

The Phonology of Incomplete Tone Merger in Dalian¹

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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

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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 born².

Northern Chinese dialects generally have fewer lexical tones compared with southern Chinese dialects. Haudricourt & Haguè (1978) attribute this tonal impoverishment to the contact of the northern variety with non-tonal languages such as Mangolian 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 [hwo⁵¹]鑊 and [kwo⁵⁵]鍋 to name the same utensil. The geographical distribution [tiŋ²¹³]鼎 (south China) [hwo⁵¹]鑊 (central China) → [kwo⁵⁵]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

² The correlation between voicing distinction of initial consonant and register was noted by Maspéro (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 & Haguè (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:

(1)	MC tone categories	MC initials	Tone split	Tone merger
	I (<i>Ping</i>)	↗ p p ^a	┌──────────┐ └──────────┘
		↘ b p ^b	
	II (<i>Shang</i>)	↗ p p ^a	┌──────────┐ └──────────┘
		↘ b p ^b	
	III (<i>Qu</i>)	↗ p p ^a	┌──────────┐ └──────────┘
		↘ b p ^b	
	IV (<i>Ru</i>)	↗ p p ^a	┌──────────┐ └──────────┘
		↘ b p ^b	

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 indistinguishable³:

(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). *Zhonghua Yuwen* 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 (Nguyên & 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 Chinese, 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.



Figure 1: the location of Dalian city

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”

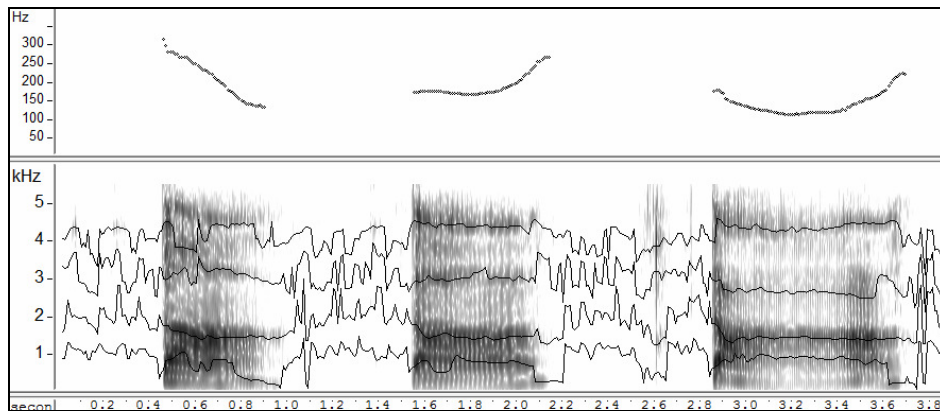


Figure 2: Pitch contour and spectrogram for [ta] “big”, [ta] “to reply” and [ta] “to hit”.

The correspondence of these tones with Middle Chinese is shown as follows:

(4)

MC tone categories		Phonation type of MC initials	Examples (Dalian)
I (<i>Ping</i>)	Yin (a)	aspirated, voiceless	toŋ ⁵¹ “east” t ^h oŋ ⁵¹ “to cross”
	Yang (b)	sonorant, voiced	t ^h oŋ ³⁵ “kid” nan ⁵¹ “man”
II (<i>Shang</i>)	Yin (a)	aspirated, voiceless	pi ²¹³ “to compare” k ^h u ²¹³ “bitter”
	Yang (b)	sonorant, voiced	si ⁵¹ “similar” zaŋ ²¹³ “to dye”
III (<i>Qu</i>)	Yin (a)	aspirated, voiceless	tɕja ⁵¹ “to marry one’s daughter” t ^h u ⁵¹ “rabbit”
	Yang (b)	sonorant, voiced	taj ⁵¹ “bag”
IV (<i>Ru</i>)	Yin (a)	aspirated, voiceless	merged into three other tones
	Yang (b)	sonorant, voiced	

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 IIb⁴. 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 Ib), /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	
	Ia	55	312	51	
	Ib	35	34	35	
	IIa	213	213	213	
	IIb	51	53	51	
	IIIa	51	53	51	
	IIIb	51	53	51	

⁴ Note that not all words derived from IIb bear a falling contour tone: some carry a falling-rising tone, such as [zaŋ²¹³] “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)

	Duration of /HL/ derived from Ia		Duration of /HL/ derived from III
[hwa] flower	473	[hwa] to paint	363
[t ^h aŋ] soup	346	[t ^h aŋ] hot to touch	328
[toŋ] winter	522	[toŋ] to freeze	375
[faŋ] perfume	443	[faŋ] to set free	306
[fej] to fly	473	[fej] to abolish	218
[ʃi] to lose	431	[ʃi] soldier	342
[san] three	365	[san] to come loose	293
[u] house	516	[u] fog	456
[faŋ] square	328	[faŋ] to set free	250
Average duration	433	Average duration	326
Standard deviation	67.77ms	Standard deviation	61.24ms

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. t_j , and (3) minimum F0 in the falling contour (min F0), which is also the endpoint, i.e. t_i . 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 (t_i-t_j) divided by the corresponding change in pitch duration (Hsieh 2007):

$$(7) \text{ Slope: } \frac{F_0(t_i) - F_0(t_j)}{\text{Time}(t_i) - \text{Time}(t_j)}$$

(8)

