INTER-TIER CORRESPONDENCE THEORY

by

LIAN HEE WEE

A dissertation submitted to

the Graduate School – New Brunswick

Rutgers, the State University of New Jersey

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

Graduate Program in Linguistics

written under the direction of

Akinbiyi Akinlabi

and approved by

Akinbiyi Akinlabi

Alan Prince

Youngmee Yu-cho

Matthew Y Chen

New Brunswick, New Jersey

May 2004

ABSTRACT OF THE DISSERTATION

Inter-tier Correspondence Theory

By LIAN-HEE WEE

Dissertation Director:

Akinbiyi Akinlabi

Inter-tier Correspondence Theory (ICT) is a theory of candidate structure. It is a response to phenomena in which both opaque and transparent derivational effects are simultaneously attested. The response that ICT provides rests upon the recognition that structural configurations are crucial in triggering alternations in the first place.

By appealing to percolation, ICT assumes that each phonological output candidate is in fact a structural representation where non-terminal nodes reconstruct the information content of the constituent nodes. However, reconstruction may be imperfect. That outputs are structural is hardly novel, since GEN generates structures to given strings. Instead, it is the carriage of information in non-terminal nodes that is noteworthy. Under ICT, terminal nodes would be identical to the input string. Alternations no longer apply to strings but to constituencies as elements of the input string percolate upwards in their constituent structures. This is an important improvement because it directly addresses the fact that mere adjacency does not trigger alternation (many marked collocations are tolerated if the offending sequence are not within the same constituent). To be precise, GEN takes an input string and maps it to candidate structures of various percolative possibilities with the terminal nodes identical to the input string and non-terminal nodes corresponding to their subordinates in a multitude of ways. Thus, ICT directly captures the insights of the containment and correspondence approaches within optimality theory. There is nothing derivational about percolation when construed as correspondence

between tiers. In fact, ICT views structural tiers as one would a multi-layered club sandwich. In making the sandwich, layers are ordered, but in eating, it hardly matters.

The usefulness of ICT is illustrated through a study of tonological alternation patterns in Mandarin and Tianjin. These languages illustrate that simultaneous exhibition of any of “feeding”, “bleeding”, “counterfeeding” and “counterbleeding” effects, are really results of alternations applying to constituents as they grow in size (in other words, upward percolation).

This dissertation studies Mandarin and Tianjin in detail, but ICT extends beyond that. To qualify ICT as a general theory for opacity, this work also takes glimpses at English, Tiberian Hebrew and Yokuts.

DEDICATION AND ACKNOWLEDGEMENTS

This dissertation is dedicated

to my parents and;

to Wong Chuen Shya (Michelle), who

for 10 years, sweetened every bitter moment of my life.

In the writing of this dissertation, I am most grateful to Akinbiyi Akinlabi. I do not think I can ever find enough courage or ability to write this dissertation if not for him. In this respect, I am also grateful to Alan Prince and Young-mee Cho who are equally indispensable as my dissertation committee members. To Matthew Chen, I owe not only inspiration, but also invaluable support and teachings. Without him, I would have neither material to write nor resources (specifically the grants from Strategic Research Grant Project No. 7000900 and Competitive Earmarked Research Grant Project No. 9040554 at the City University of Hong Kong) to live on in the final years of my graduate education. There is also the Tan Kah Kee Foundation for awarding me with the Tan Kan Kee Postgraduate Scholarship (1998). I aspire to be like my benefactors in their erudition, wisdom and kindness.

Back in 1999, Mark Baker and Hubert Truckenbrodt helped me shape the ideas presented in this work. On field work and traditional Chinese linguistics, I am indebted to Yan Xiuhong and Lu Jilun for generously sharing their ideas. Xiuhong supplemented my education on Chinese linguistics immensely. I also have Xiuhong and Liang Yuan to thank for patiently reading my drafts. Their hawk-vision greatly reduced my typographical errors. Whatever such errors that remain are entirely their fault.

I will never forget that when I first arrived in Rutgers, Joanna Stoehr saved my life by sharing her lunch with me. She didn't know it then, but I hadn't eaten for 50 hours. Carolyn Burger and the Rutgers Language Institute gave me jobs that relieved me of much hardship that plague the typical graduate student. Ed & Abby Prince gave me my first transport in New Jersey – a bicycle which was of immense importance given my fear of driving a car. Abby's mother, affectionately known to all as Mama, taught me how to make forgotten cookies and other recipes that enlivened my boring meals. It's amazing how many life-savers one gets to meet when one goes to graduate school.

Cecilia Lo ensured my survival and wellbeing when I was in Hong Kong. She was my housekeeper, my secretary, my accountant, my medical care provider. I must have done something really good in all my previous carnations to deserve all the love she has shown me. My cousin, Wong Sing, patiently taught me to paint while Jess Tsang shared with me his expertise in fine wines. These were my escapades when linguistic problems bedeviled my sleep. For a healthier balance in life in New Jersey, I owe thanks to Andre Nündel, Markus Hiller & his saxophone, Jason Yeung, Kwok Bong Fung, Eunice Pang, Mr. & Mrs. Ken Zee and the entire staff at the Noodle Gourmet. Though I have no family in the USA, I never felt alone and helpless because Mr. & Mrs. Zee made me much like their nephew. Close to my heart is Eunice, for being such a fresh gale when the Earth seemed to stop spinning. Without them, I would have found little meaning in writing this dissertation.

Finally, I would never have known linguistics if not for Tham Shiao Wei. And I would not have pursued it if not for my friends and teachers like K.P. Mohanan, Tara Mohanan and Alex Alsina at the National University of Singapore (1994-98). From them, I imbibed intellectual restlessness.

TABLE OF CONTENTS

TABLE OF TERMS AND DEFINITIONS

INTER-TIER CORRESPONDENCE THEORETIC TERMS:

Intermediate node	Any node on a tree that is not a terminal node or a root node is an intermediate node.
Inter-tier effective constraint	A constraint that applies at every tier of a tree is an inter-tier effective constraint.
Non-terminal node	Any node on a tree that is not a terminal node. This includes the root node and intermediate nodes.
Root node	The highest node of a tree. For every well-defined tree, there can be only one root node.
Root-effective constraint	A constraint that only applies at the root node of a tree is a root-effective (only) constraint.
Terminal node	The lowest node of a tree. There can be more than one terminal node.
Tier	Two nodes are in the same tier if they are dominated by the same number of branching nodes.

DERIVATIONAL PRINCIPLES:

Direction Flip Condition	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. (Chen 2000)
Moving Window	Ditonal sandhi may not apply to the same local window more than once. (Chen, Yan and Wee 2003)
No Backtracking	Do not backtrack. (Chen 2000)
One Step Principle	Only base tones undergo change in the course of a derivation. (Hsu 2002)
Preemptive Clause	When a string simultaneously contains an environment for dissimilation and for absorption, apply dissimilation first. (Chen 2000)

OT CONSTRAINTS:

ALIGN LT	Align prosodic constituents left.
ALIGN RT	Align prosodic constituents right.

ALIGN HD LT	The head of a prosodic word is aligned at the left edge of a prosodic word.
ALIGN HD RT	The head of a prosodic word is aligned at the right edge of a prosodic word.
ALIGN-XP, L	For each XP, there is a P (phonological phrase) such that the left edge of the XP coincides with the left edge of P. (Selkirk 1995)
ALIGN-XP, R	For each XP, there is a P such that the right edge of the XP coincides with the right edge of P. (Selkirk 1995)
BINARY	Non terminal nodes are binary branching.
CT COND	Across tiers, if a tone T does not share a boundary with another tone, T must have an identical correspondent.
INTF	If node A immediately dominates node B, then B must have an identical correspondent in A.
INTF-FT	If node A immediately dominates node B, then the foot structure of B must correspond to that in A.
INTF-HD	If node A immediately dominates node B and B is the head constituent, then B must have an identical correspondent in A.

NON FINAL	Word-final syllables are not footed.
NON-RECURSIVITY	Any two P (phonological phrases) that are not disjoint in extension are identical in extension.
OCP	Adjacent identical elements are forbidden. (abbr. for Obligatory Contour Principle)
OCP[TC]	No adjacent identical tone contours, written also as OCP[H], OCP[L], OCP[R] or OCP[F] depending on the tone (contour) in question.
OCP[TF]	No adjacent identical tone features, written also as OCP[x.x].
OCP[x.x]	See OCP[TF]
OCP[xy.y]	See OCP [TF]
WF-A	This is a special version of OCP[TF] which includes only OCP[xy.y]. (abbr. for Wellformedness-Absorption).
WF-D	This is a subset of OCP[TC], which includes OCP[R], OCP[F] and OCP[L] while excluding OCP[H]. (abbr. for Wellformedness-Dissimilation).

WRAP-IP Each IP (Infl Phrase) is contained in a P (Phonological Phrase).

WRAP-XP Each XP (Maximal projection of a lexical category) is contained in a P. (Truckenbrodt 1999)

In this work, all examples are numbered following this convention: (A.B.C-x) where A indicates the chapter number; B the section number; C the subsection number and; x the example number.

E.g. chapter subsection

(3 . 2 . 1 - 4)

section example

Chapter One

INTRODUCTION: PERCOLATION

The dissertation is a treatment on an issue that plagues especially Chinese tonology – combinations of transparency and opacity. By advocating an approach centering on the recognition that non-terminal nodes in a representation are information-bearing, this dissertation explains that the combination of opaque and transparent effects really take roots in the correspondence, or rather the lack of it, between two nodes that stand in a relation of domination and subordination. This chapter is dedicated to introducing the theory of inter-tier correspondence, which forms the heart of this dissertation, tailor-made more for an account to the opacity and transparency of tonal alternations rather than to tonal selection. The idea is fully fleshed out in Chapters Two and Three. The secondary matter of tone selection will be swept under the carpet till Chapter Four. While the focus is on Chinese languages, some of the machinery devised here extends beyond to include similar tonological or even general phonological phenomena (Chapter Five).

1.1. Standard account – terminals only

In phonological representations, typically, terminal nodes indicate the phonologically relevant content of the constituent while non-terminal nodes indicate organizational information. For example,

(1.1-1)

```
        node A                      non-terminal tier
       /      \      ---------------------------------------
      t        a                    terminal tier
```

In (1.1-1), node A indicates that [t] and [a] form a constituent. Node A provides us with organizational information, which in this case may indicate that it is a syllable consisting of two elements. It is the terminal nodes [t] and [a] that contain any content information. Hence, node A simply tells us that two phones form the constituent, but it is the terminal nodes that tell us what the two phones are.

Thus, when confronted with opacity effects, standard accounts, be they derivational models or parallel ones, respond in the following way: Apply rules or constraints to linear strings. Structural information, if relevant, indicates the domain for application and order of application. For expository convenience, I will refer to such standard approaches as **terminal-based theories** (terminology from Orgun 1996a, b). To illustrate this, consider a language **L** with phonological alternations to the following effect.

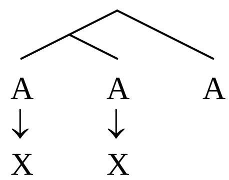
(1.1-2) $A \rightarrow X$ / __ A =

$$\begin{array}{cc} \multicolumn{2}{c}{\wedge} \\ A & A \\ \downarrow & \\ X & \end{array}$$

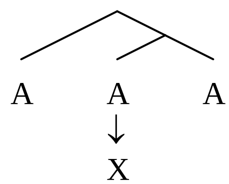
For clarity in presentation, I shall use the tree diagram in (1.1-2) as a notational equivalent[1] of the more traditional SPE type rule: $A \rightarrow X$ / __ A. Now, suppose the application of (1.1-2) in language **L** is as given in (1.1-3).

[1] The SPE notation does not make any claims about constituency, but the diagrammatic one does. As such they are not notational variants and may be empirically differentiated. I sympathize with the latter because adjacency in itself rarely triggers alternation. An example adjacency tolerance can be seen in Mandarin tone sandhi tolerance in Chapter Two, section 2.3.

(1.1-3) a.



b.



Language **L** is an exemplary case of structure-sensitivity, for in the light of (1.1-3b), (1.1-3a) appears to have excessive repair. A standard account of language L would be to apply the relevant phonological principle starting with the lowest branching constituent, but always to the linear string at the terminal nodes. (1.1-4) provides a derivational example of such an account.

(1.1-4)

	/AA/ + /A/	/A/ + /AA/
	↓	↓
apply rule to lowest constituent	X	XA
	↓	
apply rule to next constituent	X	n.a.
	[XXA]	[AXA]

Languages like **L** do exist, for example, Standard Mandarin (henceforth Mandarin[2]).

[2] By Mandarin, I refer to the standard variety referred to as Putonghua in Mainland China or Guoyu in Taiwan and Hong Kong, as opposed to local dialects of Mandarin such as Sichuan Mandarin, or the Mandarin language cluster.

