Chapter Three♠

TIANJIN DIRECTIONALITY

This chapter explores a set of phenomena related to directionality, a phenomenon commonly associated with prosody (such as Mester and Padgett 1993, Kager 1994, Hayes 1995 and Crowhurst and Hewitt 1995). This chapter will focus on Tianjin as a basis for discussion since it exhibits directional asymmetries in tone sandhi (Hung 1987, Milliken et al 1997, Chen 1985, 1986, 1987 and 2000, Wee, Yan and Chen 2004 among many). Directionality in tone sandhi is not unique to Tianjin and also attributed to a number of languages such as Hakha Lai (Hyman and van Bik 2002) and Changting Hakka (Chen 2002, Chen, Yan and Wee 2003). The reason why directionality is such a relevant topic is obvious - its very notion confronts the ideas of Inter-tier Correspondence Theory (ICT) as a potential general solution to repetitive rule application effects. With reference to Tianjin, the primary language used here for this study, this chapter argues that directionality when interpreted linearly is a façade. Instead, directional effects are simply cyclicity on uniformly left or right-branching structure. This view has to be correct because virtually all long strings yield variant parses dependent on prosodic factors (such as stress).

Taking one step at a time, directionality may quite plainly be understood as linear application insensitive to hierarchical structuring. In other words, one may describe a language as showing directionality effects if (derivationally speaking) a rule applies in

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some particular direction iteratively without regard to the organizational structure of a given string. Without doubt, directionality is asymmetrical, especially when variation in direction yields different results. Thus the term directionality is attributed to cases where one choice is preferred over the other.

Since directionality in general is a type of repetitive (or recursive) application (again to fall back on graphic derivational terms), it is relevant to the understanding of the utility inter-tier correspondence offers as a general theory in describing such effects. Though the linear nature of directionality flies in the face of ICT, there is a handle that may allow the latter to grapple with directionality. This ray of hope may be seen by considering a convenient example below.

(3-1) a. T'+T

T T

$T \rightarrow T' /$ ___ T
where T is underlying and T' is sandhied.

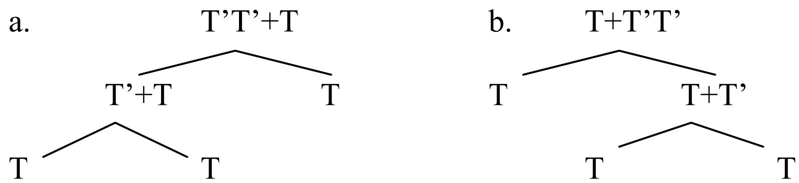
b. T + T'

T T

$T \rightarrow T' / T$ __

In (3-1), I have undertaken to write SPE type rules in the ICT notation, i.e. by putting the results of alternation in the root node. In directional terms, tone sandhi is applying regressively in (3-1a), i.e. leftwards, and progressively in (3-1b). A standard account of (3-1) is to appeal to some asymmetry in faithfulness between the two positions, thereby ensuring a regressive or a progressive alternation. Pursuing this strategy, one can envisage a tritonal string as consisting of binary constituents, either left or right-branching. Persistent faithfulness to the right constituent coupled with left-branching constituency would yield an effect similar to rightwards directionality. The reversed effect could be obtained by coupling faithfulness to the left constituent with right-branching constituency. Both are given below in (3-2).

(3-2)



Conceptualizing directionality along the lines of (3-2) calls to attention the possibilities of combining the two kinds of ditonal sandhi with the two kinds of branching structures. In order for all these possibilities to be clearly described I shall use the following terms (adopted from Chen, Yan and Wee 2003) in the ways described below.

(3-3)
a. **Regressive tone sandhi** refers to ditonal sandhi where the left tone undergoes alternation.

b. **Progressive tone sandhi** refers to ditonal sandhi where the right tone undergoes alternation.

c. **Leftwards directionality** refers to polytonal strings such that tone sandhi (progressive or regressive regardless) applies to the final substring first, then the penultimate substring, so on and so forth.

d. **Rightwards directionality** refers to polytonal strings such that tone sandhi (progressive or regressive regardless) applies to the initial substring first, then the second substring, so on and so forth.

With (3-3), one may envisage typological variation by the combination of these notions. A schematic sample of these variations with respect to a tritonal input is provided below. Notice that leftward application of regressive tone sandhi produces results similar to rightward application of progressive tone sandhi.

(3-4) Typology of directionality

	Regressive TS	Progressive TS
Leftwards	TTT → TT'T	TTT → TT'T'
Rightwards	TTT → T'T'T	TTT → TT'T

Legend: T indicates unaltered tone   T' indicates sandhied tone

A large part of this chapter will be devoted to Tianjin, starting with an introduction of the language's tonal alternations and an exemplification on why its tone sandhi patterns are described as regressive, rightward directional. Also essential is that Tianjin tonal alternations come in two categories, that which is dissimilation and that which is absorption.

This chapter is divided into three parts, with six sections. The first part is descriptive and concentrates on painting a portrait of Tianjin. It begins with an introduction to Tianjin's tonal inventory and some of its basic alternation patterns as related to the Obligatory Contour Principle (OCP). This is used as a basis to describe in detail a set of puzzles in section 3.2. Central to all the puzzles in section 3.2 is the notion of default directionality, and this is explained in section 3.3. However, section 3.3 goes on to point out that directionality is not as linear as it seems. Longer strings and also the variations that arise with structural make-up reveal that directionality in Tianjin really stems from defaults in prosodic structures (which tend to be left-branching).

The second part is section 3.4, where ICT steps in, showing that under this theory, better grasp on the puzzles of Tianjin becomes available. Consequently, this argues for ICT as more than just useful for cyclicity phenomena dealt with in Chapter 2. It must be noted that an important part of the argument lies in the denial of true directionality that is totally linear. Even a hardcore directionality case like Tianjin is really a matter of recursive prosodic structure. It is based on this that directionality is denied as a potential threat to ICT.[1]

The last part consists of section 3.5. It provides discussion on issues somewhat tangential to the main thrust of ICT, but that are nonetheless relevant because of the potential complications they can produce. Section 3.5 addresses the window within which tone sandhi targets. By refining ICT with an additional constraint that alternation processes targets only contact points, this section explains why typically only base tones undergo alternation while allowing for precisely only one situation where a tone can undergo more than one alternation. That situation arises only in languages where there are both progressive and regressive ditonal sandhi rules.

To end the chapter, section 3.6 gives a summary.

3.1. Tianjin

3.1.1. Tonal Inventory

At the risk to digression, I shall begin with an introduction to Tianjin before moving on to the presentation of some of its tone sandhi patterns. Tianjin is a northern Mandarin dialect spoken by about a population of about 8 million in Tianjin city, 30 miles south of

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[1] Denial that true directionality exists is not new. Recent works where various phenomena described as directional are debunked include Bakovic (2002) on vowel harmony and Zoll (2003) on tonal association.

Beijing. Like standard Mandarin, there are four tones in the underlying tonal inventory and in addition, a neutral tone, which pitch-value varies according to context. Another facet of correspondence between these two languages is that morphemes belonging to the same tonal category in Mandarin also belong to the same tonal category in Tianjin. In other words, these two languages partition the morphemes in the same way with regard to tonal category. Hence, references to Tone 1 morphemes across the two languages refer to roughly the same set of syllables, although the syllables would be pronounced with a high flat contour in Mandarin but a low flat contour in Tianjin. The tones of Tianjin are given below.

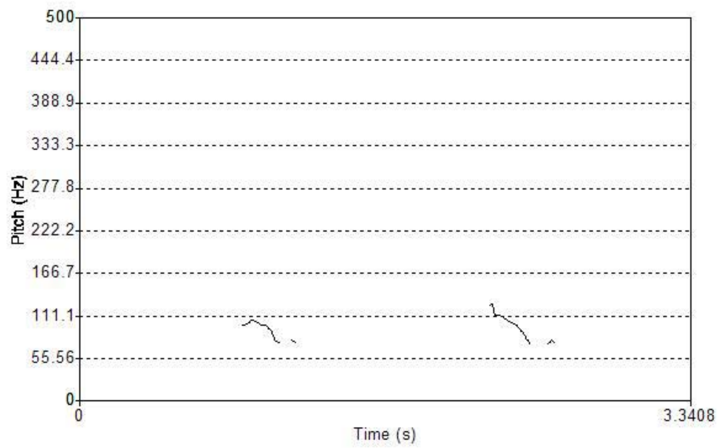
(3.1-1) Tones in Tianjin

	Abbreviation	Pitch value		Description (Chen 2000 and Wang 2002)
		Li and Liu (1985)	Shi (1990)	
First tone	T1	[21]	[11]	L (Low)
Second tone	T2	[45]	[55]	H (High)
Third tone	T3	[213]	[24]	R (Rising)
Fourth tone	T4	[53]	[53]	F (Falling)

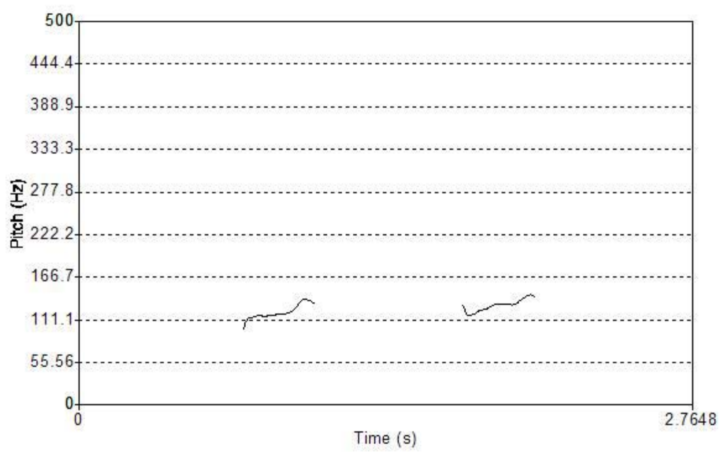
Like Mandarin, there is some discrepancy in the pitch value description of the T3. Chen (2000) bases the description on the experimental evidence of Shi (1990), and is hence quite reliable. Nonetheless, I follow the footsteps of Shih (1988) and offer the following pitch tracks, leaving it to the reader to decide if one description is better than the other. In the pitch tracks below, each syllable is articulated in isolation twice. The speaker Lu Jilun is male and in his early forties. That said, for most purposes, I will adopt Chen's (2000) and Wang's (2002) descriptions.

(3.1-2) Pitch tracks of the Tianjin tones

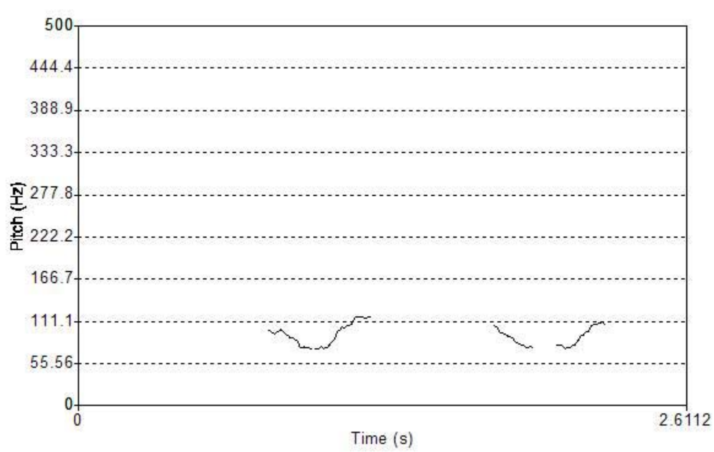
a. ma1 ‘mother’



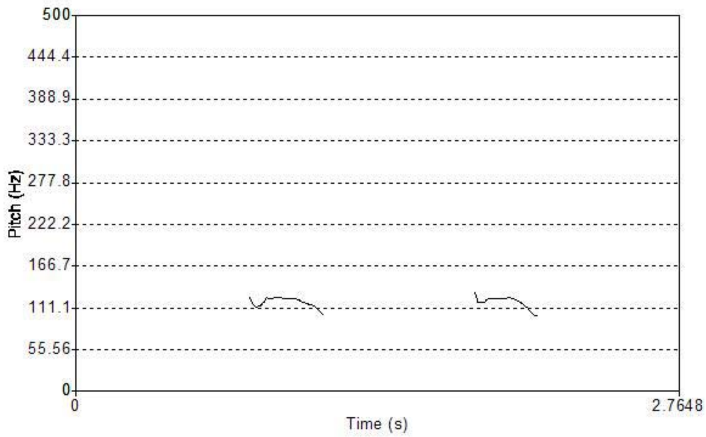
b. ma2 ‘hemp’



c. ma3 ‘horse’



d. ma4 ‘scold’



As a parallel to pitch tracks on Mandarin, the figures in (3.1-2a-d) are displays of the time function of F0 values and is the pitch track of the syllable ma in four Tianjin tones: ma1 ‘mother’, ma2 ‘hemp’, ma3 ‘horse’, and ma4 ‘to scold’.[2] Notice that despite segmental similarities, the tonal contours associated to each morpheme is markedly different between Tianjin and Mandarin. It turns out that in this case, it is perhaps plausible to stick to the descriptions given by Chen (2000) and Wang (2002), even though both tones 2 and 3 are phonetically rising and tone 4 is only falling mildly.