Falling contour derived from Ia					Falling contour derived from III				
Gloss	Duration	Max F0	Min F0	Slope	Gloss	Duration	Max F0	Min F0	Slope
[hwa] flower	473ms	286 Hz	91 Hz	-0.41	[hwa] to paint	363 ms	268 Hz	100Hz	-0.46
[t ^h aŋ] soup	346 ms	270 Hz	148 Hz	-0.35	[t ^h aŋ] hot	328 ms	277 Hz	149 Hz	-0.39
[toŋ] winter	522 ms	254 Hz	78 Hz	-0.34	[toŋ] to freeze	375 ms	264 Hz	105 Hz	-0.42
[faŋ] perfume	443 ms	252 Hz	142 Hz	-0.25	[faŋ] to set free	306 ms	281 Hz	192 Hz	-0.29
[fej] to fly	473 ms	280 Hz	115 Hz	-0.35	[fej] to abolish	218 ms	255 Hz	142 Hz	-0.51
[ʃi] to lose	431 ms	270 Hz	146 Hz	-0.29	[ʃi] soldier	342 ms	287 Hz	85 Hz	-0.59
[san] three	365 ms	268 Hz	152 Hz	-0.32	[san]to come loose	293 ms	268 Hz	156 Hz	-0.38
[u] house	516 ms	304 Hz	142 Hz	-0.32	[u] fog	456 ms	280 Hz	107 Hz	-0.38
[faŋ] square	328 ms	260 Hz	153 Hz	-0.33	[faŋ] to set free	317 ms	281 Hz	176 Hz	-0.33
Average	433 ms	272 Hz	130 Hz	-0.33	Average	326 ms	273Hz	135 Hz	-0.42
SD	67.77ms	15.54Hz	26.52Hz	-0.041	SD	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 duration⁵, 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

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	Zhauyuan	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 Shangdong 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.

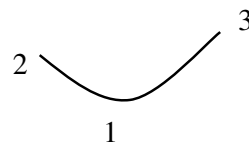
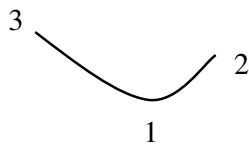
Of particular interest are Penglai, Changdao and Longkou, in which the tone value of Ia is 313, similar to that of Old Dalian, where the tone value of Ia is 312.

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)

	Ia 51	Ib 35	II 213	III 51
Ia 51	35.213			
Ib 35	35.213			
II 213	35.213	21.35	35.213	21.51
III 51	55.213		55.213	

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) → 35.213 [ts^hwɤn t^hjɛn] “Spring”
 b. 35 (Ib) + 51 (Ia) → 35.213 [zɤn tɕi^h] “one’s wife”

c.	213 (II) + 51 (Ia)	→	35.213	[ku ʂu]	“old books”
d.	51 (III) + 51 (Ia)	→	55.213	[toŋ t ^h jeŋ]	“freezing day”
e.	213 (II) + 35 (Ib)	→	21.35	[mi tʂoŋ]	“parasite”
f.	213 (II) + 213 (II)	→	35.213	[jan ʂi]	“gum (of eyes)”
g.	213 (II) + 51 (III)	→	21.51	[tswɔ ʂaŋ]	“upper left”
h.	51 (III) + 213(II)	→	55.213	[taŋ ʂu]	“kangaroo”
i.	51 (Ia) + 213(II)	→	51.213	[tɕ ^h jo y]	“autumn rain”

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.

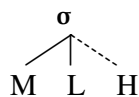
If Dalian is also a right-dominant language, why does /51/ derived from Ia surface as [213] on the second syllable? In other words, why are the falling contour derived from Ia and the one derived from III realized differently in disyllabic sequences while they are pronounced as a falling contour in citation 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 tones⁸.

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) a. 51 derived from Ia

Underlying form



→



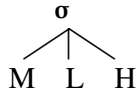
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Citation form



⁸ It is well known that different informants pronounce tones with a slight phonetic difference, and not all descriptors 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



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 sandhi⁹. 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)

	Ia 51	Ib 35	II 213	III 51
Ia 51	35.213			
Ib 35	35.213			
II 213	35.213	<u>21</u> .35	35.213	<u>21</u> .51
III 51	<u>55</u> .213		<u>55</u> .213	

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) puã31 → puã55 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 [grãt] both in masculin and in feminin 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 mapping¹⁰.

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 formulized by the following constraint:

(19) INITIALTONE/ σ_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.

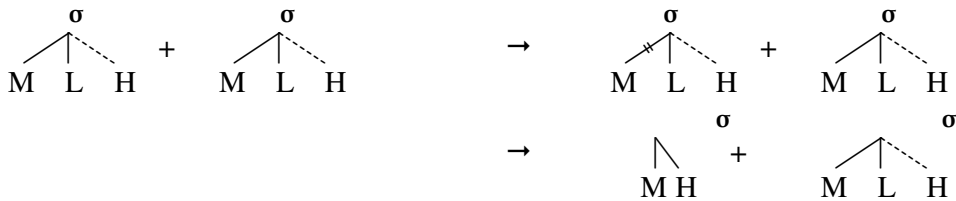
In other words, the initial portion of a tone has virtually the same status as a syllable onset, and a final tonal segment is the mirror image of a syllable coda. As a result, an initial tonal segment is generally preserved in tone sandhi.

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 INITIALTONE/ σ_1 in (20)?