(1.1-5) Mandarin tone sandhi

a. ditonal sandhi

[l] [l]
↓
[lh] (Note: [l]=low tone, [h]=high tone; [lh]=rising tone)

e.g. lao.gou ‘old dog’

b. tritonal, left-branching sandhi

[l] [l] [l]
↓ ↓
[lh][lh]

e.g. [lao.gou] hao ‘old dogs are good’

c. tritonal, right-branching sandhi

[l] [l] [l]
↓
[lh]

e.g. hao [lao.gou] ‘good old dogs’

The account outlined above crucially refers to constituents, though prima facie, rules are applying to terminal strings, (hence, terminal-based).

1.2. Challenges to standard accounts

While the standard terminal-based accounts are acceptable with structure-sensitive situations like language **L**, they do not directly address the relevance of constituency. Structure sensitivity aside, suppose now another language **L',** where rules apply recursively in one way only to be reversed if that application yields a marked form.

(1.2-1) a. $A \rightarrow X$ / __A
$B \rightarrow Y$ / __B
$Y \rightarrow C$ / __Y

b. /AAA/ $\rightarrow$ [XXA]

c. /BBB/ $\rightarrow$ [BYB] (not YYB or CYB)

Given the regressive alternations in (1.2-1a), and counterbleeding in (1.2-1b), an account for (1.2-1c) would look like the following.

(1.2-2)		
	/A AA/	/B B B/
	↓	↓
apply rule to first substring	X	Y
apply rule to next substring	X	Y
	[XXA]	*YYB
undo		BB B
		↓
apply rule to final substring		Y
		[BYB]

The strict derivational procedure in (1.2-2) is incredibly awkward, requiring derivation in one order only to be undone if that derivation yields a marked form, possibly contrary to well-established notions of strict cyclicity or bracket erasure (see Cole 1995, Mohanan 1995 for discussions on these notions). Neither does (1.2-2) explain why there should be a strange rule that undoes two prior steps in the derivation, nor does it explain what stops the *[YYB] intermediate form from becoming [CYB]. A parallel account would directly capture the fact that BYB is the least marked form in comparison with BBB, YYB and CYB, but that would not explain why /AAA/ $\rightarrow$ [XXA].

The existence of **L’** would argue against terminal-based theories because such theories do not allow one to envision constraints against certain groupings of the elements globally, but only linearly and locally at each phase of the derivation. This is because any rule or constraints target only the terminals. The logic behind this will hopefully become clearer with the proposal of an alternative approach (contra terminal-based approaches) in section 1.3.

The awkwardness of expressing language **L’** would speak well for any terminal-based account, derivational or parallel, if such languages do not exist. Languages like **L’** do exist, for example, Tianjin, a close relative of Mandarin (data from Chen 2000).

(1.2-3) Tianjin tone sandhi with rising tones

a. Tianjin ditonal sandhi with rising tones

[lh] [lh]
↓
[h]

e.g. li.fa ‘cut one’s hair’

b. Tianjin tritonal sandhi with rising tones (left-branching structure)

[lh] [lh] [lh]
↓ ↓
[h] [h]

e.g. [li.fa] suo ‘barber (hair arrange) shop’

c. Tianjin tritonal sandhi with rising tones (right-branching structure)

[lh][lh][lh]
↓ ↓
[h] [h]

e.g. mu [lao.hu] ‘tigress (female (old) tiger)’

(1.2-4) Tianjin tone sandhi with low tones

a. Tianjin ditonal sandhi with low tones

[l] [l]
↓
[lh]

e.g. fei.ji ‘air plane (fly machine)’

b. Tianjin tritonal sandhi with low tones in left-branching structure

[l] [l] [l]
↓
[lh]

e.g. [tuo.la]ji ‘tractor (pull pull machine)’

c. Tianjin tritonal sandhi with low tones in right-branching structure

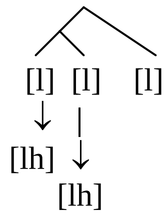
[l] [l] [l]
↓
[lh]

e.g. kai [fei.ji] ‘pilot a plane’

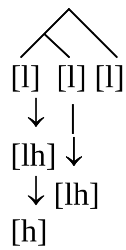
Notice that in (1.2-3), regardless of morphosyntactic constituency the rules are applying in counterbleeding order. In (1.2-4), regardless of morphosyntactic constituency, the rules are applying in bleeding order. Crucially, with (1.2-4), there is no feeding/counterfeeding application such as that in (1.2-5)

(1.2-5) Unattested Tianjin derivation

a.*



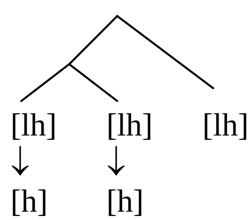
b.*



Tianjin appears to require the rules to apply in a certain order (i.e. presumably rightwards, see Chapter Three, section 3.3 for arguments) unless that application results in a tone sandhi triggering environment. To complicate matters, Tianjin can also be sensitive to morphosyntactic structures, so that /lh.lh.lh/ may optionally surface as [lh.h.lh] if the morphosyntactic constituency is right-branching (see Chapter Three, item (3.4-24)).

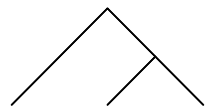
(1.2-6) Examples of Tianjin morphosyntactic sensitivity

a.



e.g. [li.fa] suo ‘barber shop’

b.



[lh] [lh] [lh]
↓
[h]
e.g. mu [lao.hu] 'tigress'

A terminal-based account of the above starting from the initial ditonal substring then the final is fine with (1.2-6a) (cf. (1.1-4)). But in the case of (1.2-6b), operations apply only to the final ditonal substring, presumably because that substring is a constituent. Thus in (1.2-6b), the application to the lowest constituent bleeds further application of the tone sandhi rules. While /lh.lh.lh/ → [h.h.lh] is always available to Tianjin, /lh.lh.lh/ → [lh.h.lh] is only available with right branching morphosyntactic structures. Clearly, terminal-based approaches do not directly address the structure-sensitivity exhibited by the language, neither are they capable of directly constraining undesirable groupings as may be seen from the /l.l.l/ → [l.lh.l] case.

To summarize, by allowing rules to apply only to terminal nodes, terminal-based accounts are awkward with structure-sensitive recursive rule application (cf. Mandarin) and in the reversal of marked recursive rule application (cf. Tianjin). In the first case, it misses the point that the domain of application is determined by the structure. In the second case, it requires the undoing of applications. Further, it is even more obscure how one can tackle the problem since references are made to the linear order (rightward application) and the constituency (counterfeeding effect). This duo-referencing underlines the importance of constituencies. The facts presented here thus undermine the traditional terminal-based approaches.

Apart from derivational models of phonology, parallel ones appear to do no better within terminal-based assumptions. A parallel account (under the correspondence approach of OT) could explain bleeding and feeding cases (to use the convenient derivational terminology). However, they run afoul with counterbleeding and counterfeeding. Forms obtained from counterbleeding application contain more alternations than necessary to yield a well-formed output sequence. Forms obtained from counterfeeding contain more marked environments than allowed. In the light of Mandarin and Tianjin, standard terminal-based accounts leave one caught between a rock and a very hard place – neither a derivational account, nor a parallel account quite does the job.

1.3. Inter-tier Correspondence Theory

One can get out of this quandary by simple appeal to percolation, exploiting crucially the relevance of structure in determining the domain of alternation. Percolation has been implicitly understood as each dominating node representing the sum of its constituents, ultimately terminal nodes, which is percolation (Jesperson 1924:96, Jackendoff 1977, Chomsky 1970, 1981, Lieber 1980, Grimshaw 1991, Orgun 1996a, b). Under this notion, the alternation rules of language **L** and **L'** may be represented as follows.

(1.3-1) a.

X+A

A A

b.

Y+B

B B

c. C+Y

Y Y

(1.3-1) corresponds to SPE rules like A → X/ __A. There is a conceptual difference in that the representations in (1.3-1) are by far richer because they contain the “derivational histories” (to use convenient derivational terminology). In a sense, both underlying and surface information are encoded in such representations. In (1.3-1), the terminal nodes correspond to the underlying string. The dominating nodes indicate constituencies as well as the information that has percolation upwards. Notice that percolation is not totally faithful in that the initial element does not have an identical correspondent. The final element has an identical correspondent in the dominating node, i.e. that element has percolated faithfully. By this logic, the representations for the derivations of /AAA/ and /BBB/ would be (1.3-2).

(1.3-2) a. XX+A

X+A A

A A

b. A+XA

A X+A

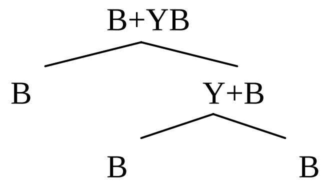
A A

c. YY+B

Y+B B

B B

d.



An account for language **L** or **L’** would simply be the mapping of the underlying sequences and their structures to one of the forms in (1.3-2). This can be done with (i) a set of faithfulness requirements on the second element in a di-elemental string; (ii) a set of markedness constraints such as the OCP against adjacency of identical elements such as AA, BB and YY and (iii) a set of mapping constraints to ensure the mappings A $\rightarrow$ X, B $\rightarrow$ Y and Y $\rightarrow$ C. Since the root node of (1.3-2c) contains a YY sequence, the character of **L’** would follow from the obedience to the OCP against YY adjacency.

This idea of percolation outlined in this chapter echoes that in Shieber (1986), Pollard and Sag (1994) and especially Orgun (1996a, b), where he advocates a “sign-based” approach over a “terminal-based” approach. It is thus that Orgun captures the interleaving effects between morphology and phonology, featuring especially cyclicity over morphosyntactic structures. Orgun’s “sign-based” approach differs from the terminal-based ones in assuming that every node in a constituent structure, including non-terminal ones, is information-bearing. They carry syntactic, semantic as well as phonological information. Orgun understands “sign” as:

> a Saussurean pairing between some phonological shape and some semantic information. In sign-based theories, a constituent structure is a statement of how the grammar justifies (licenses) the sign represented at the top node.

The contrast between these two models is illustrated in (1.3-3) for the Slave form dezonahluzé ‘child’s spoon’ from Orgun (1996b).

(1.3-3) a. “Terminal-based” approach

$$\begin{array}{ccc} & \text{N(oun)} & \\ \text{N} & & \text{N} \\ | & & | \\ \text{dezonah} & & \text{luzé} \end{array}$$

b. “Sign-based” approach

$$\begin{bmatrix} \text{SYN|CAT} & \text{noun} \\ \text{SEM} & \text{child's bearskin} \\ \text{PHON} & \text{dezonahluzhé} \end{bmatrix}$$

$$\begin{bmatrix} \text{SYN|CAT} & \text{noun} \\ \text{SEM} & \text{child} \\ \text{PHON} & \text{dezonah} \end{bmatrix} \quad \begin{bmatrix} \text{SYN|CAT} & \text{noun} \\ \text{SEM} & \text{spoon (possessed)} \\ \text{PHON} & \text{luzé} \end{bmatrix}$$

Armed now with a fair idea of percolation and its applicability to the problems at hand, I present the theory of Inter-tier Correspondence, henceforth ICT, as (1.3-4).

(1.3-4) **Inter-tier Correspondence Theory (ICT)**[3]

Carriage of information

All nodes (terminal or non-terminal) are information-bearing.

Correspondence of information

There is a correspondence of the information content between nodes that stand in immediate domination.

Violability of correspondence

Correspondence of information between nodes is not necessarily perfect.

ICT is in fact substantially similar to Orgun's (1996a, b) sign-based morphology, especially in the treatment of cyclical phenomena (as will be discussed in Chapters Two and Three). In presenting (1.3-4), this dissertation foregrounds the key assumptions behind them and also seeks to develop and to substantiate the insights through an essential study of various Chinese tone sandhi patterns. As such, relative to Orgun's work, this dissertation supplements it by showing how (1.3-4) might provide umbrella coverage for a wide range of tone sandhi phenomena that is hitherto not targeted as a whole. In view of other more standard views of phonology, this dissertation provides support and argument for a "non-terminal" (i.e. sign-based or inter-tier correspondence) perspective. This work departs from Orgun's (1996a, b) in explicitly having different structures for phonology and morphosyntax, though they may be related via various interface constraints. Orgun (1996a, b) implicitly assumes that syntactic, semantic and phonological information percolate upon the same structure. (cf. (1.3-3)). Contra Orgun,

[3] Thanks to Markus Hiller for telling me about Orgun's works, otherwise I would have naively thought that Wee (2000) was first in employing percolation for treatment of cyclical phonological phenomena.

this dissertation assumes that phonological information percolates within phonological structures. It is this property that allows for mismatches between phonology and other domains of linguistics (see Inkelas 1993 for arguments in separating phonological structures from morphosyntactic ones)

Just to provide a glimpse at how ICT might work for the kinds of patterns discussed in Mandarin and Tianjin, below is a sketch on deriving at a typology with a set of constraints, a set of candidates and a comparative tableau.