To complete the presentation of Tianjin tones, below is a table describing the neutral tones in Tianjin taken from Wang (2002). It should be of no surprise that like Mandarin (see Chapter Two, item (2.1-3)), the tones vary with context (Shih 1988, Yip 2002).

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[2] The computer program PRAAT was used in the extraction of these pitch tracks. Measurements for the tones with the syllable *ma* are as follows.

Syllable	1st utterance (sec)	2nd utterance (sec)	Average (sec)
Ma [L]	0.277560	0.262420	0.269990
Ma [H]	0.303756	0.303756	0.303756
Ma [R]	0.490773	0.506997	0.498885
Ma [F]	0.317089	0.343513	0.330301

(3.1-3) Phonetic description of neutral tone

Environment	Description of neutral tone, Wang (2002:368)
After T1 (L)	L
After T2 (H)	F
After T3 (R)	F
After T4 (F)	L

Though there are contours in the neutral tones as shown in (3.1-3), Wang (2002) notes that the duration of neutral tones are much shorter than that of fully-toned syllables. Further, note also that neutral tones are L if the preceding tone ends with a low tone (F is made up of a HL sequence), otherwise, the neutral tone is F. Arguably, the neutral tone is /L/ but acquires a [h] initial from spreading of the preceding syllable.

3.1.2. TONAL STABILITY AND OCP

With regard to tone sandhi, of ditonal sequences, Tianjin is regressive, i.e. given a sandhi-triggering ditonal sequence, it is the initial tone that undergoes alternation. With the regressive nature of Tianjin ditonal sandhi, I shall assume that its prosodic head is on the right. This will par the assumptions for both Mandarin and Tianjin.

The tone sandhi of Tianjin is by far more complex than that in Mandarin, and exhibits the following patterns with respect to ditonal sequences.

(3.1-4) Patterns of Tianjin ditonal sandhi (data from Li and Liu 1985)[3]

a. T1 → T3 / ___ T1 (L → R / __L)[4]

examples:

fei1ji1	→	fei3ji1	'air plane'
kai1hua1	→	kai3hua1	'flower (verb)'

b. T3 → T2 / __ T3 (R → H / __ R)

examples:

mai3mi3	→	mai2mi3	'buy rice'
xi3lian3	→	xi2lian3	'wash (one's) face'

c. T4 → T1 / __ T4 (F → L / __ F)

examples:

jing4zhong4	→	jing1zhong4	'net weight'
bao4gao4	→	bao1gao4	'report'

d. T4 → T2 / __ T1 (F → H / __ L)

examples:

jiao4shi1	→	jiao2shi1	'teacher'
fang4xin1	→	fang2xin1	'be assured'

In (3.1-4), I used the letter "T" followed by a numeral to indicate the tonal category under investigation. The corresponding versions of these patterns as described by Chen (2000) and Wang (2002) are given in parenthesis. Notice that no alternation

[3] Indeed most of these patterns point towards the OCP, which is essentially what Chen (2000) assumes.

changes a tone to T4. T3 alternates with T2 in (3.1-4b) and parallels that of third tone sandhi in Mandarin. This might be coincidental since T2 and T3 in Tianjin are phonetically different from those in Mandarin, but it does suggest categorical displacement rather than modification of underlying tones. A phonetically interesting parallel is (3.1-4a) described as L → R / __ L. In this case, it appears that the Mandarin tone sandhi rule (at least for those speakers whose Mandarin T3 is L, like that in Shih 1988) is found in Tianjin as well. In any case, ditonal sandhi in Tianjin is regressive.

In addition to the tone sandhi rules above, there are two patterns[5] that are hitherto unreported. These are stated below.

(3.1-5) a. T3 → T1 / __ T2 (R → L / __ H)

examples:

shen3yang2	→	shen1yang2	'Shenyang' (name of a city)
zhu3ren2	→	zhu1ren2	'master/owner'

b. T3 → T1 / __ T4 (R → L / __ F)

examples:

hao3xiao4	→	hao1xiao4	'funny/laughable'
shou3duan4	→	shou1duan4	'device/tactics'

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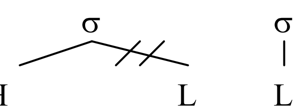
[4] Younger generation speakers actually have a different pattern. In their cases, it is L → H / __ L. This is first reported in Lu (1997). This research will be concerned with providing an account for common Tianjin, rather than this New Tianjin.

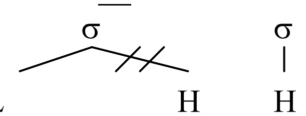
[5] This was communicated to me by Yan Xiuhong when we both assisted Matthew Chen in his research project on directionality at the City University of Hong Kong.

It is strange that these patterns were not reported before since they are quite robust and are found across the older and younger generations of Tianjin speakers. In any case, comparing (3.1-5) with (3.1-4d) where T4 $\rightarrow$ T2 / T1, one may make the following observations.

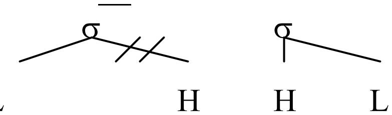
(3.1-6) a. F $\rightarrow$ H / __ L



b. R $\rightarrow$ L / __ H



c. R $\rightarrow$ L / __ F



With all the patterns of tone alternation introduced, the following repeats all these rules together for ease of future reference. These patterns are sub-divided into two categories, so that alternations such as those in (3.1-6) are put together since in these cases, the collocated tones are not totally identical, unlike those other cases of tonal alternation.

(3.1-7) a. Alternation by identity (dissimilation)

$L \rightarrow R$ / __ L (i.e. $L.L \rightarrow LH.L$)

$R \rightarrow H$ / __ R (i.e. $LH.LH \rightarrow H.LH$)

$F \rightarrow L$ / __ F (i.e. $HL.\ HL \rightarrow L.HL$)

b. Alternation by partial identity (absorption)[6]

$F \rightarrow H$ / __ L (i.e. $HL.\ L \rightarrow H.L$)

$R \rightarrow L$ / __ H (i.e. $LH.\ H \rightarrow L.H$)

$R \rightarrow L$ / __ F (i.e. $LH.\ HL \rightarrow L.HL$)

From the tonal alternations, it is plain that stability is found on the final tone of a ditonal sequence.

The two kinds of rules in (3.1-7) may be reinterpreted as two different kinds of OCP constraints – one against the adjacency of identical tone contours which I shall call OCP[TC] and the other against the adjacency of identical tone features which I shall refer to as OCP[TF] (Chen 2000:p.106 uses OCP and OCP' to refer to total identity and partial identity respectively). Thus (3.1-7a, b) may be pictorially understood as below.

(3.1-8) Tone contour (= R, F, L or H) $\leftarrow$ OCP[TC] applies here

tone feature   tone feature (=h or l) $\leftarrow$ OCP[TF] applies here

[6] Following Chen's (2000:106) observation that absorption occurs because there are two adjacent identical tone features.

Now, since in Tianjin, HH adjacency is always tolerated, it follows that dissimilation should really be only a series of OCP[TC] against R, F and L. In OT terms, this would be derived by a ranking hierarchy OCP[R]; OCP[F]; OCP[L] » FAITH » OCP[H].

OCP[TF] applies to adjacent identical tone features rather than tone contours. For example, when viewed compositionally /R/ is a sequence of [l] followed by [h]. Thus /RH/ → [LH] would be /lh.h/ → [l.h]. Notice the offending [h] adjacency in /lh.h/. Now OCP[TF] applies to both [l] and [h] tone features, since /FL/ → [HL] (i.e. /hl.l/ → [h.l], with the adjacent [l]s being the offending collocation). However, it is important to note that not all collocations of identical tone features trigger tone sandhi. For example, /HF/, /HH/ and /LR/ do not trigger tone sandhi. Evidently, collocations of identical tonal features are punished only if the first tone contour is complex (i.e. *xy.y, where x and y are tonal features. The "." indicates syllable boundary.). This effect is obtainable by a ranking hierarchy such as OCP[xy.y] » Faith » OCP[x.x].

Having now presented all the basic tonal alternations of Tianjin, the next section presents tritonal sequences so that the various intriguing properties of Tianjin tone sandhi may be demonstrated.

3.2. Puzzles of Tianjin tone sandhi

This section serves to outline exhaustively the puzzles found in Tianjin tonal alternations, though not all of them share the same degree of relevance to the matter of directionality. As such, their treatment in this chapter will differ accordingly. A brief overview of this section: 3.2.1 presents directionality; 3.2.2 shows an asymmetry in the strength of the two different tone sandhi rules; 3.2.3 features obligatory sandhi at the final substring of a tritonal sequence; 3.2.4 demonstrates that R-tone related environments must under go alternation; 3.2.5 shows that tones are stable when emphasized; 3.2.6 lists a few strange cases of ambidirectionality; 3.2.7 and 3.2.8 discuss interaction between phonology and morphosyntax. 3.2.9 gives an interim summary.

3.2.1. DIRECTIONALITY

Tianjin directionality is most easily demonstrated by considering tritonal sequences such as the following three cases (data from Li and Liu 1985, cited in Chen 2000).

(3.2-1) i. /RRR/ → HHR

examples:

[li.fa] suo	'barber shop'
mu [lao.hu]	'tigress'

ii. /LLL/ → LRL

examples:

[tuo.la] ji	'tractor'
kai [fei.ji]	'fly a plane'

iii. /FLL/ → FRL

examples:

[lu.yin] ji	'cassette recorder'
shang [feu.ji]	'board an air plane'

In (3.2-1), as in all examples cited in this work, a dot '.' indicates syllable boundary. Notice also that in these examples, the morphosyntactic structures do not affect the outcome of the input strings. The reason why (3.2-1) exemplifies Tianjin directionality is as follows. Given a sequences of three R tones, there are two sandhi sites – one located at the initial substring and the other at the final substring. Depending on where tone sandhi applies first, the resultant forms would be very different. To use a mathematical analogy given in Chen (2002), the result of 2+3x4 is dependent on which operation takes place first. By convention, multiplication precedes addition, but that could be overridden by bracketing. Likewise, tone sandhi could in principle apply to the two sandhi sites of /RRR/, /LLL/ and /FLL/ in any order and produce the following possibilities.

(3.2-2) a. Initial substring first

<table>
<tr><td>Input</td><td>R</td><td>R</td><td>R</td><td></td><td>L</td><td>L</td><td>L</td><td></td><td>F</td><td>L</td><td>L</td></tr>
<tr><td>TS at initial substring
TS as final substring</td><td>H
</td><td>|
H</td><td></td><td></td><td>R
</td><td>|
R</td><td></td><td></td><td>H
</td><td>|
R</td><td></td></tr>
<tr><td>Result</td><td>H</td><td>H</td><td>R</td><td></td><td>R</td><td>R</td><td>L</td><td></td><td>H</td><td>R</td><td>L</td></tr>
</table>

b. Final substring first

<table>
<tr><td>Input</td><td>R</td><td>R</td><td>R</td><td></td><td>L</td><td>L</td><td>L</td><td></td><td>F</td><td>L</td><td>L</td></tr>
<tr><td>TS as final substring</td><td>|</td><td>H</td><td></td><td></td><td></td><td>R</td><td></td><td></td><td></td><td>R</td><td></td></tr>
<tr><td>TS at initial substring</td><td>|</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Result</td><td>L</td><td>H</td><td>R</td><td></td><td>L</td><td>R</td><td>L</td><td></td><td>F</td><td>R</td><td>L</td></tr>
</table>

Since /RRR/ → *[LHR], tone sandhi must be applying rightwards. Likewsie, since /LLL/ → *[RRL] and /FLL/ → *[HRL], tone sandhi must be applying leftwards. Immediately, one is struck by the inconsistency in the traffic of Tianjin tone sandhi. However, the juxtaposition of /RRR/ and /LLL/ cases suggests that the default direction of tone sandhi application is rightwards, especially when one looks at the counterbleeding effects of /RRR/[7]. Leftward application happens only when rightward application yields a sandhi-triggering form, apparently to avoid opacity. For example, the rightward application of tone sandhi to /LLL/ yields *[RRL], where RR is a sandhi-triggering environment. In the case of /FLL/, it appears that the dissimilation rules apply before the absorption rules. This insight was first proposed by Chen (2000) as given below.

(3.2-3) **Direction Flip Condition** (Chen 2000:111)

> By default rules apply from left to right (in Tianjin) – unless such a mode of application produces an ill-formed output (i.e. contains an environment where dissimilation rules can apply), in which case the direction of operation is reversed.
>
> **Preemptive Clause** (Chen 2000:113f)
>
> When a string simultaneously contains an environment for dissimilation and for absorption, apply dissimilation first.

Tianjin directionality is not limited to these three cases. Following the footsteps of Chen (2000), all the cases where there are potentially more than one sandhi site in a tritonal string are provided below, the first seven of which are adapted from Chen (2000)[8].

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[7] One might attribute the /RRR/ counterbleeding and /LLL/ bleeding difference to the avoidance of R, the most marked of tone contours. This move is not possible since with /FFF/ → HLF (see P3 at (3.2-4) and later at (3.4-10)), counterbleeding rule ordering produces no R sequences. It is solely the prevention of further sandhi-triggering environments that determines directionality..