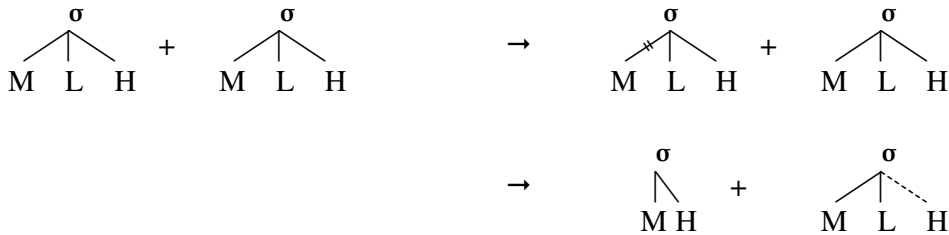
- (20) a. 51 (Ia) + 51 (Ia) → 35.213 [tshwɔŋ t^hjɛŋ] “Spring”
 b. 35 (Ib) + 51 (Ia) → 35.213 [zɔŋ tɕi^h] “one’s wife”
 c. 213 (II) + 51 (Ia) → 35.213 [ku ʂu] “old books”
 d. 213 (II) + 213 (II) → 35.213 [jan ʂi] “gum (of eyes)”

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:

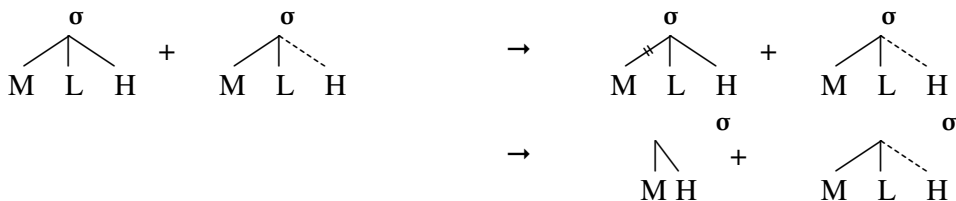
- (21) a. 51 (Ia) + 51 (Ia) → 35.213



- b. 213 (II) + 213 (II) → 35.213



- c. 213 (II) + 51 (Ia) → 35.213



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/ σ_1 ?

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

(22)

Tone sandhi rules	Input	pitch changes	Output	pitch changes
	$\overline{213}+\overline{51}$	4	$\overline{21.51}$	3
	$\overline{51}+\overline{213}$	4	$55.\overline{213}$	2
	$\overline{213}+\overline{35}$	3	$\overline{21.35}$	3
	$\overline{213}+\overline{213}$	4	$\overline{35.213}^{11}$	3

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 tone¹²; 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 $\overline{213}$ 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:

(23)

	Modern Dalian			
Tonal inventory	$\overline{51}, \overline{35}, \overline{213}$			
Maximal pitch change	$N \leq S + 1$: the number of pitch changes is inferior or equal to the number of syllables + 1 ;			
Tone sandhi rules	Input	pitch changes	Output	pitch changes
	$\overline{213}+\overline{51}$	4	$\overline{21.51}$	3
	$\overline{51}+\overline{213}$	4	$55.\overline{213}$	3
	$\overline{213}+\overline{35}$	3	$\overline{21.35}$	3
	$\overline{213}+\overline{213}$	4	$\overline{35.213}^{13}$	3

¹¹ Zhang (2002) notes that a rising contour (i.e. 35) requires a longer duration than a falling contour of equal pitch 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.

¹² This change is phonetically motivated: articulatorily, a contour tone requires the implementation of a pitch change, and pitch changes are achieved by changes in the vocal fold tension, which involve the contraction and relaxation of laryngeal muscles: pitch rises are accomplished by the contraction of cricothyroid muscles, and pitch falls by the relaxation of cricothyroid muscles and the contraction of thyroarytenoid and sternohyoid muscles (Arnold 1961, Hirano *et al.* 1969, Lindqvist 1972, Ohala 1978, Sagart *et al.* 1986). Consequently, a complicated tonal contour which involves more pitch targets would involve more complicated muscle state change, and thus prefer a longer duration to facilitate implementation.

¹³ Zhang (2002) notes that a rising contour (i.e. 35) requires a longer duration than a falling contour of equal pitch

The same conjecture goes for Mandarin: there is a complex contour tone $\overline{213}$ in citation form. Consequently, the number of pitch changes cannot exceed three in a disyllabic sequence:

(24)

Mandarin				
Tonal inventory	$55, \overline{35}, \overline{213}, \overline{51}$			
Maximal pitch change	$N \leq S + 1$: the number of pitch changes is inferior or equal to the number of syllables + 1 ;			
Tone sandhi rules	Input	pitch changes	Output	pitch changes
	$\overline{213} + \overline{213}$	4	$\overline{35}. \overline{213}$	3
	$\overline{213} + 55$	3	$\overline{51}. 55$	2
	$\overline{213} + \overline{35}$	4	$\overline{51}. \overline{35}$	3
	$\overline{213} + \overline{51}$	4	$\overline{51}. \overline{51}$	3

This concordant relationship between tonal inventory and tone sandhi is bourn out in Tianjin. In this Mandarin dialect, four lexical tones are observed: 55 (H), $\overline{35}$ (LH), 11 (L), $\overline{51}$ (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. $\overline{HL} + \overline{HL} \rightarrow \overline{L.HL}$
 b. $\overline{LH} + \overline{LH} \rightarrow \overline{H.LH}$

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

- (26) **TEMPLATICCONSTRAINTS** (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 $\overline{213} + \overline{213}$, 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 **INITIALTONE/** σ_1 , we would have $*\overline{21}. \overline{213}$, 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 *22.2̄1̄3̄ and *1̄1̄.2̄1̄3̄ would be unfaithful to the input. This faithfulness constraint can be captured by MAXTONE, which assigns a violation mark to every tone deletion. Consequently, 3̄5̄.2̄1̄3̄, 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/ σ_1

(28)

/ 2̄1̄3̄+2̄1̄3̄ /	TEMPLATICCONSTRAINTS	MAXTONE	INITIALTONE/ σ_1
a. 2̄1̄3̄+2̄1̄3̄	!!		
b. 2̄1̄.2̄1̄3̄	!	*	
☞ c. 3̄5̄.2̄1̄3̄		*	*
d. 22.2̄1̄3̄		**	
e. 1̄1̄.2̄1̄3̄		**	*

Note that the task of INITIALTONE/ σ_1 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 /5̄1̄+2̄1̄3̄/ and /2̄1̄3̄+5̄1̄/, as illustrated in (29) and (30):