(1.3-5) Constraints relevant for deriving a typology.

ALIGN LT

Align (prosodic) constituencies left.

ALIGN RT

Align (prosodic) constituencies right.

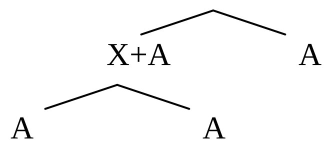
OCP

Adjacent identical elements are forbidden

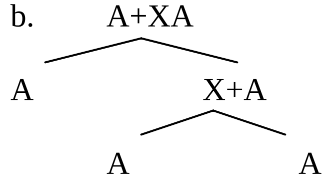
INT(ertier)**F**(aithfulness)

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

(1.3-6) Candidate a.



Candidate b.



Comparative tableau

	OCP	IntF	Align Lt	Align Rt
candidate a ~ candidate b	Cand. b	Cand. b	Cand. a.	Cand. b.

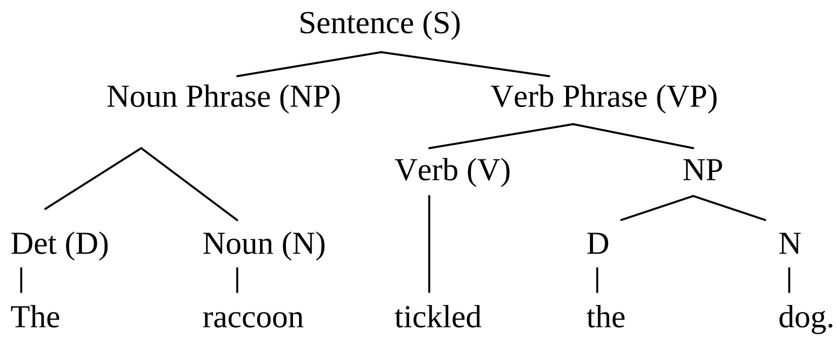
As may be seen in (1.3-6), depending on how one ranks various constraints, either the left branching candidate (a) or the right branching candidate (b) may be selected, thus in effect giving us the possibility of capturing situations described as bleeding or counterbleeding by virtue of inter-tier correspondence. Note that the two candidates given above are exactly the pair that plagues us in Mandarin and also Tianjin.

It is noteworthy that there is a disparity between IntF and traditional optimality theoretic (OT) faithfulness constraints. In traditional OT, faithfulness is a relationship of identity between the input and the output, i.e. it is global (extending over an across "intermediate" forms such as the sympathetic candidate). With ICT however, faithfulness is strictly local, applying only across tiers that stand in immediate domination. Such disparity is not unique to IntF, it is in fact implicit in O-O constraints of Transderivational Faithfulness (Benua 1997, more on this later in Chapter Five).

1.4. Percolation in syntax and phonology

While the notion of percolation has found widespread acceptance in syntax, it has received relatively little attention in phonology. To illustrate the notion of percolation in syntax, consider the following sentence and its syntactic constituency.

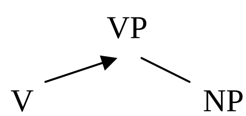
(1.4-1)



By running a series of constituency tests (a convenient list can be found in Radford 1988) such as wh-formation, substitution, conjunction and topicalization, etc, these constituencies can be easily established. However, why is it that the constituency of a D and an N called an NP? Along similar lines, why is it that the constituency of a V and an NP called a VP? It is curious that nodes such as N and V should have corresponding dominating nodes NP and VP.

An intuitive (and I believe acceptable) answer to this correspondence between a dominating node and a subordinate node would quite simply be that the constituencies “The raccoon” and “the dog” pattern like nouns and that the constituency “tickled the dog” patterns like verbs. For example, “tickled the dog” refers/describes an action of tickling, rather than some kind of dog. The entire constituent can be substituted with other verbs but not other nouns. It seems that the constituent “tickled the dog” is much more like a verb. Since this is a phrase, it would be more accurate to call it a VP than to call it an NP. To be more precise, the notion appealed to in such reasoning is the percolation of features (for details about percolation in syntax, also known as projection, see Jackendoff 1977, Chomsky 1970, 1981, Lieber 1980 and Grimshaw 1991). The features of the verb “tickled” have percolated to the entire constituent “tickled the dog”, but not the features of the NP “the dog”. This upward percolation is known as projection and is schematically shown in (1.4-2). The arrow indicates that the features of the verb have percolated upwards to the dominating constituent.

(1.4-2)



However, in syntax this notion of percolation is not uniformly applied in Standard Syntactic Theory (Chomsky 1957) as may be seen from the exocentricity of the S $\rightarrow$ NP VP rule.

(1.4-3) Phrase Structure Rules (Standard Syntactic Theory)

i.	S	$\rightarrow$	NP	VP
ii.	NP	$\rightarrow$	D	N
iii.	VP	$\rightarrow$	V	NP

A uniformly endocentric model of syntactic constituency appeared only with the advent of X-bar theory (Jesperson 1924:96, Jackendoff 1977) and the introduction of Infl to include tense, modals and other auxiliaries and the IP (Infl Phrase) in place of S.

In contrast to syntax, percolation did not receive deep discussions in phonology. The following examples show how phonological representations are essentially exocentric (i.e. not percolative).

(1.4-4) Representation of a syllable[4]

Syllable (σ) e.g. "dog"

Onset (O) Rime (R)

Nucleas (Nu) Coda (Co)

δ □ γ

(1.4-5) Feature Tree (adapted from Kenstowicz 1994:151)

d o g

root [+cons -sonor]

stricture [-contin]

cavity Oral Pharyngeal

articulator Dorsal Glottal

terminal [+voiced]

(1.4-6) Representation of Tone (Bao 1990)

Tone (T) e.g. high falling contour [53]

Register (Reg) Contour (ctr)

H h l

[4] There is some consensus that the syllable is a projection of the rime which in turn is a projection of the nucleus. In such a view, the representation of a syllable would be endocentric. In the diagram here, endocentricity is not explicit in that the labels of the nodes do not reflect any projection.

Notice that in none of the trees above is there any sign of correspondence between a dominating node and a subordinate node, i.e. there is neither percolation upwards nor downwards. Indeed, short of any strong motivation, it is hard to conceive of ways to make these models endocentric.

Nonetheless, in prosodic phonology and tonology, one might see traces where percolation appears to be implicit. For example, stress is phonetically manifested on vowels (or rather the nuclei of syllables), rather than on the consonants. However, prosodic analyses make reference to stressed syllables or stress morae. The implicit appeal is even clearer when one considers the relationship between focus and stress. (Jackendoff 1972, Rooth 1992, 1996, Selkirk 1995 among others) When a phrase receives focus, it is accented, and that accent manifests as stress on the nucleus of a syllable, as shown below.

(1.4-7) a. The rac**coon** tickled the dog.

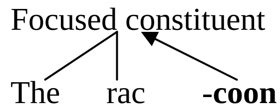
(Roughly means: It was the raccoon that tickled the dog.)

b. The raccoon tickled the **dog**.

(Roughly means: It was the dog that the raccoon tickled.)

In (1.4-7), underlined items receive focus; boldface syllables are accented. Notice that accents (=stress) are manifested on the vowels of the stressed syllable, yet, it indicates that the entire constituent is under focus.

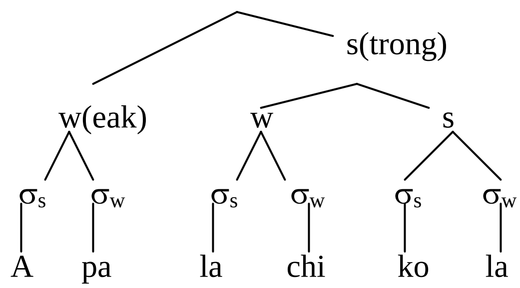
(1.4-8)



Whether one construes of focus as having percolated downwards or accents as having percolated upwards in (1.4-8), it is quite clear that this situation looks very similar to that in the percolation of verbal features in the VP “tickled the dog”.

Percolation is also common in metrical phonologies. Consider, for example, a metrical tree such as the one below (taken from Kager 1995).

(1.4-9)



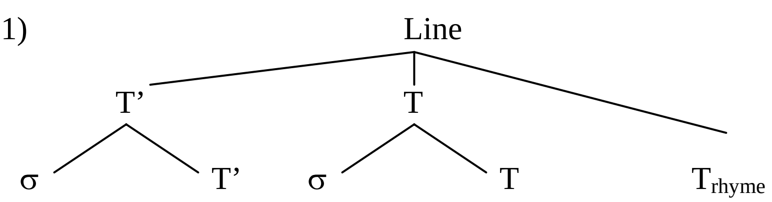
In the case of (1.4-9), one identifies the relative prominence of each syllable by looking from the top-down. The syllable that is most stressed is the one dominated by an unbroken string of S, while the weakest would be dominated by an unbroken thread of W. This can be conceived of as an example of the downward percolation of stress.

Another place where one might see the relevance of percolation in phonology is in a classical Chinese literary form known as Tang Poetry (Tang dynasty lasted from A.D.618-907, though this literary tradition continues to this day). In Tang poetry, each line has either 5 or 7 syllables. Each even-numbered syllable must contrast in tone category, where tones contours are categorized as either even (E) or oblique (O), the last syllable is reserved for rhyming, though not all lines rhyme. (Readers interested in traditional descriptions may want to visit the following Chinese web-site http://www.xys.org/xys/netters/Fang-Zhouzi/poetry_rules.txt as well as in common Chinese textbooks on verses such as Wang 1979.) Below are a few pentasyllabic lines to illustrate this.

(1.4-10)	a.	E**E**O**O**E	(but *EEOEE)
	b.	E**E**E**O**E	(but *EOEOE)
	c.	O**O**E**E**O	(but *OOEOO)
	d.	O**O**O**E**E	(but *OEOEE)
	e.	E**E**E**O**O	(but *EOEOO)
	f.	O**E**E**O**O	(but *OEEEO)

(1.4-10) indicates in boldface the tones that must contrast in each line. Under a metrical analysis along the lines of Chen (1979, 1984), a pentasyllabic line would look like the following diagram.

(1.4-11)



In (1.4-11), if T=E, then T'=O and vice versa. T_{rhyme} refers to the rhyming syllable and is not directly relevant for this discussion. σ = position where tones may belong to either category E or O generally without regard to other tones in the line. A meter such as that required in Tang poetry can be easily described if an iambic foot is made out of every two syllables starting from the left. The principle is then quite simply that adjacent feet must contrast, i.e. if the head of the first foot is E, then the head of the second foot must be O.

Assuming one accepts the prosodic account given for Tang poetry meter, it suggests quite strongly that tonal information of syllables do percolate upwards to higher prosodic units, in this case, feet. Like the endocentric model of syntax, the tonal feature of the dominating node corresponds to that of the head syllable.

1.5. Derivations and inter-tier correspondence

Up to this point, the following has been shown. Terminal-based approaches encounter principally the problem of not having direct reference to constituency. In response, this dissertation proposes the use of models where information between terminal nodes and non-terminal nodes correspond and argue that this notion is not new either to syntax or phonology. The usefulness of percolative models is most obvious in treating opacity and any phenomena described as derivational. Opacity comes in two flavors – non-surface true and non-surface apparent. McCarthy (1998) explained that:

> (i) Linguistically significant generalizations are often not surface-true. That is, some generalization G appears to play an active role in language L, but there are surface forms of L (apart from lexical exceptions) that violate G. Serialism explains this by saying that G is in force at only one stage of the derivation. Later derivational stages hide the effects of G, and may even contradict it completely.

(ii) Linguistically significant generalizations are often not surface-apparent. That is, some generalization G shapes the surface form F, but the conditions that make G applicable are not visible in F. Serialism explains this by saying that the conditions on G are relevant only at the stage of the derivation when G is in force. Later stages may obliterate the conditions that make G applicable (e.g. by destroying the triggering environment for a rule).

A phonological generalization that has been rendered non-surface-true or non-surface-apparent by the application of subsequent rules is said to be opaque.

One might recall Mandarin and Tianjin exhibit opacity of both kinds outlined above and thus any viable theory must adequately handle all such effects. The following paragraphs seek to demonstrate the promise that ICT holds. For convenience, this theory is repeated below.

(1.5-1) **Inter-tier Correspondence Theory (ICT)**

Carriage of information

All nodes (terminal or non-terminal) are information-bearing.

Correspondence of information

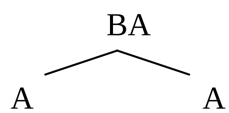
There is a correspondence of the information content between nodes that stand in immediate domination.