[8] With a tonal inventory of four, a tritonal sequence would yield 64 combinatory possibilities. 25 of which contain no sandhi sites, 24 of which require only one adjustment and thus yield the same result whether one applies sandhi in one direction or the other. Only 15 interesting cases remain.

(3.2-4) List of directional effect patterns[9]

Pattern	Input	Output	[x x] x	x [x x]	x x x
P1	FFL	LHL via LFL	[si.ji] qing 'evergreen	zuo [dian.che] 'take a tram'	si.si.san 'four.four.three'
P2	RRR	HHR via HRR	[li.fa] suo 'barber shop'	mu [lao.hu] 'tigress'	ma.zu.ka 'marzuka'
P3	FFF	HLF via FLF	[su.liao] bu 'plastic cloth'	ya [re.dai] 'subtropical'	yi.da.li 'Italy'
P4	LLL	LRL	[tuo.la] ji 'tractor'	kai [fei.ji] 'fly a plane'	san.san.san 'three three three'
P5	RLL	HRL via RRL	[bao.wen] bei 'thermos cup'	da[guan.qiang] 'speak in a bureaucratic tone'	ma.la.song 'marathon'
P6	LFF	RLF via LLF	[wen.du] ji 'thermometer'	tong[dian.hua] 'make a phone call'	san.si.si 'three four four'
P7	FLL	FRL	[lu.yin] ji 'tape recorder'	shang [fei.ji] 'board a plane'	si.san.san 'four three three'
P8	LRH	LLH	[xin.li] xue 'psychology'	gao [shui.ping] 'high standard'	san.wu.ling 'three five zero'
P9	LRF	LLF	[zhong.biao]dian 'timepiece store'	xin [shou.tao] 'new gloves'	san.wu.si 'three five four'
P10	RRH	HLH via HRH	[xiao.pin]wen 'short prose'	xie [san.wen] 'write an essay'	jiu.wu.ling 'nine five zero'
P11	RRF	HLF via HRF	[yang.lao] yuan 'old folk's home'	gui [ba.xi] 'pranks'	jiu.wu.si 'nine five four'
P12	RFF	RLF	[gan.tan] ju 'exclamation clause'	xie [bao.gao] 'write a report'	wu.si.si 'five four four'
P13	FRH	FLH	[jia.shi] yuan 'driver'	po [jiu.ping] 'broken wine bottle'	si.jiu.ling 'four nine zero'
P14	FRF	FLF	[dai.biao] hui 'representative meeting'	shang [li.bai] 'last week'	si.jiu.si 'four nine four'
P15	RFL	LHL	[bao.zheng] shu 'guarantee certificate'	xiao [jiao.che] 'small sedan car'	wu.si.san 'five four three'

For clarity, in the above table, the underline indicates the substring where tone sandhi appears to applies first. In cases where there are subsequent tone sandhi applications, the intermediate form is noted by a "via" phrase under the output column.

9 Contrary to (3.2-4)'s suggestion that Tianjin tone sandhi is oblivious to syntactic constituency, it is in fact always possible to apply tone sandhi starting from the minimum constituent, terminating tone sandhi at any constituent boundaries. In addition to the above, this table does not present various optional outputs of tritonal sandhi. Some of these options will be presented in section 3.2.4 and subsequent subsections. This table is kept pristine so that directionality issues would not be obscured.

Needless to say, this presentation is derivational and is justified more under convenience in description rather than under theory. The patterns above are most directly relevant to the matter of directionality and will be reprised in section 3.3 and subsequent sections. Before that, the following sub-sections complete the presentation of patterns in Tianjin tone sandhi.

3.2.2. DISSIMILATION PRIORITY

There is an asymmetry in the strength of dissimilation and absorption. Consider pattern P7, repeated below.

(3.2-5) /FLL/ → [FRL] (but *[HRL], cf. (3.2-4))

example: si.san.san ‘four-three-three’

As may be seen in (3.2-5), the fact that *[HRL] is not a possible output for /FLL/suggests that dissimilation is stronger than absorption.

(3.2-6) Dissimilation Priority

If both dissimilation and absorption are applicable, dissimilation takes priority. (=Chen 2000:114, preemptive principle)

3.2.3 FINAL SUBSTRING SATISFACTION

On top of directional pressures, in Tianjin tritonal sequences, there is pressure to apply tone sandhi on the final substring. This is best exemplified by sequences where there is only one sandhi site, either on the final substring or on the initial substring.

(3.2-7) a.	/LLH/ →	[LLH] ([RLH] is another option)		
	example:	san.san.ling	‘three-three-zero’	
b.	/HLL/ →	[HRL] (but *[HLL])		
	example:	ling.qi.san	‘zero-seven-three’	
(3.2-8) a.	/FLH/ →	[FLH] ([HLH] is another option)		
	example:	si.san.ling	‘four-three-zero’	
b.	/HFL/ →	[HHL] (but *[HFL])		
	example:	ling.si.san	‘zero-four-three’	

Recall from (3.1-7b) that /LL/ → [RL] and /FL/ → [HL]. Evidently, the asymmetries in (3.2-7) and (3.2-8) show that the final ditonal substring cannot contain a marked collocation.

(3.2-9) Final Substring Satisfaction

Final substring of a surface string cannot contain a tone sandhi environment.

In addition, it appears that tone sandhi is optional on the first substring, unless prohibited by R-related satisfaction (see ensuing subsection).

3.2.4. R-RELATED SATISFACTION

The earlier section[10] shows that that sandhi must apply to the final substring when the conditions are met. This section presents tonal collocations involving the R tone, hence the title of this subsection "R-related". Data below shows that any sandhi-triggering environment involving the R tone is not tolerated on the surface, regardless of its location at the initial or final substring.

(3.2-10)	a.	/RRL/ →	[HRL] (but *[RRL])	
		example:	wu.jiu.san	'five-nine-three'
	b.	/LRR/ →	[LHR] (but *[LRR])	
		example:	san.wu.jiu	'three-five-nine'
(3.2-11)	a.	/RHH/ →	[LHH] (but *[RHH])	
		example:	wu.ling.ling	'five-zero-zero'
	b.	/HRH/ →	[HLH] (but *[HRH])	
		example:	ling.wu.ling	'zero-five-zero'
(3.2-12)	a.	/LLH/ →	[LLH] ([RLH] another option)	
		example:	san.san.ling	'three-three-zero'
	b.	/HLL/ →	[HRL] (but *[HLL])	
		example:	ling.san.san	'zero-three-three'

[10] Data in this section shows options of tritonal sandhi not presented in the table in (3.2-4). They were deliberately omitted to preserve clarity.

(3.2-13) a. /FLH/ → [FLH] ([HLH] is another option)

example: si.san.ling 'four-three-zero'

b. /HFL/ → [HHL] (but *[HFL])

example: ling.si.san 'zero-four-three'

Observe that (3.2-10) and (3.2-11) require tonal alternation regardless of where the R-related tone sandhi is located. In contrast, there is some amount of tolerance in (3.2-12) and (3.2-13) with L- and F-related tonal alternations.

(3.2-14) R-related Satisfaction

Surface string cannot contain R related tone sandhi environments.

The effect in (3.2-14) may be derived by having markedness constraints pertaining to R rank higher than all faithfulness constraints.

Dissimilation priority, Final Substring Satisfaction and R-related Satisfaction may stand in conflict, especially when one considers situations where there are R-related tonal alternations in both the initial and final substrings. Some examples are given below.

(3.2-15) a. /RRF/ → [HLF] and also [RLF]

example: jiu.wu.si 'nine-five.four'

b. /RRH/ → [HLH] and also [RLH]

example: jiu.wu.ling 'nine-five.zero'

From (3.2-15), applying alternation at either the initial substring or the final substring first is acceptable. This means that Final Substring Satisfaction and R-related Satisfaction are not requirements of priority, but rather requirements of necessity. To put it plainly, the fulfillment of these conditions do not necessarily take priority, they are simply environments that are not tolerated at the surface string.

3.2.5. Stability under emphasis

Given a string of Tianjin syllables, emphasis on any of the syllables will result in the syllable keeping its tone, and hence block any alternation from applying to it. Instead alternation applies to its preceding tone wherever possible. Examples below, boldface indicates emphasized syllable.

(3.2-16) a. /**L**L/ → [LL]

b. /L**L**/ → [RL]

example: ta.shuo 'he says'

(3.2-17) a. /R**R**R/ → [HRR]

b. /**R**RR/ → [RHR]

c. /RR**R**/ → [HHR]

example: wu.jiu.wu 'five-nine-five'

To illustrate that emphasis requires the preceding syllable to undergo alternation, we evoke the examples where a sandhi site at the initial substring of a tritonal sequence prefers not to undergo alternation.

(3.2-18) a. /FLH/ $\rightarrow$ [FLH] ([HLH] is another option)

b. /F**L**H/ $\rightarrow$ [HLH] (but never [FLH])

example: zheng.fang.xing. 'perfect square'

(3.2-19) a. /FFH/ $\rightarrow$ [FFH] ([LFH) possible but not common]

b. /F**F**H/ $\rightarrow$ [LFH] (but never [FFH])

example: bao.pa.niu 'Leopard fears cow.'

It is curious that stability under emphasis is manifested by the volatility of the preceding tone. This property is stated below for ease of reference.

(3.2-20) Stability under Emphasis

An emphasized tone is exempted from any applicable alternation, but tone sandhi rules apply obligatorily to its preceding tone, if the preceding tone constitutes a sandhi environment.

(E.g. if B is emphasized in /ABC/, then B will not alternate even if BC is a triggering environment. But, if AB is a triggering environment, then A must alternate.)

3.2.6. AMBIDEXTERITY

There is a case of ambidexterity in direction of derivation. Below is an example using the tritonal sequence /FFF/, and the forms reported as attested from various sources. The columns “left to right” and “right to left” indicate the forms derivable via a corresponding direction of applying the ditonal sandhi rules.

(3.2-21)

/FFF/	Right to left		Left to right
	[FLF]	[HLF] (via FLF)	LLF (via LFF)
Li and Liu (1985)	✔		
Tan (1986)	✔	✔	
Shi (1988)	✔		✔
Lu (p.c.)	✔ (common)	✔ (few)	✔ (exist)

/FFF/ is not the only case. Other cases include /FFL/, /RRH/ and /RRF/.

(3.2-22) a /$\underline{\text{FF}}$L/ (left to right)
↓
L$\underline{\text{FL}}$
↓
LHL

b. /F$\underline{\text{FL}}$/ (right to left)
↓
FHL

(3.2-23) a. /$\underline{\text{RR}}$H/ (left to right)
↓
H$\underline{\text{RH}}$
↓
HLH

b. /R$\underline{\text{RH}}$/ (right to left)
↓
RLH

(3.2-24) a. /<u>RR</u>F/ (left to right)
↓
H<u>RF</u>
↓
HLF

b. /R<u>RF</u>/ (right to left)
↓
RLF

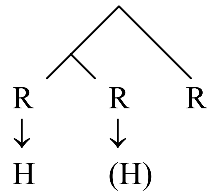
As far as I can tell the ambidexterity of these cases are not reducible to the interaction of the effects given from section 3.2.1 to section 3.2.5.

(3.2-25) /FFF/, /FFL/, /RRF/ and /RRH/ are ambidirectional.

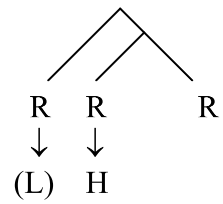
3.2.7. SYNTACTIC BLOCKING

In the presentation of the 15 patterns in the table (3.2-4), one may get the impression that there can be no interaction between phonology and morphosyntax. This is not true, as this and the next subsection will show. In all cases, tone sandhi can be blocked by morphosyntactic boundaries. In fact, even the demands of Final Substring Satisfaction (section 3.2.3) and R-related Satisfaction (section 3.2.4), may be suspended. As such, Tianjin tone sandhi exhibits optionality in the choice of applying tone sandhi rules completely. Examples abound, one will suffice here.

(3.2-26) a.



b.



Given this, one may generalize as follows:

(3.2-27) Syntactic Blocking

Tone sandhi triggering environments are tolerated if the two tones belong to different syntactic phrasal constituents.

3.2.8. SMALLEST CONSTITUENT PRIORITY

(3.2-26b) highlights the priority of smaller constituents against the requirements of default directionality. Notice that for the initial R to become L, there must be the feeding relation that the medial R first becomes H. Indeed, in Tianjin, there is always the option of applying tone sandhi to the smallest constituent first whenever constituencies are available. This option applies when one attempts to disambiguate one morphosyntactic structure from another, since after all, tone sandhi may cause otherwise different inputs to have identical surface outputs.

3.2.9. Interim summary

To wrap up, the following presents a list of all the generalizations that may be made for Tianjin up to this point. They are grouped into three categories beginning with generalizations about what processes appear to take place first (3.2-28). This followed by (3.2-29) which lists generalizations about surface strings where sandhi environments are not tolerated. Finally in (3.2-30) is a description of where tone sandhi is either blocked or where its application appears to be erratic.

