old Dalian). Tone systems of Northern Chinese dialects can thus be viewed as an innovation subsequent to tone split.

2.2 The thesis of tone merger (Wang 1982)

Wang (1982) first proposes a thesis of tone merger to account for the mechanism of tonal impoverishment in northern Chinese dialects, taking the 8-tone system, obtained after bipartition from four tone categories, as the starting point:

<table>
<thead>
<tr>
<th>(1)</th>
<th>MC tone categories</th>
<th>MC initials</th>
<th>Tone split</th>
<th>Tone merger</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (Ping)</td>
<td>p a</td>
<td>p a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II (Shang)</td>
<td>p a</td>
<td>p a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III (Qu)</td>
<td>p a</td>
<td>p a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV (Ru)</td>
<td>p a</td>
<td>p a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We shall follow one convention in the Chinese linguistics tradition in using I, II, III, and IV to stand for the four Middle Chinese tone categories, and a and b for the Yin (upper) and Yang (lower) registers respectively.

The migration of IIb into III is common to the northern variety. Lien (1986) remarks that this process occurred no later than three hundred years following the completion of Qieyun (601 AD): in Corrigenda (895 AD), Li Fu criticized Qieyun (601 AD) for mistakenly classifying “bian” (argue) and “jiu” (uncle) under Tone II. It proves that, in Li Fu’s speech at that time, words derived from IIb and those from III were already indistinguishable ³:

(2) a bian “argue” (derived from IIb) b jiu “uncle” (derived from IIb)
    a’ bian “preface” (derived from III) b’ jiu “old” (derived from III)

If the migration of IIb into III already took place in the ninth century, it means that the tonal impoverishment referred to by Haudricourt & Hagège (1978) actually began before the arrival of

³ See also Li Rong (1985): Lun Lifi dui Qieyun de Piping ji qi Xianguan Wenti (On LiFu’s Criticism of Qieyun and related matters). Zhonghuo Yuren 184: 1-9.
Mongolians in the 14th century, and that it was not originally triggered by the contact with non-tonal languages.

The question arises as to what factor initiated the migration of IIb into III in the ninth century. Conducting a survey of 480 northern Chinese dialects, Lien (1986) observes that Tone III is a merging category while Tones I, II and IV are merged categories. With respect to tone values of Tone III, his quantitative analysis reveals that high falling contour tone is by far the greatest in number in terms of tone tokens for Tone III, followed by high level tone.

Lien attributes that underlying force that pulls the rest of the tones into III to perceptual reasons, high falling contour tone being the most favored tone feature in speech perception. Actually, Broselow et al. (1987) tested American listeners’ perception of Mandarin tones when the tones were presented in isolation as well as in the context of two and three syllables. Their finding showed that Tone 4, the falling contour, was the most easily identified tone when presented in isolation, and in the final position of doublets and triplets. Moreover, from a production point of view, falling contour is also favored in languages: there is a universal intonation tendency to begin a declarative sentence with a high tone and finish it by a low tone. Liberman & Pierrehumbert (1984) observe as well a final lowering in declarative sentences in English. Pierrehumbert & Beckman (1988) underline that this phenomenon occurs, in Japanese, in declarative sentences but not in interrogative sentences. Likewise, a final lowering is observed in Lomongo (Hulstaert 1961) and Vietnamese (Nguyễn & Boulakia 1999).

Several physiological explanations have been proposed in terms of the lowering of larynx height and the gradual reduction of subglottal pressure (Collier 1975, Ohala 1978). Sinitic languages being monosyllabic, every word carries a lexical tone and some words can appear in isolation form. It is tempted to posit that, in Chinses, a word is more or less like the contraction of a sentence. Consequently, falling contour is by default the most favored tone feature in Sinitic languages, and the convergence of Tones I, II and IV to Tone III seems an inevitable course in the future developments of northern Chinese dialects.

Lien’s survey, written in 1986, mostly cites data reported in the 1960s and 1970s. As suggested in his paper, northern Chinese dialects of that time still keep the distinction between Ia and Ib. However, in a recent report on the dialects spoken in east Shandong province, a merger of Ib into III is observed (Qian et al. 2001). The same tendency is found in our data, where a reduced tonal inventory of three tones is observed, as we shall see in the next section.

3. Dalian - tone merger in progress
3.1 Tone system of Modern Dalian

Dalian is a city located at the south of Liaodong Peninsula, in Liaoning Province in Northeast China (see Figure 1). As a city located along the coast and facing Shandong Peninsula, most speakers of Dalian and other cities of Liaodong Peninsula were originally from Shandong. Dialects spoken in these two peninsulas are generally called Jiao-Liao Mandarin.
Most young speakers speak both Dalian and Beijing Mandarin, the latter being taught in schools. Our informant is a thirty-four year old female who lived in Dalian until she was 23, then came to the US to join her husband. She communicates with her husband, also from the same county, in Dalian but speaks Mandarin Chinese with speakers from other provinces in China. Little work has been done on this dialect. Some description is found in the sixties (Song 1963, 1969); however, there is no description on the tone sandhi of Dalian in Song’s papers. Song’s 1963 paper is the major reference used by Lien (1986) and still by Hirayama in his paper on the distribution of tonal systems in northern Chinese written in 2000.

On a basis of an elicitation list of 204 words, three lexical tones are classified in citation form, i.e. 51, 35, 213. The informant is then asked if the words in one tone category all carry the same tone. The full elicitation list is illustrated in §7.1.

(3) a. 51 [ta] “big” b. 35 [ta] “to reply” c. 213 [ta] “to hit”
The correspondence of these tones with Middle Chinese is shown as follows:

(4)

<table>
<thead>
<tr>
<th>MC tone categories</th>
<th>Phonation type of MC initials</th>
<th>Examples (Dalian)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (Ping)</td>
<td>Yin (a) aspirated, voiceless</td>
<td>toŋ⁵¹ “east”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tʰoŋ⁵¹ “to cross”</td>
</tr>
<tr>
<td></td>
<td>Yang (b) sonorant, voiced</td>
<td>tʰoŋ³⁵ “kid”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nan⁵¹ “man”</td>
</tr>
<tr>
<td>II (Shang)</td>
<td>Yin (a) aspirated, voiceless</td>
<td>pi²¹³ “to compare”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kʰu²¹³ “bitter”</td>
</tr>
<tr>
<td></td>
<td>Yang (b) sonorant, voiced</td>
<td>si⁵¹ “similar”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>zən²¹³ “to dye”</td>
</tr>
<tr>
<td>III (Qu)</td>
<td>Yin (a) aspirated, voiceless</td>
<td>tɛjə⁵¹ “to marry one’s daughter”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tʰu⁵¹ “rabbit”</td>
</tr>
<tr>
<td></td>
<td>Yang (b) sonorant, voiced</td>
<td>taj⁵¹ “bag”</td>
</tr>
<tr>
<td>IV (Ru)</td>
<td>Yin (a) aspirated, voiceless</td>
<td>merged into three other tones</td>
</tr>
<tr>
<td></td>
<td>Yang (b) sonorant, voiced</td>
<td></td>
</tr>
</tbody>
</table>

There is no closed syllable in Dalian, the entering tone having merged into other tones during historical evolution, just as in other northern dialects.

As can be seen from (4), the falling contour tone has three historical sources apart from some words from the entering tone: Ia, III and IIb. Recall that the merger of IIb with III took place in the ninth century (§2.2); the migration of Ia into III is a relatively recent process.