Violability of correspondence

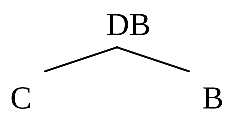
Correspondence of information between nodes is not necessarily perfect.

Consider now the rules in (1.5-2) and the patterns in (1.5-3), all cast in ICT notation. The interaction of these rules with the structural configurations should exemplify both transparent and opaque effects. Under this notion, the alternation rules would be represented as follows.

(1.5-2) a.

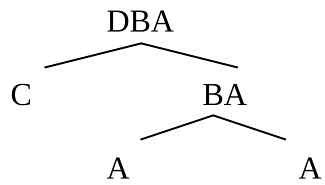


b.

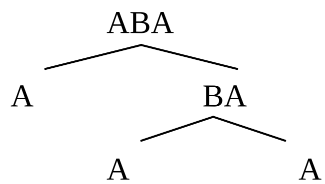


(1.5-2) corresponds to SPE rules like A $\rightarrow$ X/ __A. Such a notation is by far richer because it contains the "derivational history". In (1.5-2), the terminal nodes correspond to the underlying string. To simplify matters, the rules shown here are those where percolation is not faithful with the initial element. Interaction between the two rules above provides instances of all four rule-ordering effects: feeding, bleeding, counterfeeding and counterbleeding, shown in (1.5-3) below.

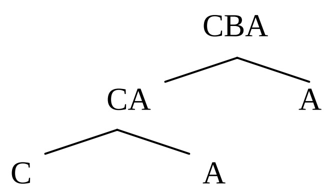
(1.5-3) a. Feeding



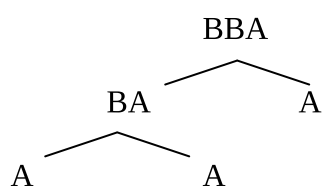
b. Bleeding



c. Counterfeeding



d. Counterbleeding



In most of the above, it is quite straightforward how ICT would apply. Quite simply, percolation is faithful unless perfect correspondence result in alternation-triggering collocations. The only case of interest is the one involving counterfeeding in (1.5-3c). This case is interesting because even with unfaithful percolation, a marked collocation is obtained and one is in need of an account as to why such a marked collocation is tolerated. Under ICT, one could imagine a constraint such as (1.5-4).

(1.5-4) Contact Condition **(CT COND)**

Across tiers, if an element X does not share a boundary with another element Y, then X must have an identical correspondent.

In the counterfeeding case in (1.5-3c), C does not share a boundary with the medial B across the topmost tier and the intermediate tier. (It does share a boundary with that medial A at the intermediate tier though.) By the contact condition, C is blocked from alternation once we are out of the bottommost tier. Later in Chapter Three, section 3.5, the usefulness of the contact condition shall be discussed in detail. For now, with the contact condition and inter-tier correspondence, the various rule ordering effects may be attributed to the following reasons.

(1.5-5) ICT account of derivation effects

a. Feeding

Feeding is the result of having multi-tiers such that an unfaithful percolation at a lower tier results in a marked collocation to be avoided in a higher tier.

b. Bleeding

Bleeding is the result of having multi-tiers such that an unfaithful percolation at a lower tier destroys otherwise marked collocations in higher tiers.

c. Counterfeeding

Counterfeeding is the result of having faithful percolation at the expense of tolerating a marked collocation. This is possible either because of a higher ranked faithfulness constraint or because of the Contact Condition (cf. (1.5-4)).

d. Counterbleeding

Counterbleeding is the result of having a structure where an unfaithful percolation to avoid marked collocations does not avoid another marked collocation at a higher tier. (Note the subtle difference between this and feeding.)

The ability to capture various rule-ordering effects makes this theory a viable option in explaining cyclicity and such iterative rule application-like phenomena. As such, an immediate question would be how such a theory might distinguish between what traditional generative phonology treats as cyclic and post-cyclic processes. What distinguishes cyclic and post-cyclic processes is that the former is iterative while the latter applies only once-and-for all after cyclic processes have taken their toll. The structural nature of the representations in ICT allows for the separation of these two levels rather naturally. Principles/constraints that have inter-tier effectiveness would correspond with (though not identical to) the cyclic level. Post-cyclic processes are the consequence of a special set of principles/constraints that are applicable only to the root node. This bifurcation of constraints/principles is important (and empirically necessary) given that cyclic processes may have an impact on post-cyclic ones. This crucial assumption is stated below.

(1.5-6) Bifurcation of constraints

Within ICT, constraints/principles are necessary of only **either of the two** following kinds:

a. INTER-TIER EFFECTIVE CONSTRAINTS

Inter-tier effective constraints apply to all tiers from the terminal nodes to the root nodes

b. ROOT-EFFECTIVE CONSTRAINTS

Root-effective constraints apply only to the root node.

It is important to note that ROOT-EFFECTIVE constraints simply allow for certain collocations to be tolerated at intermediate nodes. It does not prevent GEN from producing candidates where intermediate nodes do not contain collocations otherwise deemed marked by ROOT-EFFECTIVE constraints. Having made this point clear, the idea behind ICT is to explain the various rule ordering effects by virtue of the violability of correspondence. In this way derivational histories appear to be encoded through intermediate tiers. But under ICT, it is important to note that the conception is really about optimal structures, and therefore not a matter of encoding derivation histories.

However, intermediate tiers may or may not correspond to the intermediate forms found in classical derivational frameworks. This is because GEN is capable of generating a myriad of forms. As such a few words on the theoretical and empirical relevance of intermediate tiers are necessary. Theoretically, as mentioned, the intermediate tier (as do all tiers in the structure) expresses the (prosodic) constituencies (just like any traditional terminal-based theory), allowing for various possibilities of information correspondence. Under percolation, it becomes responsible for providing the right environments to subsequent dominating tiers so that the optimal/attested form may be inferred from the grammar. Empirically, intermediate tiers often correspond to outputs of interrupted derivations, but these forms may sometimes be masked by the effects of post-cyclic rules (or in ICT conception, root-effective (only) constraints).

1.6. Containment or correspondence

Implicit in the idea of ICT as a solution to opacity problems is the idea that each output representation contains the input. The input is encoded in the linear string at the terminal nodes. Recall from section 1.3 that given an AA string such that A $\rightarrow$ X / __A, the representation would be as below.

(1.6-1) X+A

A A

The ideas that information between nodes at different levels should correspond (though violable) and that terminal nodes are identical to the input string put the spotlight on the containment or correspondence views in optimality theory (Prince and Smolensky 1993/2002). Since optimality theory will be used as the basic framework in this dissertation, this section serves to clarify how the ICT relates to these issues.

Essentially, the containment condition is a constraint on GEN (Prince and Smolensky 1993/2002, but see also McCarthy and Prince 1993:20, Kager 1999:98ff and LaCharité and Paradis 1999:228f). It disallows GEN from removing any element from the input form. Thus GEN may never actually delete anything from the input. It may only achieve the effects of deletion by not parsing certain elements. The elements that are unparsed do not get articulated (cf. 'stray-erasure' in McCarthy 1979, Steriade 1982 and Itô 1986, 1989).

(1.6-2) **Containment** (from McCarthy and Prince 1993:20)

No element may be literally removed from the input form. The input is thus contained in every candidate form.

By containment, if an input /CVC/ surfaces as [CV], the output is assumed to be really [CV<C>], the angled parenthesis indicating that the final V is not parsed into the syllable. While this appears to be fine for accounts on syllabification, it is less straightforward with alternation. Imagine a situation where C $\rightarrow$ D / B __, so that given

/BC/, the output would be BD. It is awkward to say that D should contain C when D and C are two different entities. This is a situation where the relation between C and D is not one easily describable by simply not parsing some features or by adding others. This state of affairs would not arise if instead of containment theory, one adopts correspondence theory (McCarthy and Prince 1995). With alternation, correspondence theory appears to work more naturally than containment theory. This is so since C and D would now correspond, albeit violating some faithfulness constraints. Correspondence theory could in addition take care of the /CVC/ → [CV] case by simply saying that the final C does not have a correspondence, again a violation of faithfulness. Such violations of faithfulness must be tolerated in the name of some higher ranked markedness requirement.

But one should not jump to the conclusion that correspondence theory can do everything containment theory can do and more. These two theories have different empirical predictions as may be illustrated by the hypothetical rules in (1.6-3).

(1.6-3) Language H exhibits the following pattern

A alternation rule: $A \rightarrow B$ / __ A

C alternation rule: $C \rightarrow D$ / __ B

With (1.6-3), containment theory predicts that given /AAA/ counterbleeding effects will result, while given /CAA/ counterfeeding effects will result. This is shown below.

(1.6-4) Empirical possibilities of **Containment theory**

No element may be literally removed from the input form. The input is thus contained in every candidate form.

Counterbleeding

/AAA/	A → B / __ A	Faith
i. A[B/A]A	*!	*
ii. ☞ [B/A][B/A]A		**
iii. AAA	*!*	

Counterfeeding

/CAA/	A → B / __ A	C → D / __ B	Faith
i. ☞C[B/A]A		?	*
ii. [D/C][B/A]A			**
iii. CAA	*!		

The presence of the input environment is the reason behind counterfeeding or counterbleeding. With the case of counterfeeding, complications result from how markedness constraints work. Unless markedness constraints are insensitive to surface strings, candidate (36bi) does incur a violation in the cell marked by a question mark "?". Nonetheless, Containment theory provides a grasp on the opacity effects, but at the cost of transparent effects. The same assumption would never yield bleeding or feeding effects which are sensitive to derived environments.

However, the same two inputs /AAA/ and /CAA/ will produce bleeding and feeding effects under correspondence theory.

(1.6-5) Empirical possibilities of **Correspondence theory**

Elements in the input correspond to elements in the output. The input is not contained in any candidate form.

Bleeding

/AAA/	A → B / __ A	Faith
i. ☞ABA		*
ii. BBA		**
iii. AAA	*!*	

Feeding

/CAA/	A → B / __ A	C → D / __ B	Faith
i. CBA		*!	*
ii. ☞DBA			**
iii. CAA	*!		

The absence of the input environment in the candidates is why correspondence theory expresses bleeding and feeding effects naturally. But, opacity effects are difficult to express because the (input) triggers are now missing (although modern theories such as Sympathy Theory (McCarthy 1998), Transderivational Faithfulness Theory (Benua 1997), and two-level rules (e.g. Odden 2000) provides much useful machinery).

The implication of empirical possibilities outlined in (1.6-4) and (1.6-5) is that whichever one (if only one) of these theories is correct, then there can be no languages exhibiting rule ordering effects of the following combinations: (i) counterbleeding and bleeding; (ii) counterbleeding and feeding; (iii) counterfeeding and bleeding; (iv) counterfeeding and feeding; (v) three or more of the four rule ordering effects. The problem with such an implication is that it is contrary to fact. Mandarin, for example, exhibits both bleeding and counterbleeding.

Nonetheless, the wisdom behind both containment and correspondence must not be blighted in view of these limitations. While the containment approach is clumsy with alternation (recall beginning of this section), it seems to do well with opacity. Likewise, the correspondence approach though inelegant with opacity, is dexterous in expressing alternations and transparent effects, not to mention that it is also more consistent with the freedom of analysis[5] property of GEN. With this in mind, the ICT offers a possibility of reconciling the benefits of both the containment and the correspondence approaches. Since the terminal nodes always correspond to the input string, the input must thus be contained in every output. Further, because non-terminal nodes are information-bearing and information between tiers is related by correspondence constraints (i.e. inter-tier faithfulness), the essential character of correspondence theory is preserved[6].

1.7. Summary

This chapter outlines the fundamental ideas behind the theory of inter-tier correspondence. Crucially, it assumes that firstly non-terminal nodes are information-bearing, an idea common in syntax and perhaps less explicit in phonology, and secondly that information between nodes that stand in domination (=tiers) correspond. However, the degree of correspondence would depend on the interaction between constrains requiring correspondence and constraints on information collocation.

With inter-tier correspondence, the spotlight is turned upon the two approaches to optimality theory – the containment approach and the correspondence approach. Both approaches have merits in their own right, but have appeared incommensurable. ICT

[5] Under the freedom of analysis, GEN is allowed to create (or destroy) any structure (Prince and Smolensky (1993/2002), and also McCarthy and Prince (1993:20).

[6] Although, recall the disparity in the globality of traditional faithfulness constraints and the locality of inter-tier faithfulness.

suggests a way of harvesting the fruits of both approaches by allowing for the containment of the input at the terminal nodes and for correspondence between tiers.