(29)

/ 5̄1̄+2̄1̄3̄ /	TEMPLATICCONSTRAINTS	MAXTONE	INITIALTONE/ σ_1
a. 5̄1̄.2̄1̄3̄	!		
☞ b. 55.2̄1̄3̄		*	
c. 1̄1̄.2̄1̄3̄		*	*

(30)

/ 2̄1̄3̄+5̄1̄ /	TEMPLATICCONSTRAINTS	MAXTONE	INITIALTONE/ σ_1
a. 2̄1̄3̄+5̄1̄	!		
☞ b. 2̄1̄.5̄1̄		*	
c. 1̄3̄.5̄1̄		*	*
d. 22.5̄1̄		**	
e. 1̄1̄.5̄1̄		**	*

To summarize, tone sandhi in Dalian is primarily triggered by INITIALTONE/ σ_1 , 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.

transformation. (Gauchat, cited in Dauzat 1922)

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

- Ballard, William (1988) *The History and Development of Tonal Systems and Tone Alternation in South China*. Tokyo : Institute for the studies of languages and cultures of Asia and Africa: University of Foreign Studies.
- Barnes, Johathan (2001) Domain-initial strengthening and the phonetics and phonology of positional neutralization. In *Proceedings of NELS 32*.
- Beckman, Jill (1998) *Positional faithfulness*. Doctoral dissertation. University of Massachusetts, Amherst.
- Broselow, Ellen, Hurtig, R.R., and Ringen, C. (1987) The perception of second language prosody. In G. Ioup and S.H. Weinberger (eds.), *Inter-language Phonology, The Acquisition of Second Language Sound System*. Cambridge: Newbury House Publishers. 350-361.
- Chao, Yuen-ren (1928) *Xiandai Wuyu de Yanjiu (Study of Modern Wu Dialects)*. Beijing : Tsinghua Research Institute. Monographe 4.
- Chen, Matthew (2000). *Tone Sandhi*, Cambridge, Cambridge University Press.
- Cheng, Chin-chuan (1973) A quantitative study of Chinese tones. *Journal of Chinese Linguistics* 1: 93-110.
- Collier, René (1975) Physiological correlates of intonation patterns, *Journal of the Acoustical Society of America* 58, 249-255.
- Dauzat, Albert (1922) *La géographie linguistique*. Paris : Bibiothèque Fammарion. Bibiothèque Culture Générale.
- Di Paolo, Marianna (1988) Pronunciation and categorization in sound change. In K. Ferrara et al. (eds.) *Linguistic Change and Contact: NWAV-XVI*, Austin: Department of Linguistics, University of Texas, 84-92.
- Harris, John (1985) *Phonological Variation and Change: Studies in Hiberno-Irish*. Cambridge: Cambridge University Press.
- Milroy, James & Harris, John (1980) When is a merger not a merger? The MEAT/MATE problem in a present-day English vernacular. *English Worldwide* 1:199-210.
- Haudricourt, André (1954) De l'origine des tons en Vietnamien. *Journal Asiatique* 242.69-82. .
- Haudricourt, André (1961) Bipartition et tripartition des systèmes de tons dans quelques langues d'Extrême-Orient. *Bulletin de la Société Linguistique de Paris*, 56:163-180.
- Haudricourt, André & Hagege, Claude (1978) *La phonologie panchronique*, Paris: Presses Universitaires de France.
- Herold, Ruth (1990) *Mechanisms of merger : The implementation and distribution of the low back merger in Eastern Pennsylvania*. Doctoral dissertation, University of Pennsylvania.
- Hirayama, Hisao (2000) Patterns and distribution of tone value systems in Mandarin dialects. Ting, Pang-Hsin & Anne O. Yue (eds.) *In Memory of Professor Li Fang-Kuei: Essays of Linguistic Change and the Chinese Dialects*. 141-166, Institute of Linguistics (Preparatory Office), Academia Sinica, Taipei, and University of Washington, Seattle.

- Hombert, Jean-Marie, Ohala, John & Ewan, William (1979) Phonetic explanations for the development of tones. *Language* 55.1:37-58.
- Hyman, Larry (ed.) (1973a) Consonant types and tone. (Southern California occasional papers in linguistics, 1.) Los Angeles: USC. .
- Hyman, Larry (1973b) The role of consonant types in natural tonal assimilations. In Hyman 1973a:151-79.
- Hyman, Larry & R. G. Schuh (1974) Universals of tone rules: evidence from West Africa. *Linguistic Inquiry* 5.81-115.
- Labov William (1994) *Principles of Linguistic Change*. Vol 1: Internal Factors. Vol. 2: Social Factors. Blackwell, Oxford.
- Li Rong (1985) Lun Lifi dui Qieyun de Piping ji qi Xianguan Wenti (On LiFu's Criticism of Qieyun and related matters). *Zhonghuo Yuwen* 184: 1-9.
- Lieberman, Mark & Pierrehumbert, Janet (1984) Intonational invariance under changes in pitch range and length. In Aronoff & Oehrle (eds.) *Language Sound Structure*, MIT Press, Cambridge, 157-233.
- Lien, Chinfa (1986) Tone merger in the dialects of Northern Chinese. *Journal of Chinese Linguistics*, 14.3: 243-291.
- Maspéro, Henri (1912) Etudes sur la phonétique historique de la langue annamite: les initiales. *Bulletin de l'Ecole Francaise d'Extreme Orient* 12.114-16.
- Matisoff, James (1973) Tonogenesis in Southeast Asia. In Hyman (ed) *Southern California occasional papers in linguistics*, 1. Los Angeles: USC. 71-96.
- Nguyên, Thị Thanh Hoa & Boulakia, Georges (1999) Another look at Vietnamese intonation. In Ohala, J., Hasegawa, Ohala, M., Granville, Bailey (eds.) *Proceedings of the XIVth International Congress of Phonetic Sciences*, Berkeley: Linguistics Department, University of California, 2399-2402.
- Ohala, John (1978) Production of tone. In Victoria A. Fromkin (ed.), *Tone: A linguistic survey*: 5-39. New York : Academic Press.
- Pierrehumbert, Janet & Beckman, Mary (1988) *Japanese Tone Structure*. Cambridge: MIT Press.
- Prince, Alan & Paul Smolensky (1993) *Optimality Theory: Constraint Interaction in Generative Grammar*. Rutgers University Center for Cognitive Science Technical Report 2.
- Qian, Zengyi, Zhang, Shuzheng & Luo, Futeng (2001) *Shandong fang yan yan jiu* (Studies of Dialects in Shandong), Jinan: QiLu Press.
- Ting, Pang-hsin (1984) Wuyu shengdiao zhi yanjiu (A study of Wu dialects). *Bulletin of the Institute of History and Philology, Academia Sinica* 55: 605-638.
- Smith, Jennifer. 2002. *Phonological augmentation in prominent positions*. Ph.D. dissertation, University of Massachusetts, Amherst.
- Song, Xue (1963) Liaoning Yuyin Shuolue (A sketch of Liaoning Phonology). In *Zhongguo Yuwen* 104-114.