Our data suggests an inventory of three lexical tones; however, four tones were observed in Song’s data in the sixties, i.e. /312/ (derived from Ia), /34/ (derived from IIb), /213/ (derived from II), /53/ (derived from III). Below is a correspondence between Mandarin Chinese, Old Dalian and Modern Dalian:

(5)     MC category | Mandarin | Old Dalian | Modern Dalian |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ia</td>
<td>55</td>
<td>312</td>
<td>51</td>
</tr>
<tr>
<td>Ib</td>
<td>35</td>
<td>34</td>
<td>35</td>
</tr>
<tr>
<td>IIa</td>
<td>213</td>
<td>213</td>
<td>213</td>
</tr>
<tr>
<td>IIb</td>
<td>51</td>
<td>53</td>
<td>51</td>
</tr>
<tr>
<td>IIIa</td>
<td>51</td>
<td>53</td>
<td>51</td>
</tr>
<tr>
<td>IIIb</td>
<td>51</td>
<td>53</td>
<td>51</td>
</tr>
</tbody>
</table>

Note that not all words derived from IIb bear a falling contour tone: some carry a falling-rising tone, such as [zən²¹³] “to dye.”
In order to know if there exists a phonetic difference between the falling contour tone derived from Ia and the one derived from III, we had the informant read nine pairs with five repetitions. We measured then their respective pitch duration. It can be seen in (6) that the contours derived from III have consistently a shorter duration compared with their counterparts derived from Ia:

(6)

<table>
<thead>
<tr>
<th></th>
<th>Duration of /HL/ derived from Ia</th>
<th>Duration of /HL/ derived from III</th>
</tr>
</thead>
<tbody>
<tr>
<td>[hwa] flower</td>
<td>473</td>
<td>[hwa] to paint</td>
</tr>
<tr>
<td>[tʰən] soup</td>
<td>346</td>
<td>[tʰən] hot to touch</td>
</tr>
<tr>
<td>[toŋ] winter</td>
<td>522</td>
<td>[toŋ] to freeze</td>
</tr>
<tr>
<td>[faŋ] perfume</td>
<td>443</td>
<td>[faŋ] to set free</td>
</tr>
<tr>
<td>[fej] to fly</td>
<td>473</td>
<td>[fej] to abolish</td>
</tr>
<tr>
<td>[ši] to lose</td>
<td>431</td>
<td>[ši] soldier</td>
</tr>
<tr>
<td>[san] three</td>
<td>365</td>
<td>[san] to come loose</td>
</tr>
<tr>
<td>[u] house</td>
<td>516</td>
<td>[u] fog</td>
</tr>
<tr>
<td>[faŋ] square</td>
<td>328</td>
<td>[faŋ] to set free</td>
</tr>
<tr>
<td>Average duration</td>
<td>433</td>
<td>Average duration</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>67.77ms</td>
<td>Standard deviation</td>
</tr>
</tbody>
</table>

This result is not surprising given that the falling contour derived from Ia was pronounced as 312 in the 1960s, and a complex contour tone generally has a longer duration compared with a falling contour tone. It is interesting that the quantity of the pitch duration derived from Ia is preserved, even it is merging with the falling tone derived from III.

The next step consists of quantifying the tonal slope of these quasi-minimal pairs, in taking into consideration: (1) duration of the pitch contour (duration), (2) maximum F0 in the falling contour (max F0), which is also the beginning point, i.e. t₀, and (3) minimum F0 in the falling contour (min F0), which is also the endpoint, i.e. t₁. The slope of a contour tone is calculated according to the following equation, according to which its ratio is defined by the change in the F0 (t₁-t₀) divided by the corresponding change in pitch duration (Hsieh 2007):

(7) Slope: \[
\frac{F_0(t_0) - F_0(t_1)}{Time(t_0) - Time(t_1)}
\]
Falling contour derived from Ia  | Falling contour derived from III
---|---
**Gloss** | **Gloss** | **Duration** | **Max F0** | **Min F0** | **Slope** | **Duration** | **Max F0** | **Min F0** | **Slope**

[hwə] flower | [hwə] to paint | 473 ms | 286 Hz | 91 Hz | -0.41 | 363 ms | 268 Hz | 100 Hz | -0.46

[ʰun] soup | [ʰun] hot | 346 ms | 270 Hz | 148 Hz | -0.35 | 328 ms | 277 Hz | 149 Hz | -0.39

[ton] winter | [ton] to freeze | 522 ms | 254 Hz | 78 Hz | -0.34 | 375 ms | 264 Hz | 105 Hz | -0.42

[fun] perfume | [fun] to set free | 443 ms | 252 Hz | 142 Hz | -0.25 | 306 ms | 281 Hz | 192 Hz | -0.29

[fei] to fly | [fei] to abolish | 473 ms | 280 Hz | 115 Hz | -0.35 | 218 ms | 255 Hz | 142 Hz | -0.51

[ɕi] to lose | [ɕi] soldier | 431 ms | 270 Hz | 146 Hz | -0.29 | 342 ms | 287 Hz | 85 Hz | -0.59

[san] three | [san] to come loose | 365 ms | 268 Hz | 152 Hz | -0.32 | 293 ms | 268 Hz | 156 Hz | -0.38

[u] house | [u] fog | 516 ms | 304 Hz | 142 Hz | -0.32 | 456 ms | 280 Hz | 107 Hz | -0.38

[fun] square | [fun] to set free | 328 ms | 260 Hz | 153 Hz | -0.33 | 317 ms | 281 Hz | 176 Hz | -0.33

Average | Average | 433 ms | 272 Hz | 130 Hz | -0.33 | 326 ms | 273 Hz | 135 Hz | -0.42

SD | SD | 67.77ms | 15.54Hz | 26.52Hz | -0.041 | 61.24ms | 9.67 Hz | 34.99 Hz | -0.087

From an average point of view, it can be seen that the minimum F0 and the maximum F0 of these two falling contours are similar; however, given that HL derived from III has a shorter duration\(^5\), it has consequently a greater negative value in tonal slope, and is thus steeper than HL derived from Ia.

Recall that, after classifying the words into three tonal categories, the informant was asked if words belonging to one category carry the same tone. The falling contour category includes words derived from Ia and those derived from III, mixed in a random way. The informant replied that words derived from Ia and those derived from III bear the same tone. The fact that speakers consistently report that two classes of sounds are ‘the same,’ yet consistently differentiate them in production at better than chance level, is largely reported in the literature. Labov, Yaeger and Steiner (1972), for instance, find that speakers differentiate words like *source* and *sauce* in production, but report no distinction between them in perception. Similar near mergers have been reported in other varieties of English (e.g., *fool* and *full* in Albuquerque (Di Paolo 1988); *too* vs. *toe* and *beer* vs. *bear* in Norwich (Trudgill 1974); *line* vs. *loin* in Essex (Labov 1971, Nunberg 1980); *meat* vs. *mate* in Belfast (Harris 1985, Milroy and Harris 1980).

Given that our data is drawn from one informant, a natural question arises as to whether the tone merger in progress in Modern Dalian is due to individual variation. A close look at other Jiao-Liao Mandarin dialects is necessary in order to shed light on what is happening in Modern Dalian.