The remaining parts of this dissertation will be structured as follows. Chapters Two and Three will expound the application of ICT (which is based on the idea of percolation though not necessary with the procedural tint) on phenomena associated with iterative rule application. Using Mandarin as the main language of study, Chapter Two will show that ICT is well-equipped to describe cyclic processes by nature of the structural sensitivity built into the theory. This ushers in the issue of directionality in Chapter Three which being something understood linearly, appear to be at loggerheads with any theory that relies too heavily on structures. The case of directionality is made through a study of Tianjin tone sandhi, which exhibit directionality par excellence. Chapters Two and Three thus lay out the main architecture of ICT and its applicability.

A few unresolved issues would be taken up in Chapter Four. Firstly, Chapter Four will address the headedness assumption of Mandarin and Tianjin since this directly impacts on the analyses of these two languages. Secondly, there is the matter of non-iterative processes (neutralization and Tianjin absorption). Thirdly, Chapter Four will provide some discussion on the selection of target tones.

Having presented ICT in detail, Chapter Five relates this theory to some important precedent ideas. As such Chapter Five serves two functions - (i) it is a map that will help place this main idea behind this dissertation by relating it to other works and (ii) it is a literature review. This is followed by a conclusion.

Chapter Two

MANDARIN CYCLICITY

Traditionally, with cyclical phonology, cyclicity is understood as having an operation or set of operations apply recursively over a domain as long as conditions for application of the operation are met. To be theory-neutral, cyclicity is a kind of contextual opacity where surface forms appear to have undergone excessive redundant change when underlying forms do not conform to the wellformedness requirements of that language. This in itself does not suffice to warrant the notion of the cycle. To illustrate that a language exhibit cyclicity, it is necessary to show that the change is cycling on some structure, so that the patterns of alternation is sensitive to the organizational structure of a given underlying string. This chapter will first present a discussion of Mandarin. Of central interest is its third-tone sandhi, a phenomenon that exhibits the crucial characteristics of cyclicity. Then drawing upon the ideas of percolation and non-terminal based approaches (see Chapter One and references cited therein), I shall present a treatment of Mandarin tone sandhi. The chapter ends with a summary.

2.1. Mandarin

Tone sandhi in Mandarin (Cheng 1968, Duanmu 1989, Liu 1980, Kaisse 1985, Zhang 1997, among many others) presents strong evidence for both cyclical treatment as well as the relevance of syntactic information in phonological processes (Shih 1986 and references cited therein). Before delving deeply into the issues of cyclicity, this section presents an introduction to some important characteristics of Mandarin. Crucially, two kinds of tonal alternation will be introduced – the third tone sandhi and tone neutralization. While the relation between the latter and cyclicity is obscure, I shall nonetheless devote some paragraphs to outlining it for the following reasons. Firstly, it contrasts with tone sandhi in position stability. Secondly, it has implications on the prosody of Mandarin, an area of discussion inevitable in the study of Mandarin tone sandhi and cyclicity.

2.1.1. TONAL INVENTORY

There are four citation tones in Mandarin. (2.1-1) presents the tones in Mandarin.

(2.1-1) Tones in Mandarin

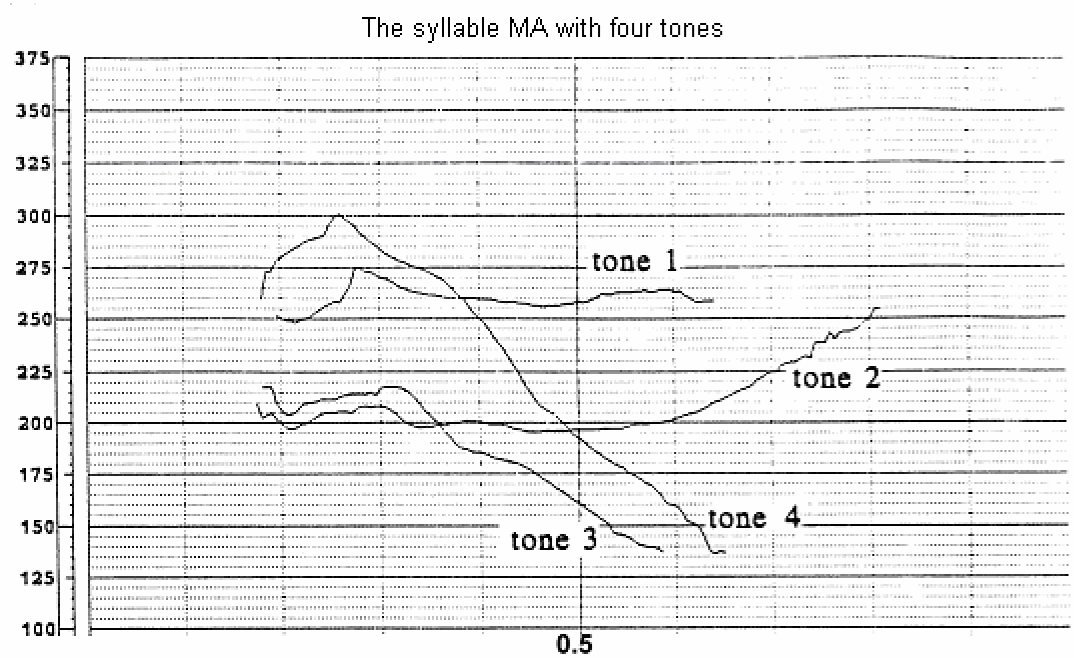
	Abbreviation	Pitch value	Yip (1980)	Description
First tone	T1	[55]	H,h	High, flat
Second tone	T2	[35]	H,lh	Rising
Third tone	T3	[11] or [214]	L,l or L,lh	Low, concave
Fourth tone	T4	[51]	H,hl	Falling

The third column in (2.1-1) presents the description of the Mandarin tone contours with the Chao "tone letter" system (Chao 1930). The digits 1 through 5 represent pitch height, 5 being highest. The descriptions provided in (2.1-1) are based on the survey of Chinese languages compiled in Yuan (1956).

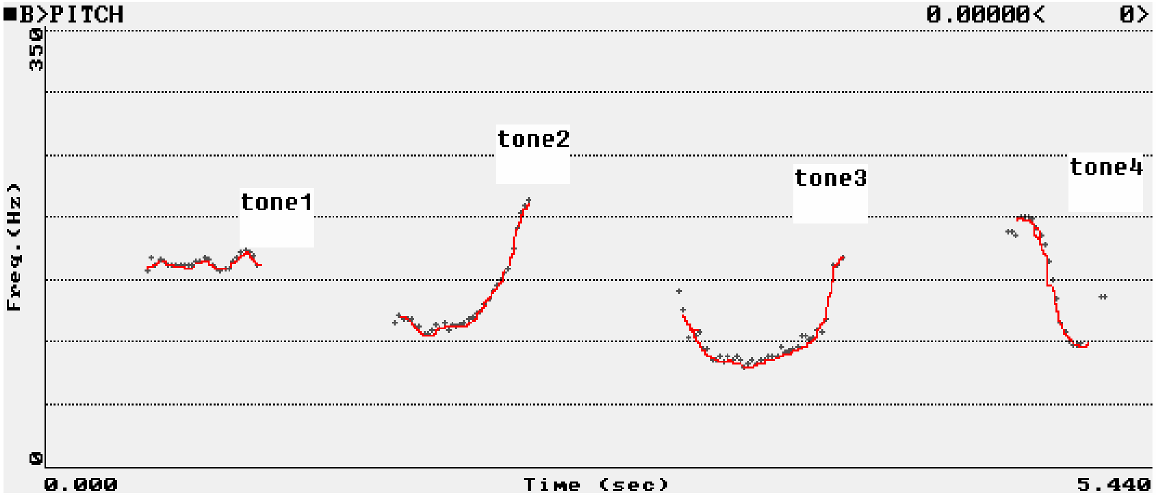
Following Yip (1980:283 and 1995) and references cited therein, in the third column, the upper case "H" denotes upper register while the lower case "h" denotes high pitch. "L" denotes lower register while "l" denotes low pitch. The contour of the tone is then described with lower case letters "h" and "l". A sequence of [l] and [h] will denote a rising tone from low to high and the reverse would describe a falling tone.

As the reader may notice, there is some discrepancy using the system described under Yip (1980) with respect to the third tone. T_3 has been described has a complex contour tone (falling then rising) in citation and in slow careful speech, but is a flat low in fast speech. This matter is unfortunately not easily resolved through a pitch-track analysis. Shih (1988) reports that T3 is low, while Hirayama (1984) reports that T3 is slightly concave. Below, I offer Shih's (1988) pitch tracks and also a set that I made from my own articulation. In both sets of articulation, the syllable ma was pronounced in isolation using each of the 4 tones. Details on the articulator of Shih's report were not provided. It appears that my articulation agrees with that reported in Hirayama.

(2.1-2) a. Pitch Tracks of the Mandarin Tones from Shih (1988)



b. Pitch Tracks of the Mandarin Tones articulated by the writer



The figures are displays of the time function of F0 values, with the y-axis representing F0 in hertz and the x-axis representing time (in seconds). It is the pitch track of the syllable ma in four tones: ma1 'mother', ma2 'hemp', ma3 'horse', and ma4 'to scold'. The pitch tracks articulated by the writer are obtained from the pitch extraction function of the CLS computer program.

In addition to these four tones, there is a neutral tone that is generally not treated as part of the tonal inventory (Yip 1980:79ff, Beijing 1995). The phonetic nature of the neutral tone is not stable, that is, one cannot confidently say if it is high, low, falling or rising. Rather, its phonetic form varies. The variation of the neutral tone with its preceding tone is shown below.

(2.1-3) Phonetic value of neutral tone

	Pitch value of neutral tone	
Environment	Beijing (1995:7)	Yip (1980:80ff)
After T1	[3]	[3]
After T2	[2]	[3]
After T3	[4]	[4]
After T4	[1]	[4]

Without regard to the differences in the values reported by Beijing and Yip, the context sensitivity exhibited in (2.1-3) argues against treating the neutral tone as part of the underlying tonal inventory.[1]

It is prudent to note that not all Mandarin speakers use neutral tones. Many Mandarin speakers who have roots in the Guangdong or Fujian provinces do not use the neutral tone at all.

2.1.2. TONAL STABILITY

Phonetic details aside, the following paragraphs will introduce tonal alternations found in Mandarin. Except where the tonal details are relevant, I will use the abbreviations provided in the first column of the table on Mandarin tones in (2.1-1). Essentially, given a disyllable sequence, tonal alternation is such that there is either (i) stability in the final syllable or (ii) stability in the initial syllable.

The case of stability in the final syllable is exemplified by the famous Mandarin third tone sandhi. When two T3 syllables are adjacent, the first will change into T2[2],

[1] Wang (1997) analyses the neutral tone as a syllable without tonal specification and claims that their ocurences can be lexically specified or derived. He cites examples of multi-syllabic sequences which initial syllable carries a neutral tone (p.161) as well as toneless inflectional morphemes (p.171) as evidence. In some sense, then the neutral tone must be part of the underlying tonal inventory for Wang.

[2] It is perhaps helpful to mention that given the variation in the actual phonetic realization of T3 as shown by the pitch tracks, treating the sandhied T2 as derived from T3 by some tonal reduction process might not be feasible, especially for those speakers whose T3 is like that given in Shih (1988). To such speakers, a low tone cannot be reduced to becoming a rising tone.

expressed as a rule in (2.1-4). The tree version of the rule is a notational variant of the SPE type.

(2.1-4) Mandarin Tone Sandhi Rule

$$\begin{array}{cc} \text{T3} & \text{T3} \\ \downarrow & \\ \text{T2} & \end{array} \qquad\qquad \text{T3} \rightarrow \text{T2} \;/\; \_\_\_ \;\text{T3}$$

Excepting for various special conditions, such as sentential boundaries or recitation speed, (2.1-4) is an iron-clad rule, and will apply whenever conditions are met. Given below is a paradigm that would illustrate the third tone sandhi, as well as the lack of sandhi in and with the other tones. Clearly, only T3 adjacency triggers tone sandhi, all other collocations are stable.

(2.1-5) a. T3+T3 (Sandhi-triggering)

i.	lao3hu3	→ lao2hu3	'tiger'
ii.	zong3tong3	→ zong2tong3	'president'
iii.	hao3jiu3	→ hao2jiu3	'good wine'
iv.	xie3gao3	→ xie2gao3	'write a script'

b. T3+T (No tone sandhi)

i.	lao3shi1	→ lao3shi1	'teacher'
ii.	lao3nian2	→ lao3nian2	'old age'
iii.	lao3zhao4	→ lao3zhao4	'Mr. Zhao'

c. Other tonal combinations (No tone sandhi)

i.	deng1guang1	→ deng1guang1	'light'
ii.	bing1tang2	→ bing1tang2	'rock sugar'
iii.	feng1si3	→ feng1si3	'sealed'
iv.	bing1kuai4	→ bing1kuai4	'ice cube'
v.	yang2guang1	→ yang2guang1	'sunglight'
vi.	niu2tou2	→ niu2tou2	'cow's head'
vii.	peng2you3	→ peng2you3	'friend'
viii.	nian2fen4	→ nian2fen4	'year'
ix.	bing4mao1	→ bing4mao1	'sick cat'
x.	nuo4yan2	→ nuo4yan2	'promise'
xi.	dian4yi3	→ dian4yi3	'electric chair'
xii.	fei4hua4	→ fei4hua4	'gibberish'

The case stability of initial tones is exemplified by tone reduction (neutralization) (Detailed analysis see Wang 1997). As aforementioned, this is the process by which the neutral tones in Mandarin are obtained. Initial tones are never reduced. This is expressed schematically in (2.1-6).