(3.2-28) Order of tone sandhi application

- a. Default direction: Apply tone sandhi from **left-to-right.**
- b. Flip condition: Apply tone sandhi from right-to-left if default application yields a form containing a sandhi environment.
- c. Dissimilation first: If both dissimilation and absorption are applicable, then dissimilation takes priority.
- d. Constituency: Tone sandhi applies to smaller constituents first.

(3.2-29) Constraints on surface strings

- a. Final Substring: Final substring of a surface string cannot contain a tone sandhi environment.
- b. R-satisfaction: Surface string cannot contain a R-related tone sandhi environment.

(3.2-30) Inapplicability or erratic application of tone sandhi

a. Emphasis: An emphasized tone is exempted from any applicable alternation, but tone sandhi rules apply obligatorily to its preceding tone.

b. Ambidirection: /FFF/, /FFL/, /RRF/ and /RRH/ are allow application in either direction.

c. Blocking: Tone sandhi triggering environments are tolerated if the two tones belong to different syntactic phrasal constituents..

Not all of the above generalizations will find their way into principles and constraints for an account of Tianjin. As it is, the above exposition serves only to flesh out the intricacies of tonal patterns in Tianjin.

3.3. Default directionality

Now acquainted with the patterns related to Tianjin polytonal sandhi (exemplified above with tritonal sequences), one is now ready to concentrate on the directionality aspect of it. As noted above, Chen (2000) claims that by default, Tianjin tone sandhi applies rightwards. In the name of rigor, perhaps the best way to justify this is to apply two hypotheses (a leftward default versus a rightward default) to all these cases and see which of them provides a coherent account. This comparison is done below. "Flip condition" and "preemptive clause" in this table refer to the two statements at (3.2-3) respectively.

These two statements, together with "Moving Window" are given below so that one may better understand the assumptions involved in hypothesizing default directionality.

(3.3-1) **Direction Flip Condition** (Chen 2000:111)

By default rules apply from left to right (in Tianjin) – unless such a mode of application produces an ill-formed output (i.e. contains an environment where dissimilation rules can apply), in which case the direction of operation is reversed.

Preemptive Clause (Chen 2000:113f)

When a string simultaneously contains an environment for dissimilation and for absorption, apply dissimilation first.

Moving Window Constraint[11]

Ditonal sandhi may not apply to the same local window more than once.

[11] Moving Window supercedes the No Backtracking constraint of Chen (2000) and also the One Step Principle of Hsu (2002). For detailed arguments see Chen, Yan and Wee (2003) and also section 3.6.

(3.3-2) Comparison of two hypotheses on default direction

<table>
<tr><th></th><th></th><th></th><th></th><th colspan="2">Hypothesis on default direction</th></tr>
<tr><th>Pattern</th><th>Input</th><th>Output</th><th>Direction</th><th>Rightward</th><th>Leftward</th></tr>
<tr><td>P1</td><td>FFL</td><td>LHL</td><td>→</td><td rowspan="2">OK</td><td>Preemptive Clause</td></tr>
<tr><td>P2</td><td>RRR</td><td>HHR</td><td>→</td><td>Impossible</td></tr>
<tr><td>P3</td><td>FFF</td><td>HLF</td><td>←</td><td rowspan="3">Flip condition</td><td rowspan="5">OK</td></tr>
<tr><td>P4</td><td>LLL</td><td>LRL</td><td>←</td></tr>
<tr><td>P5</td><td>RLL</td><td>HRL</td><td>←</td></tr>
<tr><td>P6</td><td>LFF</td><td>RLF</td><td>←</td><td rowspan="3">Preemptive Clause</td></tr>
<tr><td>P7</td><td>FLL</td><td>FRL</td><td>←</td></tr>
<tr><td>P8</td><td>LRH</td><td>LLH</td><td>→</td><td rowspan="2">Absorption counterfeeds dissimilation</td></tr>
<tr><td>P9</td><td>LRF</td><td>LLF</td><td>→</td><td>Moving Window</td></tr>
<tr><td>P10</td><td>RRH</td><td>HLH</td><td>→</td><td rowspan="2">OK</td><td rowspan="2">Preemptive Clause</td></tr>
<tr><td>P11</td><td>RRF</td><td>HLF</td><td>→</td></tr>
<tr><td>P12</td><td>RFF</td><td>RLF</td><td>←</td><td>Preemptive clause</td><td>OK</td></tr>
<tr><td>P13</td><td>FRH</td><td>FLH</td><td>→</td><td rowspan="2">Moving Window</td><td rowspan="2">Impossible</td></tr>
<tr><td>P14</td><td>FRF</td><td>FLF</td><td>→</td></tr>
<tr><td>P15</td><td>RFL</td><td>LHL</td><td>↔</td><td>OK</td><td>OK</td></tr>
<tr><td colspan="4">Conclusion</td><td>OK</td><td>P2, P13 and P14 contradict this.</td></tr>
</table>

In (3.3-2), each pattern is examined against two possible hypotheses. Under the column "direction", arrows indicate the apparent direction of derivation. Under the columns labeled "rightward" and "leftward" are the assumptions necessary for sustaining each corresponding hypothesis on default directionality. Thus, "preemptive clause", "flip condition" and "moving window" mean that these have to be invoked for an account of that pattern under each hypothesis. "Moving window" is what tolerates certain sandhi-triggering environments as in P9, P13 and P14. In the case of P8 and P9, absorption and dissimilation must have counterfeeding order to sustain a hypothesis using leftward application as default. In a nutshell, acceptance of the rightwards default entails the following derivational order. A table showing the derivations of all the 15 patterns is provided for reference.

(3.3-3) Derivation procedure for Tianjin tone sandhi

Step 1 Apply Dissimilation (cf. (3.1-7a)) rightwards

Step 2 Apply Direction Flip Condition

Step 3 Apply Absorption (cf. (3.1-7b))

Pattern	Input	Dissimilation rightwards	Flip	Absorption	Output
P1	FFL	LFL	-	LHL	LHL
P2	RRR	HHR (via HRR)	-	-	HHR
P3	FFF	LLF (via LFF)	FLF	HLF	HLF
P4	LLL	RRL (via RLL)	LRL	-	LRL
P5	RLL	RRL	HRL	-	HRL
P6	LFF	LLF	RLF (via LLF)	-	RLF
P7	FLL	FRL	-	-	FRL
P8	LRH	-	-	LLH	LLH
P9	LRF	-	-	LLF	LLF
P10	RRH	HRH	-	HLH	HLH
P11	RRF	HRF	-	HLF	HLF
P12	RFF	RLF	-	-	RLF
P13	FRH	-	-	FLH	FLH
P14	FRF	-	-	FLF	FLF
P15	RFL	-	-	LHL	LHL

It is precisely this derivational nature and its directionality that is interesting and challenging about Tianjin. In derivational frameworks, these patterns though expressible do not offer us any apparent deeper insight into why tone sandhi behaves the way it does, i.e. if there is some independent evidence for the directionality. However, there are difficulties in casting (3.3-3) into a set of universally understood constraints/principles. The following paragraphs will do two things. Firstly, it will attempt to provide some independent evidence for the rightward directionality default, and explain that this effect really comes from prosodic structures. Essentially, the rightward default stems from left-branching prosodic constituency. Secondly, it will spell out the challenges that P1-15 present, i.e. the seriatim derivation that produces at once both counterbleeding (P2) & counterfeeding (P8) opacity effects and also bleeding (P4) & feeding (P3) transparency effects. In addition, there is a special counterfeeding case in P13 and P14, where apparently, absorption does not seem to apply iteratively.

3.3.1. DIRECTIONALITY BY PROSODIC CONSTITUENCY

This subsection will attempt at providing some independent motivation for the rightward default directionality by considering two unrelated phenomena. To begin, despite its success, the Derivation Procedure for Tianjin Tone Sandhi (c.f. (3.3-3)) leaves behind a tinge of discomfort. For example, the default rightward direction is made solely so as to account for P2, P13 and P14 and perhaps has the extra merit of intuitive appeal in the temporality of language processing. Otherwise, apparently most of the applications in P1-15 can be conveniently described as leftward. Fortunately, the rightward default so badly needed for Tianjin's analysis may find substantiation from two sources – firstly on pause insertion and secondly on medial syllable swallowing[12]. The conclusion from this study is that the directionality effect of Tianjin actually stems from constituency.

Starting with pause insertion, consider the following data, where the morphosyntactic structures are arguably flat.

(3.3-4) a. /HHH/ → [HH (pause) H]

example:

ling.ling.ling ‘zero zero zero’

b. /RRR/ → [HH (pause) R]

example:

wu.wu.wu ‘five five five’

c. /LLL/ → [L (pause) RL]

example:

san.san.san ‘three three three’

Given a trisyllabic sequence of numbers “zero”, “five” and “three”, pauses may only be inserted after the initial ditonal substring when the tones are H or R. When the tones are L, then the pause is allowed only before the final ditonal substring. The most straightforward explanation to this state of affairs is to say that Tianjin prosodic constituents (feet or perhaps some other kind of rhythmic unit) are constructed rightwards. This would account for why in (3.3-4a, b), pauses are permitted only after the initial ditonal substring, regardless of the application of tone sandhi at that domain. However, interestingly, in (3.3-4c), pause is allowed before the final substring. Taken together, the phenomenon of pause insertion may be understood as follows. By default, Tianjin builds disyllabic prosodic units rightwards as evidenced by (3.3-4a) since no tone sandhi is involved here. However, when tone sandhi is involved, the prosodic grouping takes into consideration if the default grouping produces a grammatical sandhi outcome, assuming

[12] Tianjin judgments offered here and subsequently are from Lu Jilun.

that constituent tones undergo sandhi first. With (3.3-4b), the default prosodic grouping produces a grammatical tone sandhi outcome, and hence pauses are allowed after the initial substring. In (3.3-4c), the default prosodic grouping would not produce a grammatical tone sandhi outcome. This is because a left-branching grouping requires sandhi to work rightwards (by virtue of prosodic constituency), yielding a *[RRL][13]. As such, the grouping is reversed, therefore allowing pauses only before the final ditonal substring.

The second piece of evidence for the rightward construction of prosodic units comes from syllable contraction (Yan, Lu and Wee 2003).

(3.3-5) Tianjin trisyllabic contraction

a.	mau.tsə.tuŋ	→	mau.tuŋ	‘Mao Zedong’
b.	təŋ.ɕiau.pʰiŋ	→	tə.ɔ.pʰiŋ	‘Deng Xiaoping’
c.	ɕin.tɕia.pʰo	→	ɕia.pʰo	‘Singapore’

Given a trisyllabic sequence, such as the names of people, the sequence is often contracted as seen in (3.3-5). Such contraction is highly productive among Tianjin speakers when that sequence is familiar to them (in this case the names of famous people or of close friends). As may be seen in (3.3-5), contraction either involves the deletion of the medial syllable, the deletion of the medial onset or the deletion of the initial rime

[13] Rightward ad infinitum application to tone sandhi to /LLL/ could also yield the highly opaque [HRL]. But this violates the Moving Window (recall comparison on default directionality in (3.3-1) and (3.3-2).)

(3.3-5c). At the risk of providing to simplistic an account, this phenomenon may be captured by the following derivation[14].

(3.3-6) Deriving at the Tianjin trisyllabic contraction

Onset deletion:	Delete medial onset (glides are assumed to be part of the onset, Duanmu 1990, 2000, 2002).
Schwa erasure:	Lone schwas (i.e. syllables made up of only a schwa) are deleted.
Coda deletion:	Delete nasal coda of initial syllables.
Syllabification:	Syllabify remaining segments.
Lax	De-stress medial syllable (make vowels lax).

	Input:	mau.tsə.tuŋ	təŋ.ɕiau.pʰiŋ	ɕin.tɕia.pʰo
Step 1	Onset deletion	mau.ə.tuŋ	təŋ.au.pʰiŋ	ɕin.a.pʰo
Step 2	Schwa erasure	mau.__.tuŋ	-	-
Step 3	Coda deletion	mau.__tuŋ	tə.au.pʰiŋ	ɕi.a.pʰo
Step 4	Syllabification	mau.tuŋ	-	ɕia.pʰo
Step 5	Lax	-	tə.ɔ.pʰiŋ	-
	Output	ma.tuŋ	tə.ɔ.pʰiŋ	ɕia.pʰo

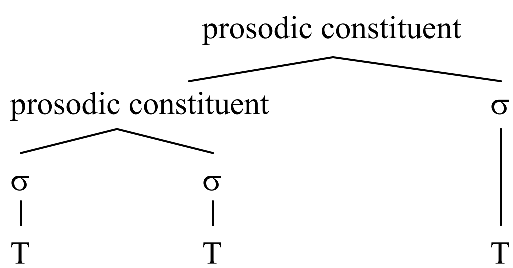
As may be seen in (3.3-6), the deletion of the medial onset and the initial nasal rime suggests certain proximity between the initial and the medial syllable. It is as if these two syllables are grouped together in the attempt to contract the trisyllabic sequence, presumably to make a disyllabic foot of some kind. Since names do not have internal morphosyntactic structure, the intimacy of the first two syllables points to their prosodic

[14] It is certainly possible to capture the contraction under OT, however this simplistic derivation suffices in making the point on the proximity between the initial and the medial syllable.

constituency. Like pause insertion, the phenomenon of trisyllabic contraction supports the idea that Tianjin prosody is built by forming disyllabic units from left to right[15].