### 3.2 Tone merger in other Jiao-Liao Mandarin dialects

In Lien’s 1986 survey, the majority of the northern variety still keep the distinction of Tone Ia and

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\(^5\) It should be noted that the difference in duration between Ia and III is *relative* and not absolute: not all words derived from Ia are longer in duration than those derived from III, but a word derived from Ia has a relative longer duration compared to its counterpart derived from III.
Tone Ib, including dialects spoken in Liaoning (42 dialects surveyed) and those spoken in Shandong (32 dialects surveyed). Only four dialects in Shandong and Liaoning embrace the migration of Ib into III:

(9) a. Shandong: Yantai, Wendeng
   b. Liaoning: Dandong, Zhuanghe

A tendency of tone merger from four tones to three tones is observed in the last two decades in Jiao-Liao Mandarin. Working on the dialects spoken in Shandong province, Qian et al. (2001) notice that, in several dialects spoken in east Shandong Peninsula, a migration of Tone Ib into Tone III is observed, especially among young speakers:

(10) MC category Weihai Yantai$^6$ Fushan Haiyang Zhaoyuan Laixie
    Ia  53 31 31 53 214 214
    Ib  (33) (55) (55) (43) (42) (42)
    IIa 214 214 214 213 55 55
    IIb 33 55 55 43 42 42
    IIIa 33 55 55 43 42 42
    IIIb 33 55 55 43 42 42

A comparison with the tendency of tone merger in dialects spoken in Shandong province suggests that Modern Dalian is experiencing a similar process, with Ia migrating into III. The tendency found in Shangdong province gives thus indirect support to the tone merger in progress found in our data.

In Shangdong province, dialects that still maintain the distinction between Ia and Ib are as follows (data from Qian et al. 2001):

(11) MC category Rongcheng Wendeng$^7$ Laiyang Penglai Changdao Longkou
    Ia  42 53 214 313 313 313
    Ib  35 44 31 55 55 55
    IIa 214 214 34 214 214 214
    IIb 44 34 51 42 42 53
    IIIa 44 34 51 42 42 53
    IIIb 44 34 51 42 42 53

$^6$ The Yantai data used by Lien (1986) and Qian et al. (2001) is the same.
$^7$ It is interesting to observe that, in Lien’s old data on Wendeng, a migration of Ib into III is attested whereas in Qian’s more recent data, such a merger is not observed. This inconsistency suggests that the migration of Ib into III is in progress and is still not stable.
Of particular interest are Penglai, Changdao and Longkou, in which the tone value of Ia is 313, similar to that of Old Dalian, where the tone value of Ia is 312.

We have seen that, in Old Dalian, there were two falling-rising tones (312 derived from Ia as well as 213 derived from IIa), and that Ia is merging into III in the modern dialect. It would be worth monitoring the evolution of Penglai, Changdao and Longkou to see if Ia will merge into III, just as in Modern Dalian.

The last question before closing this section concerns why /312/, derived from Ia, is merging with the falling contour, rather than /213/, derived from IIa. Hyman (p.c.) suggests that 312 has greater initial pitch excursion than 213, as shown in (12). Being phonetically more complex, 312, derived from Ia, is thus merging with the falling contour in the modern dialect.

(12)  a. /312/ (derived from Ia)                             b. /213/ (derived from IIa)

The next section will focus on the consequence of the near merger in tone sandhi in Modern Dalian.

4. Tone sandhi in Modern Dalian – a phonological analysis

As noted in the previous section, Ia is migrating into III in the modern dialect. Nevertheless, their underlying contrasts are preserved in tone sandhi contexts:

(13)

<table>
<thead>
<tr>
<th></th>
<th>Ia 51</th>
<th>Ib 35</th>
<th>II 213</th>
<th>III 51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ia</td>
<td>51</td>
<td></td>
<td>35.213</td>
<td></td>
</tr>
<tr>
<td>Ib</td>
<td>35</td>
<td>35.213</td>
<td></td>
<td>51.213</td>
</tr>
<tr>
<td>II</td>
<td>213</td>
<td>35.213</td>
<td>21.35</td>
<td>21.51</td>
</tr>
<tr>
<td>III</td>
<td>51</td>
<td></td>
<td>55.213</td>
<td>55.213</td>
</tr>
</tbody>
</table>

Of sixteen possible combinations, nine sequences are subject to change. In cases where tone sandhi does occur, the second syllable retains its underlying tone. However, when 51 derived from Ia is on the second syllable, it systematically surfaces as 213 whatever the tone of the preceding syllable is. Examples of tone sandhi rules are given in (14):

(14)  a. 51 (Ia) + 51 (Ia)  \rightarrow  35.213  [ts\text{\textsuperscript{h}}\text{\textsuperscript{b}}\text{\textsuperscript{w}}\text{\textsuperscript{h}}\text{\textsuperscript{v}}\text{\textsuperscript{h}}\text{\textsuperscript{n}} t\text{\textsuperscript{h}}j\text{\textsuperscript{e}}n] “Spring”

b. 35 (Ib) + 51 (Ia)  \rightarrow  35.213  [z\text{\textsuperscript{h}}\text{\textsuperscript{v}}n t\text{\textsuperscript{h}}\text{\textsuperscript{e}i}] “one’s wife”
Disregarding the falling contour derived from Ia for the moment, when tone sandhi occurs, it is the first tone that undergoes change. This fact is consistent with Northern Mandarin dialects, all right-dominant, in which the tone of the first syllable, in weak position, is subject to tone change under certain circumstances.

If Dalian is also a right-dominant language, why does /51/ derived from Ia surface as [213] on the second syllable? In other words, why are the falling contour derived from Ia and the one derived from III realized differently in disyllabic sequences while they are pronounced as a falling contour in citation form?

The falling tone derived from Ia systematically surfaces as [213] on the second syllable. Recall that in Song’s 1963 data, the lexical tone derived from Ia was /312/, a falling-rising contour tone. It seems reasonable to hypothesize that, in Modern Dalian, the surface tone [213] of Ia on the second syllable is actually the lexical tone /312/ in Old Dalian, and that it has merged with the falling contour in the modern dialect. The rationale of this conjecture is that, in a right-dominant language, when a disyllabic sequence undergoes tone sandhi, it is the tone of the first syllable that is subject to change, and the lexical tone of the second syllable remains the same. Putting aside the slight transcription difference, both 312 and 213 are falling-rising contour tones.

We posit that the underlying form of Ia is 21(3), with a final floating high tone. The difference between Ia and III resides in that the former has a final floating high tone whereas the latter has a fixed final high tone:

(15)  

\[
\begin{array}{c|c|c|c}
\text{Underlying form} & \text{Citation form} \\
\hline
\sigma & \sigma \\
M & L & H & M & L & H & L
\end{array}
\]

It is well known that different informants pronounce tones with a slight phonetic difference, and not all describers transcribe tones in the same way: a same falling-rising contour tone might be transcribed as 413, 313 or 312 by different persons. This transcription difference does not change the fact that they all represent one single phonological object, i.e. a dipping tone.
b. 213 derived from III

\[ \sigma \]

At a later stage, the floating high tone of Ia is delinked in citation form, and the remaining part is fused with the falling contour derived from III after a rule of register adjustment. However, the underlying contrasts between Ia and III are still preserved in tone sandhi\(^9\). Assuming this analysis, we can say that Dalian is a right-dominant language, and that the second syllable retains its lexical tone just as other northern Mandarin dialects.