- Song, Xue (1969) Liaoning (Jiuge Diqu) Yu Beijing Shengdiao Duiying Guanxi (Tonal correspondences between Liaoning (9 areas) and Pekenine). *Fangyan Yu Putonghua Jikan* 7: 14-18.
- Vogt, Hans (1954) Contact of languages. *Word* 10:365-74.
- Wang, William S.Y. (1982) A note on Tone Development. In *Papers for Wang Li*.
- Zhang, Jie (2002) The effects of duration and sonority on contour tone distribution, New York, Routledge.
- Zoll, Cheryl (1997) A note on multiple prominence and tone mapping. In PF: Papers at the Interface, Bruening, Kang & McGinnis (eds), *MIT Working Papers in Linguistics* 30: 97-111.

7. Appendix

7.1 Word lists

7.1.1 Monosyllables

Chinese	Transcription	Gloss
1. 春	[ts ^h ʏn ⁵¹]	spring
2. 夏	[ɕja ⁵¹]	summer
3. 麻	[ma ³⁵]	hemp
4. 秋	[tɕjo ⁵¹]	fall
5. 冬	[toŋ ⁵¹]	winter
6. 宅	[tɕaj ³⁵]	house
7. 爸	[pa ⁵¹]	father
8. 媽	[ma ⁵¹]	mother
9. 好	[haw ²¹³]	good
10. 壞	[hwaj ⁵¹]	bad
11. 古	[ku ²¹³]	ancient
12. 人	[zʏn ³⁵]	people
13. 貓	[maw ⁵¹]	cat
14. 食	[ɕi ³⁵]	eat; food
15. 狗	[ko ²¹³]	dog
16. 鳥	[njaw ²¹³]	bird
17. 早	[tsaw ²¹³]	early
18. 蟲	[tɕoŋ ³⁵]	worm
19. 手	[ɕo ²¹³]	hand
20. 腳	[tsjaw ²¹³]	foot
21. 冷	[lʏŋ ²¹³]	cold
22. 熱	[zʏ ⁵¹]	hot
23. 雲	[yn ³⁵]	cloud
24. 雨	[y ²¹³]	rain

25. 雪	[ɕɥɛ ²¹³]	snow
26. 水	[ɕwe ²¹³]	water
27. 風	[foŋ ⁵¹]	wind
28. 日	[zɿ ⁵¹]	day
29. 夜	[jɛ ⁵¹]	night
30. 眼	[jɛn ²¹³]	ear
31. 鼻	[pi ³⁵]	nose
32. 口	[k ^h o ³⁵]	mouse
33. 髮	[fa ²¹³]	hair
34. 海	[haj ²¹³]	sea
35. 老	[law ²¹³]	old
36. 陸	[lu ⁵¹]	land
37. 流	[ljo ³⁵]	to flow
38. 空	[k ^h oŋ ⁵¹]	air
39. 血	[ɕje ²¹³]	blood
40. 兄	[ɕjoŋ ⁵¹]	elder brother
41. 弟	[ti ⁵¹]	brother
42. 姊	[tɕje ²¹³]	elder sister
43. 妹	[mej ⁵¹]	sister
44. 河	[hʏ ³⁵]	river
45. 害	[haj ⁵¹]	to damage
46. 溪	[ɕi ⁵¹]	stream
47. 衣	[i ⁵¹]	clothes
48. 你	[ni ²¹³]	you
49. 我	[wo ²¹³]	I
50. 濕	[ɕi ⁵¹]	wet
51. 乾	[kan ⁵¹]	dried

UC Berkeley Phonology Lab Annual Report (2009)