The phenomena of pause insertion and trisyllabic contraction argue that tritonal sequences are by default prosodically left-branching (3.3-7). It is thus that the proximity of the first two syllables may be adequately expressed. If rules apply to minimal constituents first, this would give a default rightward directionality effect. One may wonder why the medial syllable may reduce if it were the head of the lower constituent. The answer is that at the higher constituent, it is no longer head, and hence is susceptible to reduction.

(3.3-7) Default prosodic structure

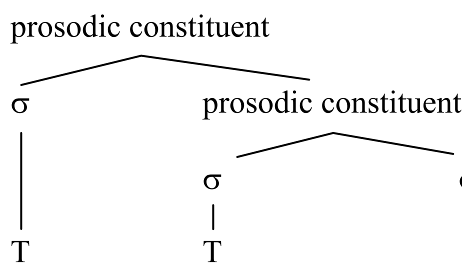


(3.3-7) does not make a claim if the tone-bearing unit is a syllable or something else. Instead, it serves merely to notate tonal association. This prosodic structure may be

[15] A tritonal sequence /FFF/ behaves like /LLL/ by allowing pause only immediately after the first syllable, hence prosodic constituency of the final substring. By this token, one would expect contraction to apply at the boundary of the medial and final syllables. It turns out that given a /FFF/ sequence such as yue4xiu4lu4, contraction applies to the onset of the medial syllable rather than the final and becomes yue.u.lu with a [HLR] tonal sequence derivable by a leftward application of tone sandhi. The pause insertion (as well as the direction of tone sandhi) thus suggests a prosodic organization different from that required by contraction. To fudge out of this problem, I appeal to the fact that contraction applies mostly only to names which rarely have sequences of identical tones. This rarity may have allowed speakers to generalize so much that contraction applies at the initial substring regardless of tonal content. Also, following contraction, some tonal information may be lost and therefore no longer constrain prosodic configuration. This allows for the widespread rightward directionality in the prosodic constituency observed in contraction. It is without contraction that tone sandhi patterns limit the prosodic constituency the way shown in (3.2-4).

assumed to be the default of Tianjin, as evidenced by the rightward directionality effects of pause insertion and contraction and also by Chen's (2000) analysis that would correctly describe the data. However, this default can be overridden, as was shown by the distribution of pauses at (3.3-4). In fact, when the tones are L, a pause is allowed only after the initial syllable, suggesting a prosodic structure of the kind below.

(3.3-8) Non-default prosodic structure



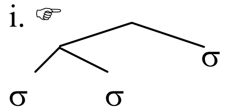
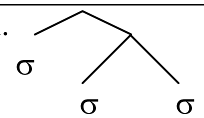
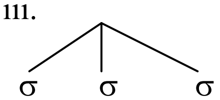
Putting aside (3.3-8) for the moment, obtaining structures such as that in (3.3-7) as default may be easily accomplished by the following constraints.

(3.3-9) Prosodic constraints active in Tianjin

BINARY	Non-terminal nodes are binary branching.
ALIGN LT	Align prosodic constituents left.

With (3.3-9), an input of three syllables would yield the default structure as optimal, as shown in (3.3-10). It goes without saying that in this case, constraints requiring the alignment of syntactic constituencies with prosodic ones must be lowly ranked.

(3.3-10) Default prosodic structure as optimal

Input: σσσ	BIN	ALIGN LT
i. ☞ 		**
ii. 		***!
iii. 	*!	**

Implicit in (3.3-9) is the idea that Tianjin tone sandhi applies iteratively starting from minimal prosodic constituents, contra linear rightward default directionality. These two conceptions are not the same. The limiting case for a strict linear application (rightward default or flipped) may be found in quadritonal sandhi sequences such as the one below (Wee, Yan and Chen 2004).

(3.3-11) /RRLL/ → [HHRL]

examples:

zhao (zi.jin.shan)	'find Mt. Zijin'
(bao.xian.xiang) bian	'beside the safe'
(wu.duo)(jin.hua)	'five gold flowers'
wu.wu.san.san	'five five three three'

input:	RR LL ↓ ↓	RRLL ↓	RRLL ↓
step 1:	HRRL ↓	HRLL ↓	RRRL ↓
step 2:	HHRL	HRLL ↓	RHRL ↓
step 3:		*HRRL	*LHRL

In (3.3-11), tone sandhi must apply edge-in[16] to get the correct result, while rightward and leftward derivation makes wrong predictions (derivation shown vertically, sandhi window underlined). Edge-in application is not possible if tone sandhi were strictly linear. Cases like (3.3-11) argue strongly against treating directionality in Tianjin as linear. If not linear, then Tianjin tone sandhi must be hierarchical. Consequently, Tianjin directionality in tritonal sequences must be an effect of default left-branching constituency. By this token, the prosodic constraints relevant to Tianjin (cf. (3.3-9)) are most probably the correct account for the directionality effect.

In addition to the two sets of phenomena above, a quick review to section 3.2 would reveal that structural information influences the application of tone sandhi. For example, emphasis (which presumably makes the emphasized element accented and consequently a head of a prosodic constituent) makes the tone stable. Also, morphosyntactic structures can affect the order which the tone sandhi rules apply. Taken in its entirety, it seems reasonable to assume that directionality effects (default or otherwise) be reduced to some hierarchical structure within which various tone sandhi rules apply.

To summarize, this subsection argues that Tianjin rightward default directionality stems from prosodic constituency. This idea presupposes that directionality effects are really working on hierarchical structures which may be supported by some of the patterns detailed in section 3.2 where structural information heavily influences the order of tone sandhi application. The next sub-section lays out the challenges presented by P1-15 to ICT.

---

[16] Wee, Yan and Chen (2004) reports that 253 out of 256 quadritonal sequences can or must be derived via edge-in ordering.

3.3.2. ORDERING EFFECTS

Of fundamental relevance to ICT, are the ordering and directionality effects of Tianjin. For clarity, albeit at the risk of being repetitive, consider again (3.3-3) presented here as (3.3-12). This will identify all the rule-ordering effects in Tianjin tritonal sandhi.

(3.3-12) Derivation procedure for Tianjin tone sandhi

Step 1 Apply Dissimilation (cf. (3.1-7a)) rightwards

Step 2 Apply Direction Flip Condition (cf. (3.3-3))

Step 3 Apply Absorption (cf. (3.1-7b))

Pattern	Input	Dissimilation rightwards	Flip	Absorption	Output
P1	FFL	LFL	-	LHL	LHL
P2	RRR	HHR (via HRR)	-	-	HHR
P3	FFF	LLF (via LFF)	FLF	HLF	HLF
P4	LLL	RRL (via RLL)	LRL	-	LRL
P5	RLL	RRL	HRL	-	HRL
P6	LFF	LLF	RLF (via LLF)	-	RLF
P7	FLL	FRL	-	-	FRL
P8	LRH	-	-	LLH	LLH
P9	LRF	-	-	LLF	LLF
P10	RRH	HRH	-	HLH	HLH
P11	RRF	HRF	-	HLF	HLF
P12	RFF	RLF	-	-	RLF
P13	FRH	-	-	FLH	FLH
P14	FRF	-	-	FLF	FLF
P15	RFL	-	-	LHL	LHL

Apparently, in (3.3-12), these effects are apprehended by the ordering of default direction dissimilation, application of the flip condition and finally the application of absorption. It is this ordering that will allow us to at once capture the feeding (e.g. P3), counterfeeding (e.g. P9), bleeding (e.g. P4) and counterbleeding (e.g. P2) effects observed in (3.3-12).

However, such a derivational account misses a few things. Firstly, it does not provide us with any deeper understanding why these procedures are ordered the way they are with reference to other known universal linguistic phenomena. Secondly, the flip condition is really motivated by the choice between two derivations, one of which produces a less marked candidate than the other in terms of dissimilation environments. This comparative character is obscured by derivational accounts such as that in (3.3-12). Thirdly, there is a conspiracy between dissimilation and the flip condition not expressed under the account in (3.3-12). Notice that both processes are trying to avoid adjacency of identical tones. Fourthly, in the form presented above, there is no reference to the prosodic constituencies as was shown to be relevant in section 3.2.1.

Without prejudice against derivation or optimization, what (3.3-12) requires is some kind of system that has the following characteristic.

(3.3-13) An account for Tianjin tone sandhi must

i. have some version of the Moving Window (cf. (3.3-1)) to capture both transparent and opaque rule-ordering effects;

ii. allow for comparison of derivations to get the direction flip effect;

iii. separate out iterative effects (dissimilation) and one-application-only effect (absorption) so that the former feeds the latter but not vice versa;

iv. express the fact that Tianjin directionality is constituency motivated and not linear (cf. section 3.3.2).

Taken in its entirety, (3.3-13) points towards a theory like ICT. Especially when viewed in the light of prosodic constituency, Tianjin tritonal sandhi looks like the cyclicity of Mandarin, only more complicated. In this case, on top of counterbleeding opacity effects, Tianjin also shows counterfeeding. The next section shall attempt to address the patterns of Tianjin tone sandhi by appeal to ICT. If successful, then the directionality of Tianjin is really not unlike the cyclicity of Mandarin and the exhaustive tone sandhi within an XP domain of Xiamen. It is this umbrella coverage that I believe gives ICT its appeal as a general solution towards phenomena exhibiting iterative application effects[17].

3.4. Inter-tier Correspondence Theory and Tianjin directionality

The application of ICT to Tianjin must take into account two effects - the direction-reversal from dissimilation (compare P2 and P4 for example) and the once-and-for-all effect where the absorption rules appear to apply with counterfeeding-like results (e.g. P13). In the latter case, absorption rules appear to apply only once to all applicable environments (after dissimilation) without regard to the outcome, i.e. the outcome could contain sandhi-triggering environments. This is clearly seen in P8, P9, P13 and P14. In this section, these two effects, the direction-reversal effect and the once-and-for-all effect, will be addressed in turn.

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[17] This must not be confused with Myers' (1991) *Persistent Rules* which applies regardless of order and level. Inter-tier correspondence theory deals with cyclicity a means of explaining certain patterns of alternations; persistent rules deals with gaps in a language.

3.4.1 DIRECTION-REVERSAL EFFECTS

Obviously, to get started on an ICT account of Tianjin tone sandhi, some constraints triggering the dissimilation and absorption processes are needed. As a mnemonic, I shall use WF-D (short for wellformedness-dissimilation) and WF-A (wellformedness-absorption) to refer to the constraints that will trigger tonal alternations parallel to the tone sandhi rules. These together with a set of other constraints relevant to an account for direction-reversal effects in Tianjin are given in (3.4-1b, c).

(3.4-1) a. Tone sandhi rules in Tianjin

Alternation by identity (dissimilation)

L → R / __ L

R → H / __ R

F → L / __ F

. Alternation by partial identity (absorption)

F → H / __ L

R → L / __ H

R → L / __ F

b. Markedness Constraints for Tianjin tone sandhi[18]

WF-D group of constraints (inter-tier effective)

*LL, *FF and *RR, where *XX means do not have XX collocation.

WF-A group of constraints (root effective only)

*[xy.y], where x and y are tone features.

c. Constraints on inter-tier correspondence and structure

INTF HD[19]

If node A immediately dominates node B and B is the head constituent, then B must have an identical correspondent in A.

INTF

If node A immediately dominates node B, then B must have an identical correspondent in A.

BINARY

Non-terminal nodes are binary branching.

ALIGN LT

Align prosodic constituents left.

Consider now an input /RRR/ and the following (partial) set of candidates generated under inter-tier correspondence.

[18] Recall OCP[TC] and OCP[TF] in section 3.1, putting aside for now another ranking hierarchy responsible for mapping a tone /T/ to [T'], e.g. L $\rightarrow$ R.
[19] Tianjin is assumed to be right-headed.

(3.4-2) Candidates for input string /RRR/

i. RR+R

R+R R

R R

ii. HH+R (winner)

H+R R

R R

iii. RH+R

R+H R

R R

iv. RH+R

H+R R

R R

v. R+HR

R H+R

R R

vi. R+H+R

R R R

The tableau below examines the application of ICT on the Tianjin input /RRR/ using the candidates in (3.4-2).

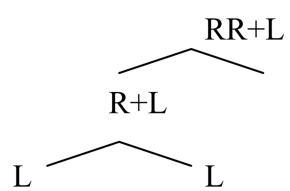
(3.4-3) Getting /RRR/ → HHR

/RRR/ candidate	BIN	WF-D	INTF-HD	ALIGN LT	INTF
i.		*!**		**	
☞ ii.				**	**
iii.			*!	**	*
iv.				**	***!
v.				***!	*
vi.	*!			**	*

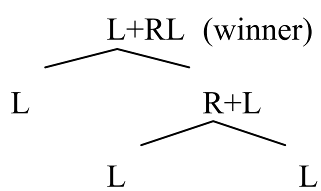
The applicability of ICT in (3.4-3) comes as little surprise. The more interesting case is to apply to /LLL/ and see if one still has a consistent ranking hierarchy. To this end, consider the following candidates generated from an input /LLL/.

(3.4-4) Candidates for input string /LLL/[20]

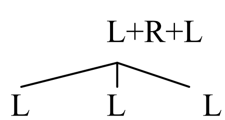
i.



ii.



iii.