We can now focus on sandhi tones on the first syllable. Two kinds of sandhi tones are observed: the first kind of sandhi tones retains the initial portion of a lexical tone, such as \[55\] and \[21\] (underlined and boldfaced), which represent the initial portion of /51/ and /213/ respectively; the second kind of sandhi tone is \[35\], which can only be followed by /213/, as shown in (16):

\[(16)\]

<table>
<thead>
<tr>
<th></th>
<th>Ia 51</th>
<th>Ib 35</th>
<th>II 213</th>
<th>III 51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ia</td>
<td>35.213</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ib</td>
<td>35.213</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>35.213</td>
<td></td>
<td>21.35</td>
<td>21.51</td>
</tr>
<tr>
<td>III</td>
<td>55.213</td>
<td>55.213</td>
<td>55.213</td>
<td></td>
</tr>
</tbody>
</table>

With respect to the first kind of sandhi tones, the question arises as to why the initial portion of a

\(^9\) Tone sandhi preserves an earlier stage of a language is a frequent phenomenon in Sinitic languages. In Jinjing (Min dialect) for example, there are seven lexical tones but eight sandhi tones. The tone category III (Qu) has two sandhi tones:

(a) puā31 → puā55 lɔ31 « halfway »
(b) pŋ31 → pŋ11 si24 « spoon »

Ting (1984) remarks that, from a diachronic point of view, (a) had a high register and (b) had a low register; these two registers have merged into one lexical tone in the modern dialect. On the basis of sandhi tones, we can conclude that there are seven lexical tones but eight base tones in this dialect. Another example comes from two dialects of Lingao on the Hainan Island (Ting 1982): there are six lexical tones in these two dialects, five of which are the same. The remaining tone is 11 in the A dialect, and 35 in the B dialect. There is no sandhi tones in the A dialect, and the sandhi tone in the B dialect is just 11. A comparative analysis implies that the base tone in B is 11. Ting’s position is echoed by Ballard (1988:107):

“Some scholars have alleged that there are always fewer tone distinctions in tone sandhi positions than in isolation, and this ‘fact’ is used as an argument for taking isolation values as basic or underlying in any given tone system. In a certain sense, tone sandhi does imply loss...however, this reduction is taken from the point of view of a tone system with eight tones, whereas Shanghai, Suzhou, Danyang, and Zhenhai already have isolation tone systems with fewer than eight tones...the isolation system plus the sandhi system allow for the internal reconstruction of eight tones in all of the dialects...in other words, the tone sandhi systems often reflect distinctions that have been lost in the isolation values for the tones....”

This hypothesis is reminiscent of the liaison in French, a phenomenon of segmental sandhi, whose conservative character is largely admitted: take the word grand for example, it was written as grant and was pronounced [ɡʁat] both in masculine and in feminine in the twelfth century. The final consonant, in weak position, dropped, but is preserved if the following word begins with a vowel. The change in spelling (grant → grand) can be explained by the influence of Latin etymology grandis, and allows to illustrate the regular alternation between grand and grande (an alternation such as gran ~ grande or grant ~ grande would be weird and irregular) as well as the lexical relation with grandeur, grandir, grandiloquent, etc.
first syllable, in weak position, is generally preserved.

Beckman (1998) proposes that root-initial syllables, syllable onsets, roots, and stressed syllables are privileged positions that are generally immune to phonological processes, whereas non-initial syllables, syllable codas, affixes and unstressed syllables have more chance to undergo phonological processes:

(17) Privileged positions Non-privileged positions
- Root-initial syllables vs. - Non-initial syllables
- Syllable onsets vs. - Syllable codas
- Roots vs. - Affixes, clitics, function words
- Long vowels vs. - Short vowels
- Stressed syllables vs. - Unstressed syllables

Following Beckman, Barnes (2001) and Smith (2002) argue that the privileged positions enjoy some perceptual advantage in the processing system, via either psychological or phonetic prominence, over the complement set of non-privileged positions. Zoll (1997) furthermore proposes a notion of *multiple prominence* in tone mapping, replacing the notion of uniform accent:

(18) Prominent positions in tone mapping (Zoll 1997)

a. imposed METRICAL penult, ante-penult, etc.
b. inherent PERIPHERAL initial and final syllable in a domain
c. inherent ORGANIC long vowels, vowels with high sonority, etc.

Zoll (1997) observes that there exist cases in which the grammar refers to the distinction between inherent and metrical positions. In Safwa, a Bantu language for instance, peripheral and metrical positions must be distinguished in order to explain the non-uniform behavior of different noun classes with respect to tone mapping\(^{10}\).

Back in Dalian, the second syllable is metrically strong, and thus preserves its underlying lexical tone. The first syllable, in metrically weak position, is not capable of carrying a complex contour and undergoes tone sandhi. We shall assume that it is more significant for the first syllable to retain its initial tonal segment, *inherently* prominent, than to retain its final segment. Consequently, it is the final tonal segment of the first syllable that drops. This observation can be formulated by the following constraint:

(19) INITIALTONE/\(\sigma_1\): Initial tone segment on the first syllable should be preserved in the output.

---

\(^{10}\) Li (2003) further develops this idea and proposes a theory of dual prominence to account for tone sandhi processes in Zhenhai, a Wu dialect: input tones occupying different prominent positions are preserved in the output; their realization in the output is determined by the location of stress, such that an input tone in initial syllable, metrically weak but inherently strong, is preserved and realized on the second syllable, metrically strong.
In other words, the initial portion of a tone has virtually the same status as a syllable onset, and a final tonal segment is the mirror image of a syllable coda. As a result, an initial tonal segment is generally preserved in tone sandhi.

The following question naturally arises: if the initial tonal segment on the first syllable tends to be preserved in tone sandhi, what triggers its deletion and the violation of INITIAL TONE/σ₁ in (20)?

(20) a. 51 (Ia) + 51 (Ia) → 35.213 [tsʰwʰn tʰjɛn] “Spring”
b. 35 (Ib) + 51 (Ia) → 35.213 [zyn tɕʰ] “one’s wife”
c. 213 (II) + 51 (Ia) → 35.213 [ku ʂu] “old books”
d. 213 (II) + 213 (II) → 35.213 [jan ʂi] “gum (of eyes)”

In (20), different inputs yield the same output [35.213], and Ia and II both surface as a dipping tone on the second syllable. As stated in (15), this apparent irregularity can be explained by assuming that Ia has a final floating high tone and II has a final fixed high tone. The reason why examples in (20a, c, d) have the same output can be explained in the same fashion:

(21) a. 51 (Ia) + 51 (Ia) → 35.213

\[
\begin{array}{c}
\sigma \\
M & L & H \\
\sigma \\
M & L & H
\end{array}
\rightarrow
\begin{array}{c}
\sigma \\
M & L & H \\
\sigma \\
M & L & H
\end{array}
\rightarrow
\begin{array}{c}
\sigma \\
M & H \\
\sigma \\
M & L & H
\end{array}
\]

b. 213 (II) + 213 (II) → 35.213

\[
\begin{array}{c}
\sigma \\
M & L & H \\
\sigma \\
M & L & H
\end{array}
\rightarrow
\begin{array}{c}
\sigma \\
M & L & H \\
\sigma \\
M & L & H
\end{array}
\rightarrow
\begin{array}{c}
\sigma \\
M & H \\
\sigma \\
M & L & H
\end{array}
\]

c. 213 (II) + 51 (Ia) → 35.213

\[
\begin{array}{c}
\sigma \\
M & L & H \\
\sigma \\
M & L & H
\end{array}
\rightarrow
\begin{array}{c}
\sigma \\
M & L & H \\
\sigma \\
M & L & H
\end{array}
\rightarrow
\begin{array}{c}
\sigma \\
M & H \\
\sigma \\
M & L & H
\end{array}
\]

In (21), the correct surface forms can be derived by assuming that the initial tonal segment on the first syllable is delinked. The remaining low rising tone [LH] is raised to [MH] due to a register
adjustment rule. The question is: why is the sandhi tone [35] preferred over *[21], the latter respecting INITIALTONE/α1?