52. 大	[ta ⁵¹]	big	90. 橙	[tʂ ^h ʝŋ ³⁵]	orange
53. 小	[çjaw ²¹³]	small	91. 黃	[hwaŋ ³⁵]	yellow
54. 好	[haw ²¹³]	good	92. 綠	[lu ⁵¹]	green
55. 壞	[hwaj ⁵¹]	bad	93. 藍	[lan ³⁵]	bleu
56. 尾	[wɛj ²¹³]	tail	94. 紫	[tʂi ²¹³]	purple
57. 沙	[ʂa ⁵¹]	sand	95. 上	[ʂaŋ ⁵¹]	up
58. 鹽	[jɛn ²¹³]	salt	96. 下	[çja ⁵¹]	down
59. 左	[tswɔ ²¹³]	left	97. 前	[tʂ ^h jɛn ³⁵]	before
60. 很	[hɣn ²¹³]	very	98. 後	[ho ⁵¹]	after
61. 右	[jo ⁵¹]	right	99. 汗	[han ⁵¹]	sweat
62. 蛋	[tan ⁵¹]	egg	100. 尺	[tʂ ^h ɿ ²¹³]	ruler
63. 多	[two ⁵¹]	many	101. 杯	[pɛj ²¹³]	cup
64. 少	[ʂaw ²¹³]	few	102. 桌	[tʂwɔ ⁵¹]	table
65. 火	[hwɔ ²¹³]	fire	103. 椅	[i ²¹³]	chair
66. 胖	[p ^h aŋ ⁵¹]	fat	104. 筷	[k ^h waj ⁵¹]	chopsticks
67. 瘦	[ʂo ⁵¹]	thin	105. 厚	[ho ⁵¹]	thick
68. 油	[jo ³⁵]	oil	106. 薄	[pwo ³⁵]	thin
69. 魚	[y ³⁵]	fish	107. 對	[twɛj ⁵¹]	right
70. 年	[njɛ ³⁵]	year	108. 錯	[tʂ ^h wɔ ⁵¹]	wrong
71. 月	[ɥɛ ⁵¹]	month	109. 是	[ʂi ⁵¹]	yes
72. 短	[twan ²¹³]	short	110. 非	[fɛj ⁵¹]	no
73. 湖	[hu ³⁵]	lake	111. 東	[toŋ ⁵¹]	east
74. 一	[i ⁵¹]	one	112. 師	[ʂi ⁵¹]	teacher
75. 二	[ɿ ⁵¹]	two	113. 南	[nan ³⁵]	south
76. 三	[san ⁵¹]	three	114. 西	[çi ⁵¹]	west
77. 四	[si ⁵¹]	four	115. 北	[pɛj ²¹³]	north
78. 五	[u ²¹³]	five	116. 美	[mɛj ²¹³]	beautiful
79. 六	[ljo ⁵¹]	six	117. 醜	[tʂ ^h o ²¹³]	ugly
80. 七	[tçi ⁵¹]	seven	118. 橋	[tʂ ^h jaw ³⁵]	bridge
81. 八	[pa ⁵¹]	eight	119. 詩	[ʂi ⁵¹]	poem
82. 九	[tçi ²¹³]	nine	120. 路	[lu ⁵¹]	road
83. 十	[ʂi ³⁵]	ten	121. 舌	[ʂɣ ²¹³]	tongue
84. 冰	[pin ⁵¹]	ice	122. 齒	[tʂi ²¹³]	teeth
85. 凍	[toŋ ⁵¹]	freeze	123. 童	[t ^h oŋ ³⁵]	kid
86. 花	[hwa ⁵¹]	flower	124. 金	[tçin ⁵¹]	gold
87. 草	[tʂ ^h aw ²¹³]	grass	125. 銀	[in ³⁵]	silver
88. 樹	[ʂu ⁵¹]	tree	126. 銅	[t ^h oŋ ³⁵]	copper
89. 紅	[hoŋ ³⁵]	red	127. 鐵	[t ^h jɛ ²¹³]	iron

UC Berkeley Phonology Lab Annual Report (2009)

128.	天	[t ^h jen ⁵¹]	sky	166.	屋	[u ⁵¹]	house
129.	地	[ti ⁵¹]	earth	167.	戰	[tʂan ⁵¹]	war
130.	船	[tʂ ^h wan ³⁵]	boat	168.	石	[ʂi ³⁵]	stone
131.	車	[tʂ ^h ʎ ⁵¹]	car	169.	頭	[t ^h o ³⁵]	head
132.	電	[tjen ⁵¹]	electricity	170.	蟻	[i ²¹³]	ant
133.	店	[tjen ⁵¹]	store	171.	香	[ɕjan ⁵¹]	fragrance
134.	貨	[hwɔ ⁵¹]	merchandize	172.	男	[nan ³⁵]	man
135.	葉	[jɛ ⁵¹]	leaf	173.	女	[nu ²¹³]	woman
136.	木	[mu ⁵¹]	wood	174.	王	[wan ³⁵]	king
137.	石	[ʂi ³⁵]	stone	175.	帝	[ti ⁵¹]	emperor
138.	繩	[ʂʎŋ ³⁵]	rope	176.	后	[ho ⁵¹]	queen
139.	方	[fan ⁵¹]	square	177.	聾	[loŋ ³⁵]	deaf
140.	圓	[ʋɛn ³⁵]	round	178.	啞	[ja ²¹³]	mute
141.	書	[ʂu ⁵¹]	book	179.	瞎	[ɕja ⁵¹]	blind
142.	獅	[ʂi ⁵¹]	lion	180.	高	[kaw ⁵¹]	tall
143.	白	[pej ³⁵]	white	181.	矮	[aj ²¹³]	short
144.	奶	[nej ²¹³]	milk	182.	難	[nan ³⁵]	difficult
145.	蔥	[ts ^h oŋ ⁵¹]	green onion	183.	病	[piŋ ⁵¹]	sick
146.	蝦	[ɕja ⁵¹]	shrimp	184.	糖	[t ^h aŋ ³⁵]	sugar
147.	米	[mi ²¹³]	rice	185.	橘	[tɕy ³⁵]	orange
148.	菜	[ts ^h aj ⁵¹]	veggie	186.	梅	[mej ⁵¹]	plum
149.	門	[mʎn ³⁵]	door	187.	蘭	[lan ³⁵]	orchid
150.	窗	[tʂ ^h aŋ ⁵¹]	window	188.	菊	[tɕy ³⁵]	chrysanthemum
151.	信	[ɕin ⁵¹]	letter				
152.	愛	[aj ⁵¹]	love	189.	竹	[tʂu ³⁵]	bamboo
153.	漆	[tɕ ^h i ⁵¹]	paint	190.	箱	[ɕjan ⁵¹]	box
154.	城	[tʂ ^h ʎŋ ³⁵]	town	191.	毯	[t ^h an ²¹³]	blanket
155.	神	[ʂʎŋ ³⁵]	god	192.	床	[tʂwan ²¹³]	bed
156.	鏡	[tɕiŋ ⁵¹]	mirror	193.	櫃	[kwej ⁵¹]	closet
157.	林	[lin ³⁵]	forest	194.	燈	[tʎŋ ⁵¹]	lamp
158.	麥	[maj ⁵¹]	wheat	195.	湯	[t ^h aŋ ⁵¹]	soup
159.	錢	[tɕ ^h jen ²¹³]	money	196.	錶	[pjaw ⁵¹]	watch
160.	酸	[swan ⁵¹]	soar	197.	通	[t ^h oŋ ⁵¹]	to cross
161.	甜	[t ^h jen ³⁵]	sweet	198.	比	[pi ²¹³]	to compare
162.	苦	[k ^h u ²¹³]	bitter	199.	似	[si ⁵¹]	similar
163.	辣	[la ⁵¹]	spicy	200.	染	[zan ²¹³]	to dye
164.	田	[t ^h jen ³⁵]	field	201.	嫁	[tɕja ⁵¹]	to marry one's
165.	房	[fan ³⁵]	house				daughter