[20] The relevant set of candidates should also include the following:
HR+L
/ \
R+L L
/ \
L L

Chen (2000) describes this candidate as "backtracking" because it seems to have applied the rules from left-to-right and then backtracked to change the first tone. Given the representation in (3.4-4iv), it would be inappropriate to describe this as "backtracking", since there is no procedure involved in the representation itself. This candidate will not be considered for now, but rather later in section 3.6 where the relevant machinery would then have developed.

The selection of either (3.4-4ii) or (3.4-4iii) as optimal, will suffice for arriving at the reversal effects of Tianjin. However, pause insertion (recall section 3.3) suggests that the desired candidate should be (3.4-4ii). This effect can be achieved with the help of the prosodic constraint BIN. (3.4-4i) can be eliminated by virtue of the high-ranking WF-D. Evaluation of candidates in (3.4-4) is given below.

(3.4-5)

/LLL/ candidate	BIN	WF-D	ALIGN LT	INTF
i.		*!	**	**
☞ ii.			***	*
iii.	*!		**	*

In (3.4-5), WF-D must rank above ALIGN LT because we know independently that INTF does not figure in the determination of the prosodic structure upon which directionality effects are observed (i.e. the direction of tone sandhi).

Having now shown that ICT can indeed handle the directionality reversal effects of Tianjin, the following presents the current ranking hierarchy for Tianjin.

(3.4-6) First Sketch Ranking Hierarchy for Tianjin Directionality

BINARY; WF-D INTF-HD

ALIGN LT INTF

This ranking hierarchy will later be enriched and refined as more ranking arguments become clear when it is applied to other patterns in section 3.4.3 and in section

3.5.3. However, before this can be done, a few words need to be said about the set of constraints encapsulated by WF-A.

3.4.2. ONCE-AND-FOR-ALL EFFECT

While the reversal of Tianjin tone sandhi may be accounted for by the strong effects of WF-D over INTF, the effects of WF-A is still at large, and do present formidable challenges of its own. A look at the derivation procedure for P8, P9, P13 and P14 (c.f. the derivation procedure for Tianjin tone sandhi in (3.3-12)) reveals that absorption rules apply only once to all applicable environments after dissimilation has taken its toll. Should the application of absorption rules result in other sandhi-triggering environments, they are left unrepaired. The once-and-for-all effect of absorption rules makes it inevitable that the **WF-A constraint applies only at the root node**, making it a constraint that does not have inter-tier effectiveness (recall from Chapter One that constraints are partitioned into two groups – those that have general inter-tier effectiveness or root-node effectiveness). This subsection provides some explanation on WF-A as a constraint applicable only to the root node and is done insofar as to facilitate explaining ICT on all the relevant patterns in Tianjin tone sandhi. Details on exactly how WF-A works will have to wait till Chapter Four.

Because absorption applies only once and without reference to constituency and also because it applies to environments created by the application of WF-D, WF-A can potentially cause a tone derived from WF-D to undergo further change. However, in all the 15 patterns from P1-15, this situation is unattested, i.e. there is no tone that undergoes more than one alternation whether to satisfy WF-D or WF-A. With Tianjin, ICT does not require further machinery to accommodate this fact. The domination of INTF-HD over INTF would derive this result rather automatically. This effect stems from the fact that Tianjin ditonal sandhi is totally regressive. This property certainly curbs the more-than-one alternation potential quite effectively.

The real challenge is in how WF-A seem to create in some cases the exact tonal sequences that WF-D is trying to avoid in the first place. Consider for example P8, where /LRH/ surfaces as [LLH], in which there is an adjacency of two L tones, disallowed by WF-D in the first place.

In response to this challenge, two possible lines of attacks are open. The first would be to constrain the domain upon which WF-D applies, thus blocking it from further application after WF-A has applied. The second would be to view the representations created by WF-A as fundamentally different from those triggering WF-D. There are difficulties with both approaches. The first approach suffers from the fact that WF-D is inter-tier effective, applicable to all nodes including root nodes. In fact otherwise, there will only be at most one tone sandhi operation given a tritonal string with only binary branches. It would therefore be quite impossible to circumscribe the domain of WF-A application beyond WF-D without ordering the two sets of operations. The second approach is flawed by the fact that examples such as [LLH] resultant from WF-A in P8, cannot be viewed as having only one L linked to two tone bearing units. Such a view undermines the possibility of WF-D from applying in the first place, since all WF-D applicable environments would then be potentially resolved by multiple associations too. I will argue in Chapter Four, that the second approach does provide a handle on this matter, i.e. understanding WF-A as modifying the representation structures will address the issue, though not because of multiple tonal associations. For now, we will take this once-and-for-all effect for granted so as to center our concern on directionality.

3.4.3. PREDICTING PATTERNS OF DIRECTIONALITY

With the ranking hierarchy of Tianjin in place, and having stipulated that WF-A applies only to the root node, this section illustrates how the directionality patterns may be predicted. Note that the relevant patterns are P1-7 and P10-12, since these patterns involve dissimilation, which is what gives Tianjin the directionality flavoring. P8, P9 and P13-15 do not involve dissimilation at all, but rather only absorption. Thus, they will not be dealt with here. Instead, their treatments will have to wait till Chapter Four. For ease of reference, the directionality-relevant patterns P1 to P7 and P10 to P12 are repeated below.

(3.4-7) Patterns where directionality is relevant

Pattern	Input	Dissimilation rightwards	Flip	Absorption	Output
P1	FFL	LFL	-	LHL	LHL
P2	RRR	HHR (via HRR)	-	-	HHR
P3	FFF	LLF (via LFF)	FLF	HLF	HLF
P4	LLL	RRL (via RLL)	LRL	-	LRL
P5	RLL	RRL	HRL	-	HRL
P6	LFF	LLF	RLF (via LLF)	-	RLF
P7	FLL	FRL	-	-	FRL
P10	RRH	HRH	-	HLH	HLH
P11	RRF	HRF	-	HLF	HLF
P12	RFF	RLF	-	-	RLF

In the ensuing paragraphs, the input of each pattern is given with a corresponding set of candidates and a tableau showing how the desired output is predicted to be optimal.

In the process of doing this, new ranking arguments would emerge to refine the ranking hierarchy that was given in (3.4-6), repeated below as (3.4-8) for ease of reference.

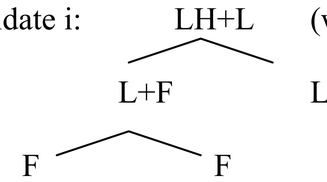
(3.4-8) First Sketch Ranking Hierarchy for Tianjin Directionality

Binary; WF-D   IntF-Hd

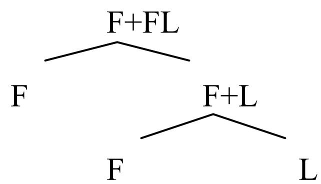
Align Lt   IntF

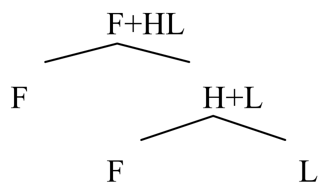
P2 and P4 have been presented in section 3.4.1 and as such will be omitted here. Beginning with P1 /FFL/ → [LFL], below is a set of candidates and a corresponding tableau. For convenience, ternary branching candidates will not be considered since they are uniformly ruled out by the Binary constraint. By the same logic, since tone sandhi is uniformly regressive, candidates ruled out by IntF-Hd will not be considered. Consequently, these constraints will be omitted from discussions below. This simplification allows focus on the ranking relation of the other constraints

(3.4-9) P1: /FFL/ → [LFL]

Candidate i: 

(winner)

Candidate ii: 

Candidate iii: 

/FFL/ candidate	WF-D	WF-A	ALIGN LT	INTF
☞ i.			**	*
ii.	*!	*	***	
iii.			***!	*

In (3.4-9) above, the difference between candidate (ii) and candidate (iii) is that the latter has an unfaithful percolation between the terminal nodes and the intermediate node. Candidate (iii) does not incur a violation of WF-A as WF-A is a root effective (only) constraint. Essentially, default left-branching structure suffices for ICT to produce an unmarked form with maximal faithfulness out of /FFL/. Moving on, consider P3 /FFF/ → [HLF].

(3.4-10) P3: /FFF/ → [HLF]

Candidate i:

LL+F

L+F F

F F

Candidate ii:

F+LF

F LF

F F

Candidate iii:

H+LF (winner)

F LF

F F

/FFF/ candidate	WF-D	WF-A	ALIGN LT	INTF
i.	*!		**	**
ii.		*!	***	*
☞ iii.			***	**

In (3.4-10), again three candidates are considered. In this case, to rule out candidate (i), WF-D must outrank ALIGN LT. Since the attested candidate is the one where WF-A must be obeyed at the root node, WF-A must be included in the ranking hierarchy to dominate INTF. The ranking hierarchy is now given as below.

(3.4-11) Second Sketch of Ranking Hierarchy for Tianjin Directionality

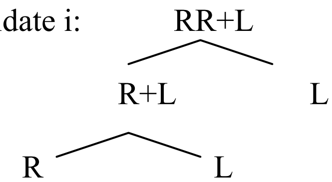
BINARY; WF-D WF-A INTF-HD

ALIGN LT INTF

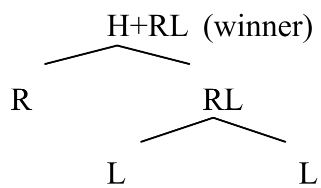
In essence, the ranking hierarchy is such that BINARY and INTF-HD are undominated. WF-D dominates ALIGN LT, both WF-D and WF-A dominates INTF. Having already discussed P4, the next case to consider would be P5 /RLL/ → [HRL].

(3.4-12) P5: /RLL/ → [HRL]

Candidate i:



Candidate ii:

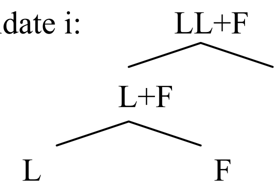


/RLL/ candidate	WF-D	ALIGN LT	INTF
i.	*!	**	**
☞ ii.		***	*

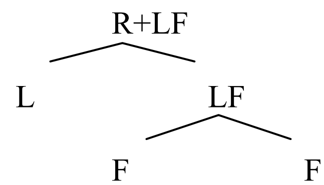
P5 appears to be rather straightforward. WF-A is not active here at all. The only matter of concern is to choose a structure where ICT does not produce a marked collocation at the root node.

Now for P6 /LFF/ → [RLF], which case is exactly similar to P5.

(3.4-13) P6: /LFF/ → [RLF]

Candidate i: 

(winner)

Candidate ii: 

/LFF/ candidate	WF-D	ALIGN LT	INTF
i.	*!	**	**
☞ ii.		***	**

P7 /FLL/ → [FRL] is not difficult either, as it is the mirror of P1 (see (3.4-9) above), although with a curious twist.

(3.4-14) P7: /FLL/ → [FRL]

Candidate i: FR+L (winner)

F+L L

F L

Candidate ii: HR+L

H+L L

F L

Candidate iii: F+RL

F R+L

L L

/FLL/ candidate	WF-A	ALIGN LT	INTF
☞ i.		**	*
ii.		**	**!
iii.		***!	*

Note that in candidate (i), the collocation FL in the intermediate tier does not constitute a WF-A violation since WF-A applies only to the root node. As such, the optimal candidate would be candidate (i), not candidate (iii) which produces a similar effect in a roundabout way.

Going on to P10 /RRH/ → [HLH], notice its similarity again with P1.

(3.4-15) P10: /RRH/ → [HLH]

Candidate i: HL+H (winner)

H+R H

R R

Candidate ii: HR+H

H+R H

R R

Candidate iii: R+LH

R L+H

R H

Candidate iv H+RH

R RH

R H

/RRH/ candidate	WF-A	ALIGN LT	INTF
☞ i.		**	*
ii.	*!	**	*
iii.		***!	*
iv.	*!	***	*

P11 /RRF/ → [HLF] is exactly like P10, but is nonetheless presented below.

(3.4-16) P11: /RRF/ → [HLF]

Candidate i: HL+F (winner)

H+R F

R R

Candidate ii: HR+F

H+R F

R R

Candidate iii: R+LF

R L+F

R F

Candidate iv: H+RF

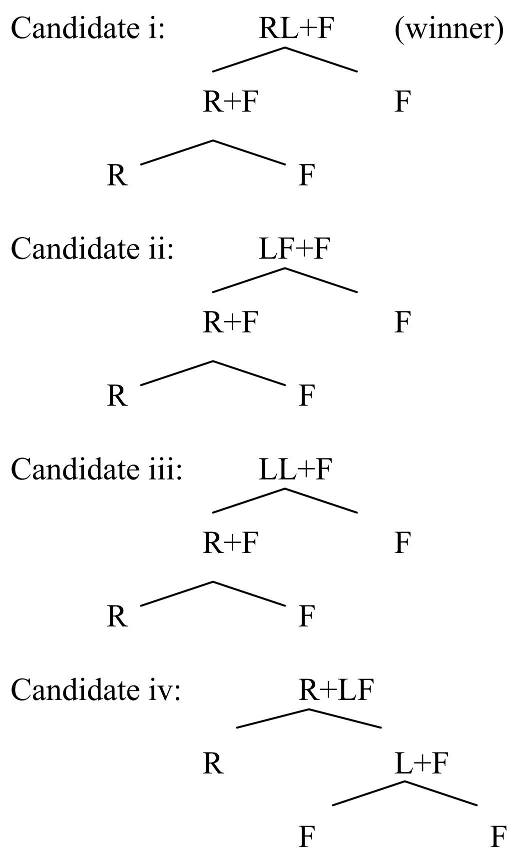
R RF

R F

/RRF/ candidate	WF-A	ALIGN LT	INTF
☞ i.		**	*
ii.	*!	**	*
iii.		***!	*
iv.	*!	***	*

Finally, to complete the picture, P12 /RFF/ → [RLF] is presented below.