Let’s first observe the number of pitch changes in the input and in the output:

<table>
<thead>
<tr>
<th>Tone sandhi rules</th>
<th>Input pitch changes</th>
<th>Output pitch changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>213+51</td>
<td>4</td>
<td>21.51</td>
</tr>
<tr>
<td>51+213</td>
<td>4</td>
<td>55.213</td>
</tr>
<tr>
<td>213+35</td>
<td>3</td>
<td>21.35</td>
</tr>
<tr>
<td>213+213</td>
<td>4</td>
<td>35.213^11</td>
</tr>
</tbody>
</table>

Two remarks are in order here: on the one hand, Dalian being a right-dominant language, the first syllable, in weak position, is not capable of carrying a complex contour tone^12; on the other hand, it can be observed from (22) that the outputs never have more than three pitch changes.

In other words, there seems to be a limit on size in terms of the number of possible pitch changes in the output. The question is: why can there be no more than three pitch changes on two syllables in Dalian?

Observe that there is a complex contour tone 213 in citation form in Dalian. So it is possible to have at most two pitch changes in citation form. It follows that the number of pitch changes should be inferior or equal to the number of syllables + 1 in a disyllabic sequence:

<table>
<thead>
<tr>
<th>Tone sandhi rules</th>
<th>Input pitch changes</th>
<th>Output pitch changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>213+51</td>
<td>4</td>
<td>21.51</td>
</tr>
<tr>
<td>51+213</td>
<td>4</td>
<td>55.213</td>
</tr>
<tr>
<td>213+35</td>
<td>3</td>
<td>21.35</td>
</tr>
<tr>
<td>213+213</td>
<td>4</td>
<td>35.213^11</td>
</tr>
</tbody>
</table>
The same conjecture goes for Mandarin: there is a complex contour tone 213 in citation form. Consequently, the number of pitch changes cannot exceed three in a disyllabic sequence:

(24)

<table>
<thead>
<tr>
<th>Mandarin</th>
<th>55, 35, 213, 51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximal pitch change</td>
<td>( N \leq S + 1 )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tone sandhi rules</th>
<th>Input</th>
<th>pitches</th>
<th>Output</th>
<th>pitches</th>
</tr>
</thead>
<tbody>
<tr>
<td>213+213</td>
<td>4</td>
<td>35, 213</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>213+55</td>
<td>3</td>
<td>51.55</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>213+35</td>
<td>4</td>
<td>51.35</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>213+51</td>
<td>4</td>
<td>51.51</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

This concordant relationship between tonal inventory and tone sandhi is born out in Tianjin. In this Mandarin dialect, four lexical tones are observed: 55 (H), 35 (LH), 11 (L), 51 (HL) (Chen 2000). There is no complex contour tone in citation form. It follows that the number of pitch changes should be inferior or equal to the number of syllables \( N \leq S \). Actually, when there are two successive contour tones in a disyllabic sequence, the following rules apply:

(25) a. \( \overline{HL} \overline{H}L \rightarrow \overline{L}HL \)

b. \( \overline{LH} + LH \rightarrow H.LH \)

Back in Dalian, we assume that tone sandhi is triggered by the violation of either of the following constraints, which we refer to as TEMPLATIC CONSTRAINTS.

(26) TEMPLATIC CONSTRAINTS (Dalian & Mandarin):

a. \( N \leq S + 1 \) : the number of pitch changes is inferior or equal to the number of syllables + 1;

b. \( N \leq \sigma_1 \) : there can be no more than one pitch change on the first syllable.

In the sequence 213+213, not only are there two pitch changes on the first syllable, but there are four pitch changes on two syllables. If the initial portion of the tone on the first syllable was preserved in virtue of INITIAL TONE/\( \sigma_1 \), we would have *213.213, with four pitch changes on two syllables, in the output: the templatic constraint would be violated. If two tonal segments were deleted on the first excursion (i.e. 53). On the other hand, there is a universal intonation tendency to begin a declarative sentence with a high tone and finish it by a low tone. Several physiological explanations have been proposed in terms of the lowering of larynx height and the gradual reduction of subglottal pressure (Collier 1975, Ohala 1978). Consequently, in the present analysis, a falling pitch across word boundaries is not counted as a pitch change.
syllable, outputs such as *22.213 and *11.213 would be unfaithful to the input. This faithfulness constraint can be captured by MaxTone, which assigns a violation mark to every tone deletion. Consequently, 35.213, with three pitch changes on two syllables and only one tonal deletion, surfaces as the selected candidate. The constraint ranking is summarized as follows, and the selection process is illustrated in (28):

(27) TEMPLATICCONSTRAINTS >> MAXTONE >> INITIALTONE/ σ₁

<table>
<thead>
<tr>
<th></th>
<th>TEMPLATICCONSTRAINTS</th>
<th>MAXTONE</th>
<th>INITIALTONE/ σ₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 213+213</td>
<td>!!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. 21.213</td>
<td>!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. 35.213</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>d. 22.213</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. 11.213</td>
<td>**</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

Note that the task of INITIALTONE/ σ₁ only involves retaining initial tonal segment, and it is MAXTONE which counts the number of tone segments deleted in tone sandhi.

The same constraint ranking can be applied to /51+213/ and /213+51/, as illustrated in (29) and (30):

(29) /51+213/ | TEMPLATICCONSTRAINTS | MAXTONE | INITIALTONE/ σ₁ |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 51.213</td>
<td>!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. 55.213</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. 11.213</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

(30) /213+51/ | TEMPLATICCONSTRAINTS | MAXTONE | INITIALTONE/ σ₁ |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 213+51</td>
<td>!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. 21.51</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. 13.51</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>d. 22.51</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. 11.51</td>
<td>**</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

To summarize, tone sandhi in Dalian is primarily triggered by INITIALTONE/ σ₁, which requires the retention of an initial tonal segment on the first syllable. This constraint is outranked by the faithfulness constraint MAXTONE. The templatic constraints, stated in (26), outranks the above two constraints.
One final puzzle remains: there is an exception to our constraint ranking. 51 (Ia) + 213 (II) yields [51.213], with four pitch changes on two syllables, rather than *[55.213] as predicted by our constraint ranking:

(31)

<table>
<thead>
<tr>
<th></th>
<th>51 (Ia)</th>
<th>213 (II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>51 (Ia)</td>
<td>35.213</td>
<td>51.213</td>
</tr>
<tr>
<td>213 (II)</td>
<td>35.213</td>
<td>35.213</td>
</tr>
</tbody>
</table>

The input 51 (Ia) + 213 (II) should have undergone tone sandhi but didn’t: if the underlying form of Ia on the first syllable was 21(3), then the output should have been *[35.213] as in other cases. If the underlying form of Ia was 51, then the output should have been *[55.213]. Note that this is the only instance where Ia surfaces as 51 in tone sandhi.

Maybe a broader question is involved in the present case: what is the consequence of an incomplete merger on the phonological processes of a language?