UC Berkeley Phonology Lab Annual Report (2009)

202.	袋	[tɛj ⁵¹]	bag
203.	紙	[tɕi ²¹³]	paper
204.	子	[tsi ²¹³]	son

7.1.2 Disyllabic sequences

Chinese	Transcription	Gloss			
1. 是非	[ʂ ⁵⁵ fe ²¹³]	right and wrong	34. 房車	[faŋ ³⁵ ɕi ²¹³]	van
2. 風雪	[foŋ ⁵¹ ɕɥe ²¹³]	wind and snow	35. 頭髮	[t ^h o ³⁵ fa ²¹³]	hair
3. 啞女	[ja ³⁵ ny ²¹³]	mute woman	36. 東南	[toŋ ⁵¹ nan ³⁵]	southeast
4. 熱奶	[zɣ ⁵¹ naj ²¹³]	hot milk	37. 舌頭	[ʂɣ ³⁵ to ³⁵]	tongue
5. 流血	[ljo ³⁵ ɕje ²¹³]	bleed	38. 圓形	[ɥen ³⁵ ɕin ³⁵]	round
6. 秋雨	[t ^h jo ⁵¹ y ²¹⁴]	autumn rain	39. 神明	[ʂɣn ³⁵ miŋ ³⁵]	divinities
7. 船長	[tʂ ^h wan ³⁵ tʂ ^h ɑŋ ³⁵]	length of a boat	40. 麻油	[ma ³⁵ jo ³⁵]	sesame oil
8. 薄情	[pwo ³⁵ tɕ ^h in ³⁵]	heartless	41. 貨源	[hwo ⁵¹ ɥen ³⁵]	supply of
9. 船長	[tʂ ^h wan ³⁵ tʂɑŋ ²¹³]	captain		goods	
10. 白色	[pa ³⁵ sɣ ⁵¹]	white	42. 書本	[ʂu ⁵¹ pɣ.l ²¹³]	books
11. 八仙	[pa ³⁵ ɕjɛn ²¹³]	Eight	43. 袋鼠	[taj ⁵⁵ ʂu ²¹³]	kangaroo
	Immortals		44. 壞人	[hwaj ⁵¹ zɣn ³⁵]	bad guy
12. 長椅	[tʂ ^h ɑŋ ³⁵ i ²¹³]	long bench	45. 嫁人	[tɕja ⁵¹ zɣn ³⁵]	to get married
13. 七夕	[tɕ ^h i ³⁵ ɕi ²¹³]	Chinese	46. 書僮	[ʂu ⁵¹ t ^h oŋ ³⁵]	page boy
	Valentine's Day		47. 熱油	[zɣ ⁵¹ jo ³⁵]	hot oil
14. 似乎	[si ⁵⁵ hu ⁵¹]	it seems that	48. 東北	[toŋ ⁵¹ pɛk ²¹³]	northeast
15. 醜女	[tʂ ^h o ³⁵ ny ²¹³]	ugly woman	49. 兔腳	[t ^h u ⁵¹ tɕjaw ²¹³]	rabbit legs
16. 北美	[pɛj ³⁵ mej ²¹³]	North America	50. 車頂	[tʂ ^h ɣ ⁵¹ tiŋ ²¹³]	car roof
17. 冷水	[lɣ ³⁵ ʂwej ²¹³]	cold water	51. 對錯	[twej ⁵¹ ts ^h wɔ ⁵¹]	right and
18. 雪水	[ɕɥe ³⁵ ʂwej ²¹³]	snow-broth		wrong	
19. 小樹	[ɕjaw ²¹ ʂu ⁵¹]	little tree	52. 冰凍	[piŋ ⁵¹ toŋ ⁵¹]	to freeze
20. 好狗	[haw ³⁵ ko ²¹³]	good dog	53. 綠樹	[lu ⁵¹ ʂu ⁵¹]	green tree
21. 米蟲	[mi ²¹ ko ³⁵]	parasite	54. 東西	[toŋ ³⁵ ɕi ²¹³]	east and west
22. 好人	[haw ²¹ zɣn ³⁵]	nice person	55. 日夜	[zɿ ⁵¹ je ⁵¹]	day and night
23. 月亮	[ɥe ⁵¹ zɣn ⁵¹]	moon	56. 嫁妝	[tɕja ⁵⁵ tswaŋ ²¹³]	dowry
24. 火柴	[hwɔ ²¹ tʂ ^h ɛj ³⁵]	a match	57. 沙石	[ʂa ⁵¹ ʂi ³⁵]	sand and stone
25. 田野	[t ^h jɛn ³⁵ je ²¹³]	field	58. 蛋黃	[tan ⁵¹ hwɑŋ ³⁵]	egg yolk
26. 桌上	[tswɔ ²¹ ʂɑŋ ⁵¹]	on the table	59. 古人	[ku ²¹ zɣn ³⁵]	the ancients
27. 好貓	[haw ³⁵ maw ²¹³]	good cat	60. 早安	[tsaw ³⁵ an ²¹³]	good morning
28. 奶媽	[naj ³⁵ ma ²¹³]	nursing mother	61. 方圓	[faŋ ⁵¹ ɥen ³⁵]	neighborhood
29. 一次	[i ²¹ tsi ⁵¹]	one time	62. 乾洗	[kan ⁵¹ ɕi ²¹⁴]	dry clean
30. 小花	[ɕjaw ³⁵ hwa ²¹³]	little flower	63. 乾燥	[kan ⁵¹ tsaw ⁵¹]	dry
31. 白米	[pa ³⁵ mi ²¹³]	white rice	64. 方形	[faŋ ⁵¹ ɕin ³⁵]	square
32. 冷風	[lɣ ³⁵ foŋ ²¹³]	cold wind	65. 冬天	[toŋ ³⁵ t ^h jɛn ²¹³]	winter
33. 油漆	[jo ³⁵ ɕi ²¹³]	paint	66. 凍天	[toŋ ⁵⁵ t ^h jɛn ²¹³]	freezing day
			67. 凍季	[toŋ ⁵¹ tɕi ⁵¹]	freezing season
			68. 冬季	[toŋ ³⁵ tɕi ⁵¹]	winter season
			69. 夏天	[ɕja ⁵⁵ t ^h jɛn ²¹³]	summer