(3.4-17) P11: /RFF/ → [RLF]



/RFF/ candidate	WF-D	ALIGN LT	INTF
☞ i.		**	*
ii.	*!	**	*
iii.	*!	**	**
iv.		***!	*

3.4.4. PROSODIC RIGHT-HEADEDNESS

Thus far, Tianjin has been assumed to be right-headed, essentially due to the fact that ditonal sandhi is uniformly regressive. Beyond this, there are two main reasons behind this assumption. Firstly, it is because a left-headed assumption is not viable. The unfeasibility stems from the various tone sandhi rules found in Tianjin. Under a left-headed hypothesis, regressive ditonal sandhi must be triggered by a requirement that the head tone have certain tonal character, such as possession of a high tone feature or having a complex contour. However, the chain shifting nature of Tianjin ditonal sandhi (recall, F → L; L → R; R → H) makes it impossible to attribute a wellformedness requirement on the left element in a ditonal sequence under a left-headedness hypothesis. Notice that contour tones become flat tones and vice versa, likewise a high tone feature may be gained or lost.

The second reason behind right-headed assumption is that it provides a handle on two of the puzzling phenomena in Tianjin tonal alternations: stability of tones under emphasis and the intolerance of sandhi-triggering environments at final substring of tritonal sequences. Recall from section 3.2.9 the following generalizations.

(3.4-18) Stability under Emphasis

An emphasized tone is exempted from any applicable alternation, but tone sandhi rules apply obligatorily to its preceding tone.

(E.g. if B is emphasized in /ABC/, then B will not alternate even if BC is a triggering environment. But, if AB is a triggering environment, then A must alternate.)

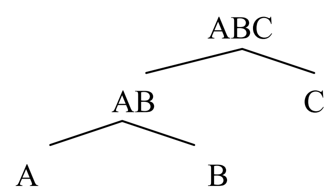
(3.4-19) Final Substring Satisfaction

Final substring of a surface string cannot contain a tone sandhi environment.

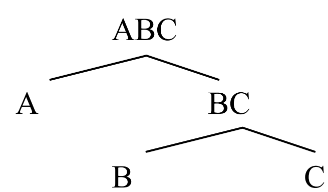
With (3.2-18), the explanation is straightforward. Emphasis is prosodically prominent, thus making any element that receives it a prosodic head. Heads are stable, and thus are exempt from tone sandhi. Because Tianjin ditonal sandhi is regressive, it follows that if “x” is head, then any element preceding “x” would have any of the applicable sandhi rules apply to it.

With the explanation to (3.4-18), (3.4-19) would actually follow from the prosodic right-headedness assumption. Given a right-headed structure, the final element, regardless of configuration would be a head that is never dominated by a non-head constituent, see schematic example below.

(3.4-20) a left-branching structure



b. right-branching structure



In (3.4-20a), “C” is head and there are no constituents dominating it that is a non-head since the dominating node is the root node. In (3.4-20b), the node “BC” dominates “C”, but “BC” is the head of the constituent “ABC” just as “C” is the head of “BC”. Again, “C” is not dominated by any non-head constituent. Effectively, “C” is the big giant head regardless of configuration and as such is prosodically most prominent. The only missing link now is (3.4-21).

(3.4-21) Prominence of head of heads[21]

A head element in a prosodic configuration that is never dominated by non-head constituents is the most prominent head.

(3.4-21) is hardly novel and is in fact a common idea in metrical theory (see Kager 1995 and references therein such as Liberman 1975, Liberman and Prince 1977 and Halle, Harris and Vergnaud 1991). With (3.4-21), it is hardly surprising that final substrings never contain a marked collocation on the surface. The great prominence of the final syllable imposes its stability by requiring that the syllable before it undergo any applicable tone sandhi. As this matter is only of tangential concern to the foci of ICT and to the matters or iterative rule application, I shall let the matter rest here without pursuing any further on the exact details.

3.4.5. PUZZLES OF TIANJIN IN THE LIGHT OF ICT

In light of ICT, apparently a substantial part of the puzzles outlined in section 3.2 becomes apprehensible. ICT relates to each set of effects (repeated from (3.2-28), (3.2-29) and (3.2-30)) as follows.

[21] One could conceive of this as a constraint so that it potentially interacts with other constraints on headedness. However, nothing about the discussion on Tianjin at hand demands this view or otherwise.

(3.4-22) Order of tone sandhi application

Phenomena:

a. Default direction: Apply tone sandhi from **left-to-right.**

b. Flip condition: Apply tone sandhi from right-to-left if default application yields a form containing a sandhi environment.

c. Dissimilation first: If both dissimilation and absorption are applicable, then dissimilation takes priority.

d. Constituency: Tone sandhi applies to smaller constituents first.

Explanation:

Default directionality stems from the way prosodic structures are hierarchically constructed. Tone sandhi would apply to smaller constituents before applying to larger ones. Flipping in directionality is the result of the combination that WF-D outranks default prosodic constituency and the relative faithful inter-tier correspondence of constituents.

Since WF-D has inter-tier effectiveness while WF-A is applicable only to the root node, it follows that when dissimilation would apply before absorption.

(3.4-23) Constraints on surface strings

Phenomena:

a. Final Substring: Final substring of a surface string cannot contain a tone sandhi environment.

b. R-satisfaction: Surface string cannot contain a R-related tone sandhi environment.

Explanation:

An account for R-satisfaction would be to (i) break-up the WF-D constraint set into element constraints pertaining to each of the tonal contours R, F, H and L and then (ii) rank the R-related WF-D constraint higher than all other (faithfulness) constraints. This would ensure that all R-related tone-sandhi triggering environments are never tolerated.

The same strategy however cannot be taken for the Final Substring requirement. Unlike R-satisfaction, the final substring of a polytonal sequence may in principle belong to any level in the hierarchical structure. The Final Substring requirement stems from the hypothesis that Tianjin prosody is right-headed. Regardless of structural configuration, the rightmost (i.e. the final) element will be the head that is never dominated by non-head constituents. Assuming this gives it a certain prosodic prominence akin to emphasis, it must be most stable. In Tianjin, emphasis on a tone requires tone sandhi rules to apply obligatorily on the preceding tone, it follows that there will be no tone sandhi triggering sequences on the surface of any final substring.

(3.4-24) Inapplicability or erratic application of tone sandhi

Phenomena:

a. Emphasis: An emphasized tone is exempted from any applicable alternation, but tone sandhi rules apply obligatorily to its preceding tone.

b. Ambidirection: /FFF/, /FFL/, /RRF/ and /RRH/ are allowed application in either direction.

c. Blocking: Tone sandhi triggering environments are tolerated if the two tones belong to different syntactic phrasal constituents.

Explanations:

Emphasis on a syllable makes it the head of its foot and heads are usually stable. Since Tianjin tone sandhi operates on prosodic constituents it follows that stressed syllables keep their tones. Tianjin ditonal sandhi is regressive, so the syllable preceding the stressed one must undergo sandhi wherever applicable.

By the same token, tone sandhi could be blocked by syntactic boundaries if one can contain WF-D to apply only within a particular phonological domain (recall Chapter Two where Mandarin tone sandhi can be contained to within phonological phrases). One can treat stability under emphasis and syntactic blocking with the same device, i.e. the foregrounding of syntactic boundary and emphasis mark the right edge confines of the domain within which WF-D applies. Recall that Tianjin tritonal sandhi attest to optional outputs pertaining to default prosodic structures (directionality effect) and also to morphosyntax (cf. Chapter

One, section 1.2). The matter with morphosyntax is that when one tries to disambiguate one syntactic structure from another, stress (emphasis) is placed at crucial structural junctures so as to foreground the relevant morphosyntactic configuration. In other words, disambiguating morphosyntactic structures forces the building of prosodic structures congruent with morphosyntax. Such cases of optionality therefore remain consistent with the idea that tone sandhi applies to prosodic structures rather than morphosyntactic ones.

Regrettably, explanation to the four isolated cases of ambidirectionality is evasive, whether one appeals to inter-tier correspondence or otherwise. As such, one is forced to accept them as exceptions until some better explanation comes along.

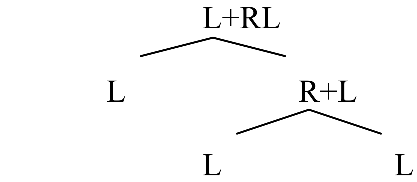
It does seem that ICT is capable of handling the bulk of the problems presented in Tianjin without many assumptions beyond that already needed for an account of Mandarin in Chapter Two. As such, considering ICT as a candidate for a unified account of iterative rule application (cyclical or directional) seems feasible.

3.5. From the root to the leaves

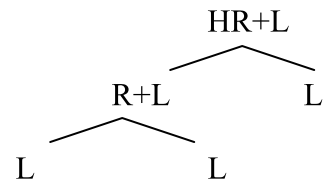
Thus far, in dealing with Tianjin, the chapter has alluded to a convenient version of WF-D and WF-A, defined in such a way that given some tone A, tone A may not alternate to tone C if such an alternation require an intermediary tone B. For example, given the way WF-D is defined, a tone like L may become R, but not become H though one might envisage a scenario where L $\rightarrow$ H via R. To highlight the problem, consider the following comparisons, under the following.

(3.5-1) Two candidates for input string /LLL/

i.



ii.



/LLL/ candidate	WF-D	ALIGN LT	INTF
⚐ i.		***!	*
💣 ii.		**	**

Legend: 💣 - unattested optimal candidate; ⚐ - desired optimal candidate

In reading (3.5-1), recall that in Tianjin, L → R / __ L and R → H / __ R. I shall assume that the choice of L → R and R → H is derivable by some well-defined ranking hierarchy responsible for tonal selection. The matter of tonal selection will be discussed in the next chapter, but for now the focus is on the locus of alternation. With this in mind, section 3.5 seeks an account for the peculiarity that no tone in Tianjin undergoes more than one alternation. To begin, the following subsection presents three intimately relevant devices described in the works of Chen (2000), Chen, Yan and Wee (2003) and Hsu (2002).

3.5.1. Tracks, windows and steps

Recall from section 3.4.2 that if there is to be any interaction between WF-D and WF-A, it is that the former feeds the latter (cf. P3 where /FFF/ → [HLF] via FLF). Even then, there are no cases where a given tone undergoes more than one alternation. This curious state of affairs is constrained by either Chen (2000) with No Backtracking, Chen, Yan and Wee (2003) with the Moving Window constraint and by Hsu (2002) with the One Step Principle. All three of which are given below.

(3.5-2) a. **No Backtracking** (Chen 2000:p.116)

Do not backtrack.

b. **Moving Window** (Chen, Yan and Wee 2003)

Ditonal sandhi may not apply to the same local window more than once.

c. **One Step Principle** (Hsu 2002:p4)

Only base tones undergo change in the course of a derivation.

To varying degrees, they essentially seek to ensure that a tone does not undergo more than one alternation. Basically, "No backtracking" does not allow a derivation to reverse in direction thus implicitly assuming a particular linear order of parsing; the Moving Window does not assume a particular order on which collocations undergo alternation but only preempts parsing to the same collocation more than once; the One Step Principle makes no reference to collocations, but simply works against changing the tone of a particular syllable more than once.

To illustrate the difference between the devices in (3.5-2), consider how the three devices respond to the schematic scenarios as presented below. The underline in (3.5-2) indicates the collocation where tone sandhi applies.

(3.5-3) Reactions of the devices in (3.5-2)

Case 1: backtracking (i.e. /ABC/ → $\underline{\text{DB}}$C → D$\underline{\text{EC}}$ → $\underline{\text{FE}}$C)

Case 2: consistent target (i.e. /ABC/ → $\underline{\text{AD}}$C → A$\underline{\text{EC}}$)

Case 3: multiple recursion (i.e. /AB/ → CB → DB)

	Case 1	Case 2	Case 3
No Backtracking	✗	✓	✓
Moving Window	✗	✓	✗
One Step Principle	✗	✗	✗

Legend: ✓ - allows; ✗ - disallows

Evidently, the three devices in (3.5-2) are relevant to understanding the lack of multiple alternations in Tianjin. The next sub-section goes on to relate ICT with the insights behind these three devices.

3.5.2. Relating ICT with the moving window

ICT, by its very appeal to structure and information percolation, derives the effect of Moving Window naturally. At each tier, there is a collocation of the constituents, as illustrated below.