Recall that 51 (Ia), which can be represented as underlingly 21(3), is merging with 51 (III) in Modern Dalian, and 21(3) only surfaces on the second syllable in a disyllabic sequence. However, this tone merger in progress cannot have no effect on tone sandhi. It is possible that the tone merger in progress results in competing forms in tone sandhi and a reorganization of the grammar:

(32) Ia $\rightarrow$ 21(3) in Old Dalian and in tone sandhi

$\Rightarrow$ 51 in Modern Dalian

Competing forms

There are two competing forms in Dalian: Ia is realized as a falling-rising contour in Old Dalian and in tone sandhi in the modern dialect. Meanwhile, Ia is realized as a falling contour in citation form in Modern Dalian. 51 (Ia) + 213 (II) being the only case where Ia surfaces as the current citation form, we would like to suggest that this sequence is actually an innovation and a variation during the tone merger in progress. As Vogt (1954) puts it:

What therefore in a history of linguistic system appears as a change will in a synchronic description appear as a more or less free variation between forms of expression, equally admissible within the system. (Vogt 1954:367)

The phenomenon in Dalian buttresses Dauzat’s position according to which sound change is more complicated than the regularity hypothesis claimed by Neogrammarians:

The phonetic law does not affect all items at the same time: some are designed to develop quickly, others remain behind, some offer strong resistance and succeed in turning back any effort at
Some 40 years later, Wang reviewed the situation in similar terms:

"It is generally believed that splits can only result from a conditioned change, and that contrasts are possible only after something happens to the condition of the change. But if we accept the fact that a sound change (conditioned or unconditioned) may not complete its course due to other competing changes, then clearly we may also need to recognize incomplete sound changes as a cause of splits." (Wang 1969:21)

5. Conclusion

The present work has dealt with the current state of tone merger in Northern Chinese, with a special focus on Dalian. Our first-hand data, as well as a comparative study with other dialects spoken in the neighboring Shandong province, suggests that Modern Dalian is experiencing a tone merger, Ia (Yinping) being integrated into III (Qu).

However, the tone merger in Modern Dalian is incomplete on two grounds. On one hand, a slight phonetic difference is observed between the falling contour derived from Ia (Yinping) and the one derived from III (Qu). Both of them have similar F0 values, but the falling contour derived from Ia has a longer duration compared with the falling contour derived from III. Meanwhile, the underlying contrasts of these two contours surface in tone sandhi contexts. The above phenomena attest, as claimed by Wang (1969), that sound change is not lexically abrupt, and could take a long period of time to complete its course.

A phonological analysis was proposed to account for the apparently complex tone sandhi rules in Modern Dalian. We hope to have shown that tone sandhi in Dalian is primarily triggered by the violation of templatic constraints, requiring no more than three pitch changes on two syllables. Moreover, it is interesting to notice that a rising tone, phonetically more complex, may be preferred over a falling contour in metrically weak position due to high ranked templatic constraints. It follows from our analysis that phonetics is not the only factor in shaping sound systems and dictating phonological processes.

Last but not least, it has been suggested in the literature that the underlying category difference in a near merger situation may be supported by contact with another dialect that maintains the distinction (Labov 1994) or by orthographic differences (Faber and Di Paolo 1995). Yu (2007), who works on the near tone merger between the lexical rising tone and the morphologically derived rising tone in Cantonese, mentions that underlying category difference in a near merger situation can be sustained by grammar-internal factors as well. The present study illustrates another instance of preservation of underlying category difference in a near merger situation: the underlying difference between Ia and III is preserved in tone sandhi contexts.
6. References


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Song, Xue (1963) Liaoning Yuyin Shuolue (A sketch of Liaoning Phonology). In Zhongguo Yuwen 104-114.
7. Appendix

7.1 Word lists

<table>
<thead>
<tr>
<th>Monosyllables</th>
<th>Chinese</th>
<th>Transcription</th>
<th>Gloss</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 春</td>
<td>tsʰ-yun⁵¹</td>
<td>spring</td>
<td>25. 雪</td>
<td>[ʂue²¹³] snow</td>
</tr>
<tr>
<td>2. 夏</td>
<td>[ɛja⁵¹]</td>
<td>summer</td>
<td>26. 水</td>
<td>[ʂwe²¹³] water</td>
</tr>
<tr>
<td>3. 麻</td>
<td>[ma³⁵]</td>
<td>hemp</td>
<td>27. 風</td>
<td>[fon⁵¹] wind</td>
</tr>
<tr>
<td>4. 秋</td>
<td>[tejo⁵¹]</td>
<td>fall</td>
<td>28. 日</td>
<td>[zi⁵¹] day</td>
</tr>
<tr>
<td>5. 冬</td>
<td>[toŋ⁴¹]</td>
<td>winter</td>
<td>29. 夜</td>
<td>[je⁵¹] night</td>
</tr>
<tr>
<td>7. 爸</td>
<td>[pa⁵¹]</td>
<td>father</td>
<td>31. 髮</td>
<td>[fa²¹³] hair</td>
</tr>
<tr>
<td>8. 媽</td>
<td>[ma⁵¹]</td>
<td>mother</td>
<td>32. 口</td>
<td>[kʰo³⁵] mouse</td>
</tr>
<tr>
<td>9. 好</td>
<td>[haw²¹³]</td>
<td>good</td>
<td>33. 髪</td>
<td>[fa²¹³] hair</td>
</tr>
<tr>
<td>10. 壞</td>
<td>[hwaj⁵¹]</td>
<td>bad</td>
<td>34. 海</td>
<td>[ha²¹³] sea</td>
</tr>
<tr>
<td>11. 古</td>
<td>[ku²¹³]</td>
<td>ancient</td>
<td>35. 老</td>
<td>[law²¹³] old</td>
</tr>
<tr>
<td>12. 人</td>
<td>[zyŋ³⁵]</td>
<td>people</td>
<td>36. 陸</td>
<td>[lu⁵¹] land</td>
</tr>
<tr>
<td>13. 貓</td>
<td>[maw⁵¹]</td>
<td>cat</td>
<td>37. 流</td>
<td>[liŋ³⁵] to flow</td>
</tr>
<tr>
<td>14. 食</td>
<td>[ʂi³⁵]</td>
<td>eat; food</td>
<td>38. 空</td>
<td>[kʰoŋ⁵¹] air</td>
</tr>
<tr>
<td>15. 狗</td>
<td>[ko²¹³]</td>
<td>dog</td>
<td>39. 血</td>
<td>[cje²¹³] blood</td>
</tr>
<tr>
<td>17. 早</td>
<td>[tsaw²¹³]</td>
<td>early</td>
<td>41. 弟</td>
<td>[t⁵¹] brother</td>
</tr>
<tr>
<td>18. 蟲</td>
<td>[tson⁵¹]</td>
<td>worm</td>
<td>42. 姊</td>
<td>[tʃe²¹³] elder sister</td>
</tr>
<tr>
<td>19. 手</td>
<td>[ʂo²¹³]</td>
<td>hand</td>
<td>43. 妹</td>
<td>[mej⁵¹] sister</td>
</tr>
<tr>
<td>20. 腳</td>
<td>[tsjaw²¹³]</td>
<td>foot</td>
<td>44. 河</td>
<td>[hr⁵¹] river</td>
</tr>
<tr>
<td>21. 冷</td>
<td>[lun²¹³]</td>
<td>cold</td>
<td>45. 害</td>
<td>[haj⁵¹] to damage</td>
</tr>
<tr>
<td>22. 熱</td>
<td>[zy⁵¹]</td>
<td>hot</td>
<td>46. 溪</td>
<td>[ci⁵¹] stream</td>
</tr>
<tr>
<td>23. 雲</td>
<td>[yn³⁵]</td>
<td>cloud</td>
<td>47. 衣</td>
<td>[t⁵¹] clothes</td>
</tr>
<tr>
<td>24. 雨</td>
<td>[y²¹³]</td>
<td>rain</td>
<td>48. 你</td>
<td>[ni²¹³] you</td>
</tr>
</tbody>
</table>