(2.1-6)

$$\begin{array}{cc} T_{\alpha} & T_{\beta} \\ & \downarrow \\ & T_0 \end{array}$$

0 = neutral tone

(2.1-7) Examples of neutralization (data from Zhang 1977)

a.	i. sheng1xing4	'nature of character'	noun
	ii. sheng1xing0	'untamed'	adjective
b.	i. zhang4ren2	'sir'	noun
	ii. zhang4ren0	'father-in-law'	noun
c.	i. di3xia4	'underneath'	adjective
	ii. di3xia0	'underneath'	noun
d.	i. gao4shi4	'relate, tell, proclaim'	verb
	ii. gao4shi0	'notice, proclamation'	noun
e.	i. da2shou3 /da3shou3/	'hit hand'	verb phrase
	ii. da2shou0	'bouncer, fighter'	noun

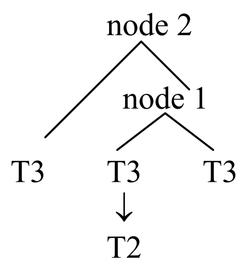
Only a small sample of neutralization is presented above, although all tonal collocations have neutralization examples. Notice in (2.1-7) that initial tones are never reduced, hence are stable. Note however, that the minimal pairs in (2.1-7) do not necessarily imply that the neutral tone is part of the underlying tonal inventory. The contrast between (i) and (ii) in (2.1-7) must come from some kind of morphology that reduces the tone of the second syllable. This is evident from the syntax~phonology co-variation that (i) and (ii) are often different in syntactic category. Further, constituents with reduced tones are never XPs. For example, (ei) is an XP, while (eii) is not.

That Mandarin tonal alternations exhibit stability in both initial and final positions is peculiar if one attempts to relate this to prosodic issues. Argument by stability in tonal alternation points in opposite directions – in terms of stability, tone sandhi argues for iambs and neutralization for trochees. The relevance of this issue should become clear later when one attempts an analysis for Mandarin tone sandhi.

2.1.3. CYCLICITY AND INTERACTION WITH NEUTRALIZATION

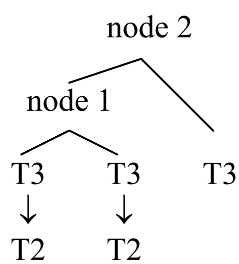
Armed now with the two tonal alternations found in Mandarin, this section goes on to show that Mandarin T3 sandhi is described as cyclical because of its structure sensitivity. Given a string of 3 syllables, the resultant surface form is dependent on the prosodic structure of that string. (2.1-8) exemplifies this.

(2.1-8) a.



(e.g. hao3 zong2tong3 'good president.')

b.



(e.g.zong2tong2 hao3 'Hello! President.')

Looking at (2.1-8a) in isolation simply suggests the most economic way of satisfying the tone sandhi requirements. (2.1-8b) alone says nothing more than the fact that the tone on the right edge will not undergo sandhi, but otherwise requires every T3 to alternate into T2. However, when (2.1-8a) and (2.1-8b) are considered together, it appears that tone sandhi is applying from the smallest constituent upwards and will apply as long as the environment is met. It is thus that Mandarin T3 sandhi has been treated as cyclical application of the tone sandhi rule. The opacity effect in (2.1-8b), which is the need to change more tones than necessary, is made transparent with recursive application from the innermost constituent upwards. This derivation is shown below.

(2.1-9) Cyclical derivations

	(2.1-8a)	(2.1-8b)
Node 1	$/T_3T_3/ \rightarrow [T_2T_3]$	$/T_3T_3/ \rightarrow [T_2T_3]$
Node 2	$/T_3/ + T_2T_3 \rightarrow [T_3T_2T_3]$	$[T_2T_3] + /T_3/ \rightarrow [T_2T_2T_3]$

T3 sandhi interacts with neutralization too, as may be seen in (2.1-7e), repeated here in a slightly different format for clarity.

(2.1-10)	UR	:	/da3/ 'hit' + ↓	/shou3/ 'hand'
	T3 sandhi	:	da2	shou3 'hit hand' ↓
	Neutralization	:	[da2	shou0] 'bouncer/fighter'

More examples of the /T3+T3/ → [T2 T0] kind

i.	ba2shou0	'handle'
ii.	che2shou0	'hand-pulling (adj.)'
iii.	da2dian0	'arrange'
iv.	jiang2fa0	'saying'
v.	na2li0	'where'
vi.	qi2huo0	'become ablaze'
vii.	zao2qi0	'wake up early in the morning'

One finds more interaction between neutralization and tone sandhi with Mandarin reduplicated forms. Like (2.1-10), they exhibit contextual opacity in that they trigger T3 sandhi, consistent with the T3 Sandhi Rule (2.1-4). This suggests that that the reduplicant must have tonal information relevant to sandhi. It is puzzling how tone sandhi could result from neutral tones unless the tones were there in the first place before they were neutralized. In any case, to wrap up this introduction to Mandarin, the following presents the patterns related to reduplication of a Mandarin syllable. Note that some reduplicants, whose base tones supposedly trigger sandhi, do not trigger sandhi (2.1-11aiii).

(2.1-11)a. With Neutralized Tones (nouns)

T_{α} RED
↓
T_0 0 = neutral tone

i. gong1 'grandfather' → gong1gong0 'eunuch'

ii. niang2 'mother' → niang2niang0 'lady'

iii. nai3 'milk' → nai3nai0 'granny'

iv. ba4 'father' → ba4ba0 'daddy'

b. With Tone Sandhi (other lexical categories)

T_{α} RED
↓ ↓
$T_{\alpha'}$ T_{α} α' = sandhied tone

i. zou3 'walk' → zou2zou3 'walk (emphatic)'

ii. xiao3 'small' → xiao2xiao3 'very small'

c. With Neutralized Tones and Tone Sandhi

$$\begin{array}{cc} T_{\alpha} & \text{RED} \\ \downarrow & \downarrow \\ T_{\alpha'} & T_0 \end{array}$$

i. zou3 'walk' → zou2zou0 'take a short walk'

ii. xiao3 'small' → xiao2xiao0 'smallish'

d. With Atypical Sandhi

$$\begin{array}{cc} T_{\alpha} & \text{RED} \\ \downarrow & \downarrow \\ T_{\alpha} & T_{\alpha'} \end{array} \qquad \alpha' = \text{sandhied tone}$$

i. hao3 'good' → hao3hao1de0 'properly'

ii. man4 'slow' → man4man1de0 'slowly'

2.2. Inter-tier correspondence and cyclicity

Putting aside for the matter on neutralization, let us just instead assume that Mandarin has a right-headed prosody. Further, tone sandhi applies to phonological/prosodic structures, not syntactic structures. In the case of Mandarin, it happens that these two structures match. The interface between prosodic structures and syntactic configurations that will derive this match will be discussed in section 2.3. This provides the firmest grasp on the matter of tone sandhi, which is what is central to the cyclic nature that this chapter addresses. I will postpone matters on prosodic headedness till section 2.4.

This section zeroes-in on the third tone sandhi aspect of the problem since it is this that exhibits the crucial characteristics of cyclicity, i.e. the exhibition of both bleeding and counterbleeding rule-ordering effects depending on the recursivity of the domain of application. The following paragraphs now move on to applying Inter-tier Correspondence Theory (ICT) to the tone sandhi phenomenon.

2.2.1. INTER-TIER CONSTRAINTS AND MANDARIN TONE SANDHI

The constraints relevant for tone sandhi are given as follows.

(2.2-1) ICT constraints and others relevant for tone sandhi

INT(ertier)**F**(aithfulness) **HD**(head)

If node A immediately dominates node B and B is the head constituent, then B must have an identical correspondent in A. (Mandarin is assumed here to be right headed.)

INTF

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

OCP [T3][3]

Do not have adjacent T3 (within a prosodic constituent)[4].

Cast in OT, INTF in this analysis parallels the IDENT constraints while the tone sandhi is triggered by a markedness constraint, say OCP [T3]. By being positionally faithful to the constituent on the right, it will follow that the first T3 of a T3T3 sequence will be the one that changes. In this analysis, the IDENT constraints are replaced by INTF (Inter-tier Faithfulness, Wee (2000) uses a different name, PERCOLATE) and INTF-HD. However,

[3] Following Bao (1999). The exact nature of this is not a main concern at this point.
[4] That prosodic constituent here refers to the phonological phrase, which will be discussed in section 2.3.

faithfulness to other special positions such as left or head of the constituent is also possible. In any case, INTF-HD is really a kind of positional faithfulness constraint (See Beckman 1998 for detailed discussion on positional faithfulness). Given the way the ICT constraints are formulated, it is important to note that correspondence is strictly between immediately dominating nodes. This would become clear when one consider cases involving more tiers in the next sub-section. To see some of the constraints in action, consider the following candidates as outputs of the ditonal input /T3T3/ and a corresponding tableau. The attested candidate is (2.2-2b), indicated in parenthesis as 'winner'.

(2.2-2) Input: /T3+T3/ e.g. hao jiu 'good wine'

a. candidate (i): T3+T3

T3 T3

b. candidate (ii): T2+T3 (winner)

T3 T3

c. candidate (iii): T3+T2

T3 T3

Input: /T3T3/	INTF-HD	OCP [T3]	INTF
Candiate (i)		*!	
☞Candidate (ii)			*
Candidate (iii)	*!		*

Legend: ☞ = attested optimum * = violation mark ! = crucial violation mark

It is clear that candidate (i) violates one count of OCP [T3] since both tones have percolated faithfully, i.e. the dominating node has one occurrence of T3 adjacency. However, since both the left and the right nodes have perfect correspondence between the two tiers, there is neither the general INTF violation nor the specific INTF-HD violation. At this point, it is probably worth noting that INTF and INTF-HD have a special relationship. Violation of INTF-HD entails violation of INTF, but not vice versa. Candidates (ii) and (iii) do not incur any violations of OCP [T3], but have other violations of their own. The left constituent of candidate (ii) does not have an identical correspondent at the dominating node. This translates to a violation of INTF. By virtue of not having an identical correspondence between the right constituent and the dominating node, candidate (iii) violates INTF-HD and also INTF. Candidate (iii) has all the violations of candidate (ii) in addition to one of its own, which makes it harmonically bound. There is no ranking that will make this candidate optimal. The competition is between candidate (i) and candidate (ii). To ensure that candidate (ii) surfaces as winner, one simply has to ensure that INTF-HD and OCP [T3] both outrank INTF. In the above tableau, the lack of crucial ranking between OCP [T3] and INTF-HD is indicated by the dashed line while the crucial ranking is reflected by the solid line.

It is important to note that under this analysis, the constraints are **checked at every node in the representation**. Candidate (ii) is predicted to be the optimal candidate under this ranking and would correspond to the phonetic articulation T2T3. The immediate question that arises is the choice of T2 over other tonal possibilities. I will side-step this for the moment (saving this for a later chapter on tonal selection) and concentrate on how this analysis preserves the insight that bleeding and counterbleeding of the Mandarin T3 Sandhi rule is simply the result of having right or left-branching structures. When faithful to the right constituent (i.e. the assumed prosodic head), right-branching structures produce bleeding because nodes on the left asymmetrically c-command nodes on the right, while left-branching structures produce counterbleeding effects because nodes on the right asymmetrically c-command nodes on the left.

2.2.2. CAPTURING CYCLICITY

Having explained how the ICT constraints evaluate each candidate, consider now a tritonal left-branching input of T3s and some corresponding candidates. For ease of reference and clarity, violated constraints and the number of violations are indicated at every corresponding tier of each candidate.

(2.2-3) Input: /T3+T3/ +/T3/ e.g. [zong tong] hao 'Hello!Mr. President.'