(3.5-4)

root tier: A+BC

tier 1: B+C

terminal tier: A B C

In (3.5-4), a sequence such as /ABC/ will have two windows – AB and BC. At tier 1, BC comes into contact and here that collocation is evaluated for markedness and faithfulness. The window "moves" as one goes on to the root tier, where now A comes into contact with BC. Understanding the Moving Window in this light allows for windows to be looked at in varying "directions" depending on the structural configuration. For example, given a sequence /ABCD/, the ICT view would predict that rule ordering effects would be (i) rightwards if the structure were uniformly left-branching; (ii) leftwards if the structure were uniformly right-branching; and (iii) edge-in if branching were neither uniformly left or right-branching (cf. for example (3.3-11) repeated below as (3.5-5), a four-tonal sequence where the application of tone sandhi applies from the two edges inwards).

(3.5-5) /RRLL/ → [HHRL]

examples:

zhao (zi.jin.shan)	'find Mt. Zijin'
(bao.xian.xiang) bian	'beside the safe'
(wu.duo)(jin.hua)	'five gold flowers'
wu.wu.san.san	'five five three three'

input: $\underline{RR}\ \underline{LL}$

$\downarrow\ \ \downarrow$

step 1: $H\underline{RR}L$

$\downarrow$

step 2: HHRL

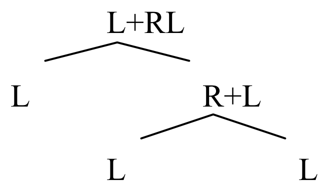
Given what has been presented on Tianjin, all three possibilities are attested. We have seen in Tianjin tritonal sequences cases belonging to (i), (ii) and (iii). Moving Window allows for such a possibility too without offering an explanation for the correlation between structures and the order of which windows to peep into first. The ability to decide which window to peep into first, as well as its affinity to the original insight behind the Moving Window device argues for the usefulness of ICT in understanding such phenomena.

Since in Tianjin, there are no cases where a tone A becomes some other tone C via an intermediate tone B, one might quite safely assume that a combination of the One-Step Principle and inter-tier correspondence sufficiently explains why the candidate (ii) in (3.5-6) below cannot be optimal given a /LLL/ sequence.

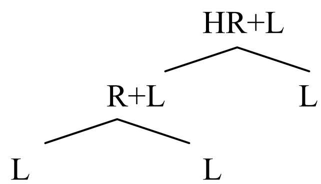
(3.5-6) Incorporating the One-Step Principle (cf. (3.5-1))

OSP Only base tones can undergo alternation

i.



ii.



/LLL/ candidate	OSP	ALIGN LT	INTF
☞ i.		***	*
ii.	*!	**	**

Notice in (3.5-6) above that if OSP is a part of the constraint hierarchy, it must outrank ALIGN LT. That said, incorporating the OSP into ICT appears to capture the Moving Window insight rather completely. However, this is only an illusion. In the next sub-section, I digress away from Tianjin to present a relevant case of Changting Hakka, where the simple combination of the OSP with ICT proves futile – consequently leading to a slightly more elaborate theory.

3.5.3. A DIGRESSION – CHANGTING HAKKA AND THE CONTACT CONDITION

To begin, (3.5-7) are some tone sandhi rules found in Changting Hakka (from Chen, Yan and Wee 2003). This is followed by a tritonal /RML/ sequence and its derivation.

(3.5-7) Some ditonal sandhi rules of Changting Hakka

F L	R L	M L
↓ ↓	↓	↓
R F	F	L

e.g.	li.mao 'courtesy'	huang.dou 'soy bean'	gong.lu 'highway'

where R=[lh], F=[hl], L=[l], H=[h], M is a mid tone.

(3.5-8) /RML/ → [RFL] (from Chen, Yan and Wee 2003)

e.g. [chang.ting] hua "Changting dialect"
xing [gong.lu] "take the highway"

$$
\begin{array}{ll}
 & \mathrm{R}\underline{\mathrm{ML}} \\
 & \downarrow \\
 & \underline{\mathrm{RL}}\mathrm{L} \\
 & \downarrow \\
 & \mathrm{R}\underline{\mathrm{FL}} \\
 & \downarrow\downarrow \\
* & \mathrm{RRF} \quad \text{(unattested derivation of /RML/)}
\end{array}
$$

What is special about (3.5-8) is that this is a case where the OSP is violated, because in this case, the medial M alternates via L to finally become F. Yet, at the same time, there is no further alternation to yield RRF which would have no further sandhi-triggering collocations. The implication behind situations such as (3.5-8) is that One Step Principle cannot be the correct approach.

The problem with the OSP is this. In order for [RFL] to be derived from /RML/, some sandhi-triggering constraints WF must be ranked above the OSP. Such a ranking ensures that the medial M will be able to alternate more than once. However, WF » OSP will predict that alternations take place up to a point where there are no more sandhi-triggering collocations, i.e. till *[RRF], contrary to fact. The OSP is thus inadequate. It is this inadequacy that shows us how the combination of the OSP with ICT does not quite do the job of Moving Window. However, that this combination does not work well should not be taken as grounds for rejection of ICT altogether - it is the combination that does not work, not its parts.

If the OSP fails, can No Backtracking do better? The answer is no, which again could be illustrated with Changting Hakka, this time involving three other rules that forms a circular chain shift.

(3.5-9) a. Circular chain shifts in Changting Hakka

	H M ↓ F	F M ↓ R	R M ↓ H
e.g.	song.shu 'give a book'	huo.che 'train'	tao.hua 'peach blossom'

b. Failure of No Backtracking

HM
↓
FM
↓
RM not attested as output of /HM/
↓
HM not attested as output of /HM/

In (3.5-9b), there is no backtracking since the sandhi window has remained the same throughout. There is no doubt that No Backtracking is inadequate.

Since neither the OSP nor No Backtracking works, the solution must require a more elaborate way of incorporating the Moving Window into ICT. With careful observation, it should be easily recognizable that at each tier, it is the collocation of constituents (i.e. the contact of constituents), rather than just a linear string, that is evaluated. Thence, at the root tier of (3.5-4), repeated below as (3.5-10), evaluation is on the contact of A with BC, not the string ABC.

(3.5-10)

root tier:	A+BC		
tier 1:		B+C	
terminal tier:	A	B	C

With this in mind, I propose the following constraint that will replace the OSP.

(3.5-11) Contact Condition (CT COND)

Across tiers, if a tone T does not share a boundary with another tone, T must have an identical correspondent.

To appreciate the effects of CT COND, consider the following structure and correspondences.

(3.5-12)

ABC+DE					root tier
AB+C			DE		tier 2
AB					tier 1
A	B	C	D	E	terminal tier

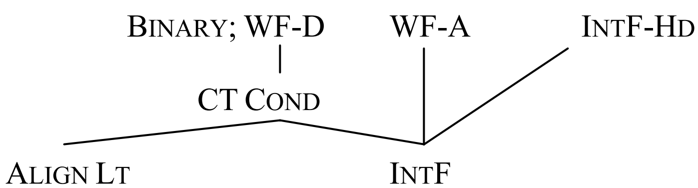
In (3.5-12), at tier 1, AB and DE are collocations that will be evaluated such that if any of these four elements do not correspond with the terminal tier, there is no violation of the CT COND. Moving on to tier 2, any unfaithful correspondence in A between tier 1 and tier 2 would constitute a violation of the CT COND. This is because at across tier 1 and tier 2, A does not share a boundary with another tone. It is B and C that shares a boundary. The same logic applies to the root tier. Between tier 2 and the root tier, only C and D share a boundary, as such only unfaithful correspondences of C or D do not violate the CT COND. Unfaithful correspondences of A, B or E across tier 2 and the root tier would be violations of the CT COND.

Going back to the Changting case where /RML/ → [RFL] (cf. (3.5-8)), the CT COND will be able to handle such situations because in the alternation of the medial tone /M/, it shares boundaries twice. What one needs a a well-defined ranking hierarchy that will yield the ditonal sandhi patterns of that language, and CT COND together with the structure and inter-tier correspondence will do the rest of the work.

Returning from this detour of Changting Hakka to Tianjin, replacing OSP with CT COND is fine with the case of /LLL/ (cf. (3.5-6)) because in the case of the initial L becoming H via R, there is no boundary that the derived R is sharing with the medial tone between the root tier and its immediately dominated tier. There is also no danger of CT COND over-applying because even with the WF-A constraints in Tianjin, only underived tones alternate. However, it is important to note that given P15 (i.e. /RFL/ → [LHL]), CT COND must be dominated by WF-A. The reason behind this is a combination of two factors: Tianjin's default structure is left-branching (as is the case for P15) and WF-A applies only at the root node (being a root-effective only constraint). Thus in order for the initial R to become L in P15 /RFL/ → [LHL], WF-A must apply to the initial ditonal substring at the expense of CT COND. As such, as far as I can tell, CT COND together with ICT captures the insights behind Moving Window most squarely.

With the CT COND, the account for Tianjin tone sandhi directionality can be finalized as follows.

(3.5-13) Ranking hierarchy for Tianjin Directionality (Final)



3.5.4. THE DOUBLY OPAQUE CASE OF HAKHA LAI

The preceding paragraphs have shown that ICT must be understood in light of collocation of constituents at each tier rather than plain linearity of the elements. In addition, languages like Changting Hakka make constraints like CT COND crucial. This subsection seeks to provide further support for the CT COND by presenting Hakha Lai, a Kuki-Chin language spoken in Chin State Myanmar and parts of Mizoram State, India. In this presentation, I draw upon the research of Hyman and van Bik (2002).

To begin, here are two relevant tone sandhi rules about Hakha Lai.

(3.5-14)	RF rule	R → F / R __
	FL rule	F → L / F __

Given the two rules in (3.5-14), note that in a sequence like /RRR/, the outcome is [RFF], as shown in (3.5-15a) rather than (3.5-15b).

(3.5-15)	a.	R R R	b.	* R R R
		↓ ↓		↓
		R F F		R F R
		↓		
	*	R F L		

What is so striking about (3.5-15) is that the outcome contains a marked sequence [FF] when obviously less marked candidates such as [RFL] or [RFR] are conceivable. Also, the RF rule must be applying leftwards or simultaneously to both windows rather than rightwards. This is because otherwise, it would not be possible to get [RFF] out of /RRR/ from the two rules in (3.5-14). Such a situation can be easily understood if it can be determined that the prosodic structure of a /RRR/ is right-branching. Under such a structural configuration, ICT and the CT COND (with a well defined ranking hierarchy that would produce the effects of the rules in (3.5-14)) would naturally produce this result[22]. A right-branching structure would yield the effect of dealing with the final substring first while CT COND would ensure that at the root node, only tones the initial window alternates.

Although Hakha Lai does not argue conclusively for CT COND, the point that this subsection seeks to make is that CT COND and the ICT can provide coverage as a general theory rather than one made ad hoc for Tianjin or Changting Hakka.

[22] Though there are regressive as well as progressive ditonal sandhi rules in Hakha Lai, Hyman and van Bik (2002) reports that there are no cases in Hakha Lai where a tone undergoes more than one alternation, i.e. there are no cases that violate the One-Step Principle.

3.6. Summary

There are two main themes that underline this chapter. Firstly, it addresses the challenge that directionality poses to ICT. The essential strategy taken in response to this challenge is that there is no such thing as directionality without reference to structure. Secondly, through a study of Tianjin, this chapter argues for ICT as a viable theory to capture languages where transparent and opaque derivational effects manifest simultaneously.

On the first theme, the main point is that there is no such thing as directionality in the application of rules. The illusion of linear directionality lies in not looking at long enough strings. Given a long enough structure, there is always option on parsing that structure in a way corresponding to the morphosyntactic constituencies. The effect of linear directionality must therefore be the result of a language having some kind of default uniformity in the construction of prosodic structure. That default breaks down when strings get longer. This actually gives us a typology of directionality versus cyclicity. Understood in the light of ICT, directionality is a special form of cyclicity. It is special only in that the structure is uniformly left or right-branching. This typology can be easily obtained by the interaction between constraints on prosodic constituencies with constraints on syntax-prosody alignment. Herein lies an appeal of ICT, i.e. it has the ability to relate these two phenomena both characterized by the iterative application of rules. Traditional approaches are forced to handle directionality and cyclicity differently.

Moving on to the second theme, one of the most important challenges that Tianjin poses to derivational and parallel frameworks alike, is the reversal in direction of rule application. Recall that reversal happens precisely only when default application yields a sequence more marked that otherwise. This situation requires at once a theory that can encode derivation history and also a theory that allows for a comparison of the results of different derivations. With the help of percolation, ICT rises up to this challenge.

Towards the end of the chapter, there is actually a third theme. This is the discussion on the window within which evaluation occurs at each tier. It should be clear that this has an impact on the relation between input elements and output elements because this effectively constrains the environments within which a derived entity can undergo further changes.

Having now covered the “iterative rule application aspects” of things in chapters 2 and 3, the next chapter goes on to explore the possibilities of ICT in handling “non-iterative rule application” effects. This distinction is comparable to that between cyclic processes and post-cyclic ones. It is here that we will review the feasibility of assuming that both Mandarin and Tianjin are right-headed. Another issue relates to the mapping of underlying elements to surface ones. Since this mapping is not something that ICT is set-up to do, such discussion will be limited only to Mandarin and Tianjin - the two main languages explored in this work.