Appendix 7.1 Word lists

7.1.1 Monosyllables

UC Berkeley Phonology Lab Annual Report (2009)
52. 大 [ta\(^{51}\)] big
53. 小 [cja\(^{213}\)] small
54. 好 [haw\(^{213}\)] good
55. 壞 [hwa\(^{51}\)] bad
56. 尾 [we\(^{213}\)] tail
57. 沙 [s\(^{51}\)] sand
58. 鹽 [jen\(^{213}\)] salt
59. 左 [tswo\(^{213}\)] left
60. 銀 [h\(^{213}\)] very
61. 右 [jo\(^{51}\)] right
62. 蛋 [tan\(^{51}\)] egg
63. 多 [two\(^{51}\)] many
64. 少 [saw\(^{213}\)] few
65. 火 [hwa\(^{213}\)] fire
66. 胖 [p\(^{h}aŋ\(^{51}\)] fat
67. 瘦 [s\(^{51}\)] thin
68. 油 [jo\(^{35}\)] oil
69. 魚 [y\(^{35}\)] fish
70. 年 [nje\(^{35}\)] year
71. 月 [q\(^{51}\)] month
72. 短 [t\(^{213}\)] short
73. 湖 [hu\(^{35}\)] lake
74. 一 [i\(^{51}\)] one
75. 二 [t\(^{51}\)] two
76. 三 [san\(^{51}\)] three
77. 四 [si\(^{51}\)] four
78. 五 [u\(^{213}\)] five
79. 六 [ljo\(^{51}\)] six
80. 七 [tei\(^{51}\)] seven
81. 八 [p\(^{51}\)] eight
82. 九 [tejo\(^{213}\)] nine
83. 十 [ši\(^{35}\)] ten
84. 冰 [pin\(^{41}\)] ice
85. 冷 [ton\(^{51}\)] freeze
86. 花 [hwa\(^{51}\)] flower
87. 草 [ts\(^{h}a\(^{213}\)] grass
88. 樹 [śu\(^{51}\)] tree
89. 紅 [hon\(^{35}\)] red
90. 橙 [tš\(^{h}y\(^{35}\)] orange
91. 黃 [hw\(^{35}\)] yellow
92. 綠 [lu\(^{51}\)] green
93. 藍 [lan\(^{35}\)] bleu
94. 紫 [tsi\(^{213}\)] purple
95. 上 [šu\(^{51}\)] up
96. 下 [cja\(^{51}\)] down
97. 前 [tc\(^{h}j\(^{35}\)] before
98. 後 [ho\(^{51}\)] after
99. 汗 [han\(^{51}\)] sweat
100. 只 [t\(^{h}i\(^{213}\)] ruler
101. 杯 [pe\(^{213}\)] cup
102. 桌 [ts\(^{213}\)] table
103. 椅 [i\(^{213}\)] chair
104. 筷 [k\(^{h}w\(^{51}\)] chopsticks
105. 厚 [ho\(^{51}\)] thick
106. 薄 [p\(^{w}\(^{35}\)] thin
107. 對 [tw\(^{51}\)] right
108. 錯 [ts\(^{h}w\(^{51}\)] wrong
109. 是 [ši\(^{51}\)] yes
110. 非 [fe\(^{51}\)] no
111. 東 [to\(^{51}\)] east
112. 師 [ši\(^{51}\)] teacher
113. 南 [nan\(^{35}\)] south
114. 西 [ći\(^{51}\)] west
115. 北 [pe\(^{213}\)] north
116. 美 [me\(^{213}\)] beautiful
117. 丑 [tš\(^{h}o\(^{213}\)] ugly
118. 橋 [tc\(^{h}jaw\(^{35}\)] bridge
119. 詩 [ši\(^{51}\)] poem
120. 路 [lu\(^{51}\)] road
121. 舌 [šy\(^{213}\)] tongue
122. 齒 [tš\(^{21}\)] teeth
123. 童 [t\(^{h}oŋ\(^{35}\)] kid
124. 金 [t\(^{c}i\(^{51}\)] gold
125. 銀 [in\(^{35}\)] silver
126. 鉛 [t\(^{h}oŋ\(^{35}\)] copper
127. 鐵 [t\(^{h}je\(^{213}\)] iron
| 128. 天 | [tʰjen⁵¹] | sky | 166. 屋 | [u⁵¹] | house |
| 129. 地 | [ti¹¹] | earth | 167. 戦 | [tʂan⁵¹] | war |
| 130. 船 | [tʂʰwan⁴³] | boat | 168. 石 | [ʂɨ³⁵] | stone |
| 131. 車 | [tʂʰɤ⁵¹] | car | 169. 頭 | [tʰɤ⁶] | head |
| 132. 電 | [tʃen⁵¹] | electricity | 170. 蟻 | [tᵣ⁴⁹] | ant |
| 133. 店 | [tʃen⁵¹] | store | 171. 香 | [ɕjan⁵¹] | fragrance |
| 134. 貨 | [hwɔ⁵¹] | merchandise | 172. 男 | [nɑn³⁵] | man |
| 135. 葉 | [je⁵¹] | leaf | 173. 女 | [nu²¹³] | woman |
| 137. 石 | [ʂɨ³⁵] | stone | 175. 帝 | [ti¹¹] | emperor |
| 138. 繩 | [ʂɤn⁵] | rope | 176. 后 | [ho⁵¹] | queen |
| 139. 方 | [faŋ⁵¹] | square | 177. 聰 | [loŋ³⁵] | deaf |
| 140. 圓 | [ʂɨn⁵] | round | 178. 嗝 | [ja²¹³] | mute |
| 142. 獅 | [ʂɨ¹¹] | lion | 180. 高 | [kaw⁵¹] | tall |
| 143. 白 | [pej²°] | white | 181. 矮 | [ɑj²¹³] | short |
| 144. 奶 | [nej²¹³] | milk | 182. 難 | [nɑn³⁵] | difficult |
| 145. 蔥 | [tʂʰoŋ⁵¹] | green onion | 183. 病 | [piŋ⁵¹] | sick |
| 146. 蝦 | [ɕja⁵¹] | shrimp | 184. 糖 | [tʰɤn³⁵] | sugar |
| 147. 米 | [mi²¹³] | rice | 185. 橘 | [tɕy³⁵] | orange |
| 148. 菜 | [tsʰaj⁵¹] | veggie | 186. 梅 | [mej⁵¹] | plum |
| 149. 門 | [mɤn³⁵] | door | 187. 蘭 | [lan³⁵] | orchid |
| 150. 窗 | [tʂʰaj⁵¹] | window | 188. 菊 | [tɕy³⁵] | orchid |
| 151. 信 | [ɕin⁵¹] | letter | 189. 竹 | [tʂu³⁵] | bamboo |
| 152. 愛 | [aj⁵¹] | love | 190. 箱 | [ɕjan⁵¹] | box |
| 153. 漆 | [tɛʰi⁵¹] | paint | 191. 毯 | [tʰan²¹³] | blanket |
| 154. 城 | [tʂʰɤŋ³⁵] | town | 192. 床 | [tʂɤn²¹³] | bed |
| 155. 神 | [ʂɤŋ³⁵] | god | 193. 櫃 | [kwej⁵¹] | closet |
| 156. 鏡 | [tɕiŋ⁵¹] | mirror | 194. 燈 | [tɤŋ⁵¹] | lamp |
| 157. 林 | [lin³⁵] | forest | 195. 湯 | [tʰɤn⁵¹] | soup |
| 158. 麥 | [maj⁵¹] | wheat | 196. 錶 | [pjaw⁵¹] | watch |
| 159. 錢 | [tɕʰjen²¹³] | money | 197. 通 | [tʰɤŋ⁵¹] | to cross |
| 160. 酸 | [swan⁵¹] | sour | 198. 比 | [pi²¹³] | to compare |
| 161. 甜 | [tʰjen³⁵] | sweet | 199. 似 | [si⁵¹] | similar |
| 162. 苦 | [kʰu²¹³] | bitter | 200. 染 | [zan²¹³] | to dye |
| 163. 辣 | [la⁵¹] | spicy | 201. 嫁 | [tɕja⁵¹] | to marry one’s |
| 164. 田 | [tʰjen⁵¹] | field | daughter | | |
202. 袋 $[\text{te}^{51}]$ bag
203. 紙 $[\text{t̄si}^{213}]$ paper
204. 子 $[\text{tsi}^{213}]$ son
### 7.1.2 Disyllabic sequences