Candidates — Violations:count

a. candidate (i):

T3T3+T3 — OCP [T3]:2

T3+T3 — OCP [T3]:1

T3 T3 T3

b. candidate (ii): (winner)

T2T2+T3 — INTF:1

T2+T3 — INTF:1

T3 T3 T3

c. candidate (iii):

T3T2+T3

T3+T2 INTF-HD:1; INTF:1

T3 T3 T3

d. candidate (iv):

T3T2+T3 INTF:2

T2+T3 INTF:1

T3 T3 T3

In (2.2-3), evaluation of the candidate is done at every tier. The result of the evaluation is given by indicating the relevant constraint at each offending tier. The number of violations is given after a colon following the constraints. Semicolons separate different constraints that are simultaneously violated, for example candidate (iii). Using candidate (iv) as an example, the lower branching node has one count of INTF violation because the leftmost T3 does not have an identical correspondent at the intermediate tier. The highest branching node has two counts of INTF violations because in this case, it faithfully corresponds to both members of its left constituent. (2.2-4) provides an OT tableau to illustrate how the attested candidate is predicted to be optimal.

(2.2-4) Left-branching, tritonal T3 (counterbleeding effect)

Input: /T3T3/ + /T3/	INTF-HD	OCP [T3]	INTF
Candiate (i)		*!**	
☞Candidate (ii)			**
Candidate (iii)	*!		*
Candiate (iv)			***!

As may be seen from the above paragraphs, ICT correctly predicts the counterbleeding effects of Mandarin tone sandhi whenever given a left-branching structure. Next, consider a right-branching input. As above, so the below will present the candidate set, the relevant violations and their number of tokens, and also an OT tableau.

(2.2-5) Input: /T3/ +/T3+T3/ e.g. hao [zong tong] 'good president.'

	Candidates	Violation : count
a.	candidate (i):	
	T3T3+T3	OCP [T3]:2
	T3+T3	OCP [T3]:1
	T3 T3 T3	
b.	candidate (ii): (winner)	
	T3+T2T3	
	T2+T3	IntF:1
	T3 T3 T3	
c.	candidate (iii):	
	T2+T2T3	IntF:1
	T2+T3	IntF:1
	T3 T3 T3	
d.	candidate (iv):	
	T2+T3T2	IntF:1
	T3+T2	IntF-Hd:1; IntF:1
	T3 T3 T3	

(2.2-6) Right-branching, tritonal T3 (bleeding effect)

Input: /T3/ + /T3T3/	INTF-HD	OCP [T3]	INTF
Candidate (i)		*!**	
☞Candidate (ii)			*
Candidate (iii)			**!
Candidate (iv)	*!		**

The ICT has successfully mimicked the counterbleeding and bleeding effects of Mandarin tone sandhi. Crucially, it captures the insight that these effects stem from the recursive application of the same alternation process, in such a way sensitive to structure. Indeed, this approach guarantees structure sensitivity since it is upon this basis that information between tiers corresponds.

2.3. Phonological phrases[5]

Though ICT can capture the effects of cyclicity, the analysis presented thus far would not predict the data in (2.3-1), although it is attested. Such data suggest that any analysis of cyclicity must be complemented by some means of determining the domain within which a pattern cycles.

(2.3-1) [$_{\textbf{topic}}$ zhe4 zhong2 **jiu3**] [$_{\text{S}}$ **wo3** ai4 he1].

this CL wine I love drink

"This kind of wine, I like to drink."

[5] This section is adapted from Wee (2000) under the same heading. Thanks to Hubert Truckenbrodt for many of the ideas here.

Notice in (2.3-1), there are two T3s that are adjacent. Tone sandhi seems to have been blocked by the topic boundary. In fact, tone sandhi can also be blocked at the right edge of a preverbal XP when read slowly too. This is shown in (2.3-2).

(2.3-2) [$_{\mathbf{NP}}$ zhe4 zhong2 **jiu3**] **hao3** he1.

This CL wine good drink

"This kind of wine is good to drink".

When read normally, (2.3-2) would not have two adjacent T3s. It is with very slow reading that (2.3-2) is possible. (2.3-1) and (2.3-2) do not contradict the analysis proposed so far. Rather, they point to some fine-tuning in the direction of finding out the domain of cyclicity. The challenge is in accounting for the tolerance of adjacent T3s in these special cases.

Sandhi blocking presented above is reminiscent of tone sandhi in Xiamen Chinese (Amoy), also Taiwanese, Chaozhou and other Southern Min languages. In Xiamen Chinese, within an XP, the right-most syllable will keep its citation/underlying tone while the tones of all the other syllables will undergo tone sandhi. (2.3-3) provides some examples. The numbers in (2.3-3) indicate the tonal contours, following Chao's (1930) tone letters.

(2.3-3) Data from Chen (1987)

p'ang /44/ 'frangrant' + tsui/53/ 'water' → p'ang [22] tsui[53] 'perfume'

we /24/ 'shoe' + tua /21/ 'laces' → we[22] tua [21] 'shoe laces'

ts'u /21/ 'house' + ting/53/ 'top' → ts'u[53] ting[53] 'roof top'

pang/21/ 'put' + hong/44/ 'wind' + ts'e /44/ 'kite' → pang[53] hong[22] ts'e [44] 'fly a kite'

Notice that in (2.3-3), the rightmost syllable preserves its tone while all the preceding ones undergo sandhi. However, sandhi is not unbounded. It is blocked when it encounters the right edge of another XP, schematically shown in (2.3-4).

(2.3-4) $[[_{XP}\ \sigma\quad \sigma\quad \sigma\quad \boldsymbol{\sigma}\ ]\qquad [_{YP}\ \sigma\quad \sigma\quad \sigma\quad \boldsymbol{\sigma}]]$

The final syllable in the XP in (2.3-4) will not undergo tone sandhi. This is because here there is the right edge of that XP. Chen (1987) argues that there is a tone group boundary at the right edge of every XP in Xiamen Chinese and postulates the following rule.

(2.3-5) Tone Sandhi Rule (TSR) from Chen (1987)

T → T' / ___ T within a tone group

Key: T = base tone, T' = sandhi tone

2.3.1. CONSTRAINTS ON THE INTERFACE BETWEEN PROSODY AND SYNTAX

Since syntactic relevance is evident, this section shall take as its point of departure a set of constraints on the interface between prosody and syntax. Within OT, Selkirk (1995) and Truckenbrodt (1999) have proposed two relevant kinds of constraints for capturing the Xiamen tone sandhi phenomenon. Selkirk's alignment constraints attempt to map the boundaries of phonological phrases to the boundaries of syntactic phrases. She does so by requiring tone groups to be aligned with syntactic phrases. Truckenbrodt explains why the sandhi rule does not apply across the right edge of an XP with a constraint WRAP-XP. In so doing, Truckenbrodt treats tone groups as phonological phrases (P-phrases). The set constraints are stated in (2.3-6).

(2.3-6) **ALIGN-XP, R** (from Selkirk 1995)

For each XP, there is a P-phrase (phonological phrase) such that the right edge of the XP coincides with the right edge of P-phrase.

ALIGN-XP, L (from Selkirk 1995)

For each XP, there is a P-phrase such that the left edge of the XP coincides with the left edge of P-phrase.

WRAP-XP[6] (from Truckenbrodt 1999)

Each XP is contained in a P-phrase.

NON-RECURSIVITY (from Truckenbrodt 1999)

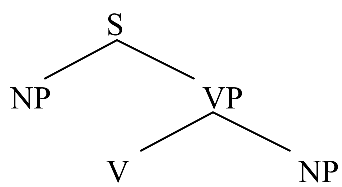
Any two P-phrases that are not disjoint in extension are identical in extension.

[6] In Truckenbrodt (1999), XP does not include functional projections but only lexical projections.

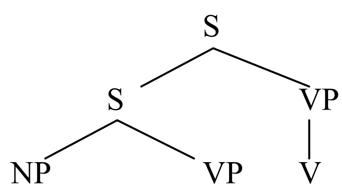
The insight behind the constraint WRAP-XP is that it allows phonological rules to be contained within a domain to prevent over-application. (For an illustration of its effect, see Truckenbrodt 1999 for treatment of Kimatuumbi tone insertion.)

To illuminate the insights behind the constraints listed in (2.3-6), one may consider the following two syntactic representations and how each constraint would respond to the kinds of corresponding prosodic structures. For current purposes, discussions on ALIGN-XP, L shall be withheld until later.

(2.3-7) a.



b.



The following tableaux (2.3-8) show the reaction of the constraints on prosodic constituency, which is marked by the square brackets.

(2.3-8)

Input: (2.3-7a)	ALIGN-XP, R	WRAP XP	NON-RECURSIVITY
i. [NP] [V [NP]]			*
ii. [NP V NP]	*		
iii. [NP] [V NP]			
iv. [NP] V [NP]		*	
Input: (2.3-7b)	ALIGN-XP, R	WRAP XP	NON-RECURSIVITY
v. [NP] [VP] [VP]			
vi. [NP VP] [VP]	*		
vii. [NP VP VP]	**		

Notice that in (2.3-8), one cannot see clearly the effects of ranking these constraints since all the candidates are harmonically bounded by either (2.3-8iii) or (2.3-8v)[7]. Nevertheless, it should exemplify how these constraints react to various prosodic configurations given a particular syntactic structure. At this point, let me introduce a new constraint that belongs to the WRAP family of constraints.

(2.3-9) **WRAP-IP**

Each IP (Infl phrase) is contained in a P (phonological phrase).

Assuming ALIGN-XP, R to be undominated, one can consider the effects of including the WRAP IP constraint with respect to NON-RECURSIVITY. This is illustrated in (2.3-10).

[7] Ranking of ALIGN XP, R, WRAP XP and NON-RECURSIVITY is non-trivial if the input syntactic constituency has two complements [V NP NP]. When WRAP XP;ALIGN XP,R » NON-RECURSIVITY, one would expect a recursive structure [[V NP] NP]. When NON-RECURSIVITY » ALIGN XP, R, then one would get [V NP NP]. For details, see Truckenbrodt (1999).

(2.3-10)

Input: (2.3-7a)	ALIGN-XP, R	WRAP IP	NON-RECURSIVITY
i. [NP] [V NP]		*	
ii. [[NP] [V NP]]			*
Input: (2.3-7b)	ALIGN-XP, R	WRAP IP	NON-RECURSIVITY
iii. [NP] [VP] [VP]		**	
iv. [[NP] [VP] [VP]]		*	*
v. [[[NP] [VP]] [VP]]			**

As can be seen in (2.3-10), depending on the relative ranking between WRAP IP and NON-RECURSIVITY, one may obtain different prosodic structures given a particular syntactic constituency. Armed with these constraints on prosody-syntax interface, it is now possible to provide an account for the blocking effects in both Xiamen and Mandarin tone sandhi.

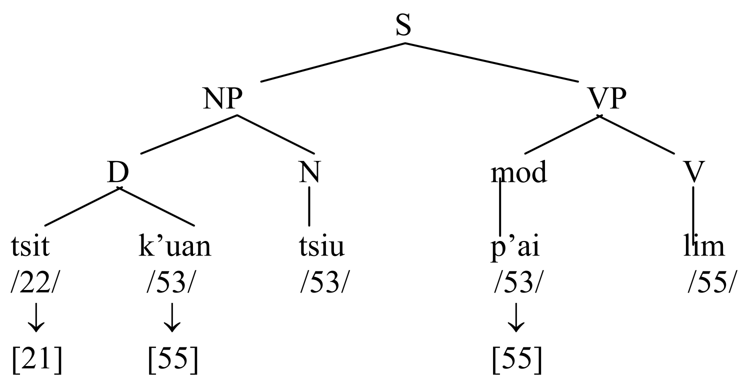
2.3.2. THE TONE SANDHI DOMAIN OF XIAMEN

Unlike Mandarin tone sandhi, tone sandhi in Xiamen has not been and need not be thought of as a cyclic phenomenon. The analyses that were provided by Chen (1987), Selkirk (1995) and Truckenbrodt (1999) have been treating the phenomenon as simple rule application within a domain. I will demonstrate this with (2.3-11).

(2.3-11) tsit[21] k'uan [55] tsiu[53] p'ai[55] lim [55].

This CL wine bad drink

This kind of wine drinks terribly.



Given the syntactic structure in (2.3-11) and a ranking where NON-RECURSIVITY » WRAP, one gets the following prosodic structure as optimal (See 2.3-10(i) and (iii)).

(2.3-12) Prosodic Structure of (2.3-11)

Input: syntactic tree in (2.3-11)	ALIGN-XP, R	NON-RECURSIVITY	WRAP XP	WRAP IP
i.☞ [tsi k'uan tsiu] [p'ai lim]				*
ii. [[tsi k'uan tsiu] [p'ai lim]]		*!		