70. 夏季	[ɕja ⁵¹ tɕi ⁵¹]	summer season	102. 人氣	[zɤn ³⁵ tɕ ^h y ⁵¹]	popularity
71. 秋天	[tɕ ^h jo ³⁵ t ^h jen ²¹³]	fall	103. 桌上	[tswɔ ²¹ tɕ ^h y ⁵¹]	on the table
72. 秋季	[tɕ ^h jo ⁵¹ tɕi ⁵¹]	fall season	104. 左上	[tswɔ ²¹ tɕ ^h y ⁵¹]	upper left
73. 春天	[tɕ ^h wɤn ³⁵ t ^h jen ²¹³]	spring	105. 古書	[ku ³⁵ ʂu ²¹³]	old books
74. 春季	[tɕ ^h wɤn ³⁵ tɕi ⁵¹]	spring season	106. 古區	[ku ³⁵ tɕ ^h y ²¹³]	old district
75. 空氣	[k ^h oŋ ⁵¹ tɕ ^h i ⁵¹]	air	107. 古趣	[ku ²¹ tɕ ^h y ⁵¹]	archaic flavor
76. 溪流	[ɕi ⁵¹ ljo ³⁵]	small stream			
77. 貓狗	[maw ⁵¹ ko ²¹³]	cat and dog			
78. 冬雪	[toŋ ⁵¹ ɕɤɛ ²¹³]	winter snow			
79. 秋雨	[tɕ ^h jo ⁵¹ y ²¹³]	autumn rain			
80. 放心	[faŋ ⁵⁵ ɕin ²¹³]	to feel relieved			
81. 飛機	[fɛ ³⁵ tɕi ²¹³]	airplane			
82. 廢機	[fɛ ⁵⁵ tɕi ²¹³]	clunker plane			
83. 失足	[ʂi ⁵¹ tɕi ³⁵]	to stumble			
84. 士卒	[ʂi ⁵¹ tɕi ³⁵]	soldier			
85. 三場	[san ⁵¹ tɕ ^h aŋi ²¹³]	three sections			
86. 散場	[san ⁵⁵ tɕ ^h aŋi ²¹³]	to empty after the show			
87. 屋前	[u ⁵¹ tɕ ^h jen ³⁵]	in front of the house			
88. 霧前	[u ⁵¹ tɕ ^h ɛn ³⁵]	in front of the fog			
89. 方形	[faŋ ⁵¹ ɕ ^h in ³⁵]	square			
90. 放行	[faŋ ⁵¹ ɕ ^h in ³⁵]	to let through			
91. 杯下	[pɛj ⁵¹ ɕ ^h ja ⁵¹]	underneath the cup			
92. 被下	[pɛj ⁵¹ ɕ ^h ja ⁵¹]	underneath the blanket			
93. 生產	[ʂɤn ⁵¹ tɕ ^h an ²¹³]	production			
94. 盛產	[ʂɤn ⁵¹ tɕ ^h an ²¹³]	to produce abundantly			
95. 花布	[hwa ⁵¹ pu ⁵¹]	cotton prints			
96. 畫布	[hwa ⁵¹ pu ⁵¹]	canvas			
97. 湯水	[t ^h aŋ ⁵¹ ʂwej ²¹³]	soup and water			
98. 燙水	[t ^h aŋ ⁵⁵ ʂwej ²¹³]	hot water			
99. 詩人	[ʂi ⁵¹ t ^h jen ²¹³]	poet			
100. 史人	[ʂi ²¹ t ^h jen ²¹³]	the Ancients			
101. 人妻	[zɤn ³⁵ tɕ ^h y ²¹³]	one's wife			