<table>
<thead>
<tr>
<th>Chinese Transcription</th>
<th>Gloss</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>[si soo]</td>
<td>length of a boat</td>
<td>goods</td>
</tr>
<tr>
<td>[swa soo]</td>
<td>heartless</td>
<td>calms</td>
</tr>
<tr>
<td>[tsaw soo]</td>
<td>captain</td>
<td>captain</td>
</tr>
<tr>
<td>[paj soo]</td>
<td>white</td>
<td>white</td>
</tr>
<tr>
<td>[pa soo]</td>
<td>Eight</td>
<td>Eight</td>
</tr>
<tr>
<td>[si soo]</td>
<td>it seems</td>
<td>right and wrong</td>
</tr>
<tr>
<td>[tsaw soo]</td>
<td>North America</td>
<td>North America</td>
</tr>
<tr>
<td>[lu soo]</td>
<td>cold water</td>
<td>good morning</td>
</tr>
<tr>
<td>[tsaw soo]</td>
<td>snow-broth</td>
<td>gold</td>
</tr>
<tr>
<td>[cu soo]</td>
<td>little tree</td>
<td>gold</td>
</tr>
<tr>
<td>[haw soo]</td>
<td>good dog</td>
<td>good dog</td>
</tr>
<tr>
<td>[mi soo]</td>
<td>parasite</td>
<td>cold</td>
</tr>
<tr>
<td>[haw soo]</td>
<td>nice person</td>
<td>nice person</td>
</tr>
<tr>
<td>[tek soo]</td>
<td>moon</td>
<td>moon</td>
</tr>
<tr>
<td>[haw soo]</td>
<td>a match</td>
<td>a match</td>
</tr>
<tr>
<td>[tsaw soo]</td>
<td>on the table</td>
<td>on the table</td>
</tr>
<tr>
<td>[haw soo]</td>
<td>good cat</td>
<td>good cat</td>
</tr>
<tr>
<td>[maw soo]</td>
<td>nursing mother</td>
<td>nursing mother</td>
</tr>
<tr>
<td>[maw soo]</td>
<td>one time</td>
<td>one time</td>
</tr>
<tr>
<td>[maw soo]</td>
<td>little flower</td>
<td>little flower</td>
</tr>
<tr>
<td>[maw soo]</td>
<td>white rice</td>
<td>white rice</td>
</tr>
<tr>
<td>[maw soo]</td>
<td>cold wind</td>
<td>cold wind</td>
</tr>
<tr>
<td>[maw soo]</td>
<td>paint</td>
<td>paint</td>
</tr>
</tbody>
</table>

**Notes:**
- [si soo] means "length of a boat.
- [swa soo] means "heartless.
- [tsaw soo] means "captain.
- [paj soo] means "white.
- [pa soo] means "Eight.
- [si soo] means "it seems that.
- [tsaw soo] means "North America.
- [lu soo] means "cold water.
- [tsaw soo] means "snow-broth.
- [cu soo] means "little tree.
- [haw soo] means "good dog.
- [mi soo] means "parasite.
- [haw soo] means "nice person.
- [tek soo] means "moon.
- [haw soo] means "a match.
- [tsaw soo] means "on the table.
- [haw soo] means "good cat.
- [maw soo] means "nursing mother.
- [maw soo] means "one time.
- [maw soo] means "little flower.
- [maw soo] means "white rice.
- [maw soo] means "cold wind.
- [maw soo] means "paint.

**Examples:**
- [tsaw soo] means "North America.
- [haw soo] means "cold water.
- [tsaw soo] means "snow-broth.
- [cu soo] means "little tree.
- [haw soo] means "nice person.
- [tek soo] means "moon.
- [haw soo] means "a match.
- [tsaw soo] means "on the table.
- [haw soo] means "good cat.
- [maw soo] means "nursing mother.
- [maw soo] means "one time.
- [maw soo] means "little flower.
- [maw soo] means "white rice.
- [maw soo] means "cold wind.
- [maw soo] means "paint.

**Transcriptions:**
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- [paj soo] means "white.
- [pa soo] means "Eight.
- [si soo] means "it seems that.
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- [lu soo] means "cold water.
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**Notes:**
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- [maw soo] means "white rice.
- [maw soo] means "cold wind.
- [maw soo] means "paint.
70. 夏季 [cia51 tci51] summer season
71. 秋天 [tci51 jo35 tjen213] fall
72. 秋季 [tci51 jo51 tci51] fall season
73. 春天 [tci51 wen35 tjen213] spring
74. 春季 [tci51 wen35 tci51] spring season
75. 空氣 [k’on51 tci51] air
76. 溪流 [ci51 ljo35] small stream
77. 貓狗 [maw51 ko213] cat and dog
78. 冬雪 [t0n51 cu213] winter snow
79. 秋雨 [tci51 y213] autumn rain
80. 放心 [fa73 cin213] to feel relieved
81. 飛機 [fe35 tci213] airplane
82. 廢機 [fe55 tci213] clunker plane
83. 失足 [shi51 tci35] to stumble
84. 士卒 [shi51 tci35] soldier
85. 三場 [san51 tsh213 aji] three sections
86. 散場 [san55 tsh213 aji] to empty after the show
87. 屋前 [u51 tci35] in front of the house
88. 霧前 [u51 tci35] in front of the fog
89. 方形 [fan51 cin35] square
90. 放行 [fan51 cin35] to let through
91. 杯下 [pe51 chia51] underneath the cup
92. 被下 [pe51 chia51] underneath the blanket
93. 生產 [syn51 tsh213 an] production
94. 盛產 [syn51 tsh213 an] to produce abundantly
95. 花布 [hwa51 pu51] cotton prints
96. 畫布 [hwa51 pu51] canvas
97. 湯水 [tsh151 swej213] soup and water
98. 漁水 [tsh155 swej213] hot water
99. 詩人 [shi51 tjen213] poet
100. 史人 [shi21 tjen213] the Ancients
101. 人妻 [syn51 tci51] one’s wife