(candidate 2.3-12(i))

Now that one has arrived at the prosodic structure in (2.3-12i), the blocking effect of Xiamen tone sandhi may be accommodated by stipulating that a set of wellformedness constraints, WF [8], applying within the limits of a P-phrase. The ICT constraints would determine which tones should change. Thus, supposing that WF requires any non-phrase-final tone to undergo tone sandhi, a high-ranking INTF-HD. will dictate that at the first level, [tsit], [k'uan] and [p'ai] undergo tonal alternation. Now, when one looks at the next level, the markedness constraint cannot apply since [tsiu] and [p'ai] are no longer in the same P-phrase. So at this level all the tones may percolate without violating WF. The result will be the surface articulation in (2.3-11). Under this analysis, Xiamen tone sandhi would be similar to Mandarin in that the tone sandhi is the result of having a (set of) markedness constraint(s), WF, and INTF-HD outranking INTF. The difference lies in NON-RECURSIVITY which disallows further embedding of P-phrases in Xiamen. This will become evident in the following section where the blocking of Mandarin tone sandhi is addressed.

Though Xiamen tone sandhi is not cyclic (cf. earlier accounts of Chen 1987 and Truckenbrodt 1999), the apparatus developed here with ICT enables expression of the typological relation between Mandarin and Xiamen.

2.3.3. THE TONE SANDHI DOMAIN OF MANDARIN

Having seen how ICT can be compatible with blocking effects of Xiamen tone sandhi, one may employ the same strategy with the blocking effects of Mandarin tone sandhi. Essentially, one can say that in Mandarin, the places where adjacent T3s are tolerated are precisely phonological boundaries, such that the P-phrases are not constituents of a

[8] Horwood (2000) hypothesizes quite successfully that these constraints are Anti-faithfulness constraints. For current purposes, I will simply use WF to represent the block of relevant constraints.

higher P-phrase. This is especially evident given that adjacent T3 tolerance is more likely in slow speech than fast ones.

Without further ado, consider a ranking such as WRAP-IP; ALIGN-XP, R » NON-RECURSIVITY » WRAP XP. Using this ranking hierarchy, consider (2.3-13), where an example of adjacent T3 tolerance is provided together with a tableau in which a few possible prosodic structures are evaluated against this input.

(2.3-13) Adjacent T3 tolerance (repeated from (2.3-1))

[$_{\textbf{topic}}$ zhe4 zhong2 **jiu3**] [$_S$ **wo3** ai4 he1].

this CL wine I love drink

"This kind of wine, I like to drink."

Input: syntactic configuration [$_{topic}$ zhe4zhong2jiu3][$_S$wo3ai4he1].	ALIGN-XP, R	WRAP IP	NON-RECURSIVITY	WRAP XP
i. ☞ [zhezhongjiu] [[wo] [aihe]]			*	
ii. [zhezhongjiu] [wo ai he]	*!			
iii. [[zhezhongjiu] [[wo] [aihe]]]			**!	
iv. [zhezhongjiu] [wo] [aihe]		*!		

(Candidate (2.3-13i))

Under this ranking, candidate (2.3-13i) turns out to be the optimal corresponding prosodic structure. This is because undominated ALIGN-XP R will dictate that there are as many right P-phrase boundaries as there are XPs. WRAP IP requires that all these P-phrases be embedded within a P-phrase that covers the IP/S even if that were to violate NON-RECURSIVITY. Since NON-RECURSIVITY dominates WRAP XP, there may be no recursive structures of P phrases beyond the highest syntactic node corresponding to the IP or S.

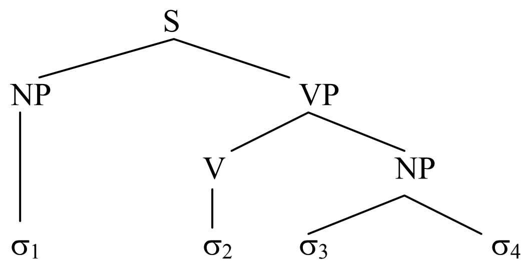
In a prosodic representation such as (2.3-13i), the topic and the sentence no longer belong to the same phonological phrase. Such a representation allows for an account of blocking in Mandarin tone sandhi similar to that in Xiamen. This is because the adjacent T3s no longer belong to the same phonological phrase. If OCP [T3] operates only within P-phrases, then this adjacency does not constitute a violation. These tones may faithfully percolate to the root node. (2.3-2) can be accounted roughly the same way. Notice that in this slow reading case, adjacent T3s are tolerated between the subject NP and the VP. To get this result, one simply has to assume that in slow speech, NON-RECURSIVITY outranks all the WRAP Constraints, similar to that in Xiamen. This mode of analysis may be extended to cover situations of fast speech. In fast speech, except for the rightmost T3, all consecutive T3 syllables undergo alternation. To achieve this result, one simply needs to rank NON-RECURSIVITY above ALIGN XP, R.

The appeal of this analysis extends beyond these two Chinese languages. Slave (Rice 1987) presents another case where phonological conditions seem to be sensitive to IP domains. In Slave, high tones are aligned to the right edge across phrasal boundaries and apparently are blocked only when one reaches the S or the S', corresponding to the IP or the CP in more modern syntactic frameworks.

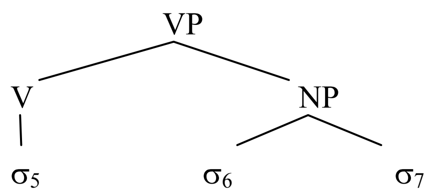
2.3.4. A LESSON FROM RIGHT-BRANCHING STUCTURES

While the prosody-syntax interface constraints work well in predicting the tone sandhi blocking in Mandarin, it is useful to take a step back and apply them to simple right-branching syntactic structures. In so doing, it will become clear that right-branching syntactic constituency actually yields a flat prosodic structure. This calls forth the need for a constraint such as ALIGN XP, L. (2.3-14) illustrates this.

(2.3-14) a.



b.

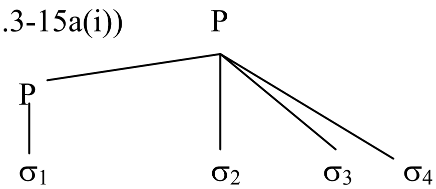


By ALIGN-XP R, one would have expected there to be a right edge of a P-phrase to be at σ_1, σ_2, σ_4, σ_5 and σ_7 in the trees above. Since ALIGN-XP-R; WRAP IP » NON-RECURSIVE, one would expect recursive P-phrases to be possible. However, the effect of NON-RECURSIVITY can still be felt so that (2.3-14a) has the prosodic structure in (2.3-15a).

(2.3-15) a. Erroneous Prosodic tree for (2.3-14a)

Input: syntactic tree in (2.3-14a)	ALIGN-XP, R	WRAP IP	NON-RECURSIVITY	WRAP XP
i. ☞ $[[\sigma_1]\ \sigma_2\sigma_3\sigma_4]$			*	
ii. $[[\sigma_1]\ [\sigma_2\sigma_3\sigma_4]]$			**!	
iii. $[[\sigma_1]\ [\sigma_2[\sigma_3\sigma_4]]]$			**!*	
iv. $[\sigma_1]\ [\sigma_2\sigma_3\sigma_4]$		*!		*

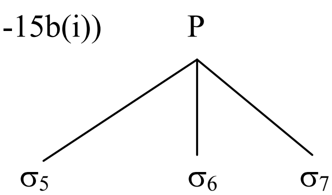
(Candidate (2.3-15a(i)))



b. Prosodic tree for (2.3-14b)

Input: syntactic tree in (2.3-14b)	ALIGN-XP, R	WRAP IP	NON-RECURSIVITY	WRAP XP
i. ☞ $[\sigma_5\sigma_6\sigma_7]$				
ii. $[\sigma_5]\ [\sigma_6\sigma_7]$				*!

(Candidate (2.3-15b(i)))



(2.3-15ai) as the optimal candidate for a right-branching structure is problematic. Suppose that σ_1, σ_2, σ_3 and σ_4 are all T3. With a flat structure and a requirement that the rightmost syllable to remain unchanged, two possibilities remain open to resolve the tone clash. One would predict that either σ_1 and σ_3 undergo tone sandhi or σ_2 and σ_3 undergo tone sandhi. This is because given a string of 4 syllables, minimally two must change to avoid adjacent third tones. However, the second case is not attested.

There is no problem with (2.3-15b). In (2.3-15b), by virtue of INTF-HD, σ_7 must percolate faithfully. Thus, only σ_6 will change since it is the minimal change required to satisfy OCP [T3].

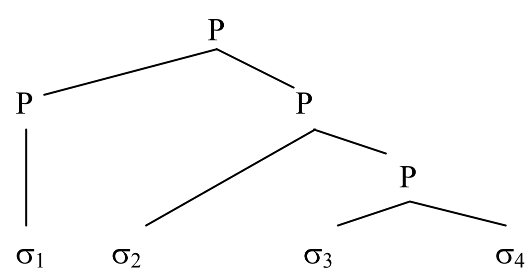
A simple way to resolving the problem caused by structures such as (2.3-15a) without creating adverse effects on the analysis thus far is to appeal to ALIGN XP, L, repeated below.

(2.3-16) **ALIGN-XP, L** (from Selkirk 1995)

For each XP, there is a P (phonological phrase) such that the left edge of the XP coincides with the left edge of P.

A high-ranking ALIGN XP, L would rule against the structure in (2.3-15ai) in preference for the structure (2.3-15aiii), shown below in (2.3-17).

(2.3-17) Structure of candidate (2.3-15aiii)



(2.3-17) is a recursive right-branching structure. The workings of INTF, INTF-HD and OCP [T3] will be as per outlined earlier, producing the effect of modifying only the tones of σ_1 and σ_3. To obtain this structure as optimal, it is crucial that ALIGN XP, L dominates NON-RECURSIVITY. The ranking hierarchy is now updated as follows.

(2.3-18) Ranking hierarchy for Mandarin syntax~prosody interface

Align XP, R   Align XP, L   Wrap IP

Non-Recursivity

Wrap XP

The high-ranking of Align XP, L and Align XP, R may make the use of Wrap XP look superfluous. To think so would be a grave mistake. Wrap XP would require that CPs be contained in phonological phrases. However, it is necessary that CPs be excluded from being contained in phonological phrases since tone sandhi does not apply across the topic boundary. At the risk of being repetitive, it is worth mentioning that the alignment constraints do not dictate that CPs be contained within phonological phrases. They simply require that the edges of CPs coincide with the edges of phonological phrases. Since the constituents of CPs are XPs, it follows that if these lower XPs correspond to phonological phrases, the edges of CPs would align with the edges of phonological phrases.

2.3.5. Blocking the preverbal NP

Recall now (2.3-2), where adjacent T3s are apparently tolerated between the preverbal NP and the following verb. The data are repeated below with a few other examples.

(2.3-19)a. [$_{NP}$ zhe4 zhong2 **jiu3**] **hao3** he1.

This CL wine good drink

"This kind of wine is good to drink."

b. [$_{NP}$ **jiu3**] **hao3** he1.

wine good drink

"Wine is good to drink."

c.? [$_{NP}$ **wo3**] **hen3** pang4.

I very fat

"I am very fat."

d.* Ma1ma0 xiang4xin0 [$_{NP}$ **wo3**] **hen3** pang4.

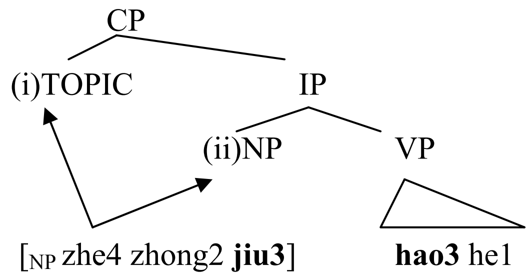
Mother believe I very fat

"Mother believes that I am very fat.

In (2.3-19a, b) adjacent T3s are allowed. There is apparently less tolerance in (2.3-19c) and zero tolerance in (2.3-19d), indicated by the boldface typescript. It goes without saying that in all the above cases, applying tone sandhi would yield grammatical forms. It is the tolerance that is puzzling since if the preverbal NP is the subject in all these cases, then (2.3-19a-c) are certainly unexpected. After all, WRAP IP does require that subject NPs be contained within phonological phrases, subsequently undergoing tone sandhi.

The entire set of data can easily be accounted for if one assumes that cases where T3 adjacency is tolerated are where the preverbal NPs are topics rather than subjects. Given (2.3-19a), for example, there are two possible syntactic parses.

(2.3-20)

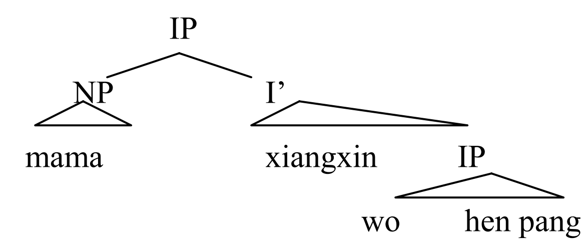


This CL wine good drink

"This kind of wine is good to drink."

The NP zhe zhong jiu may be parsed into the (i) spec IP position or into (ii) spec CP position. This is why in Mandarin, the distinction between topics and subjects is difficult. Subjects can often be topicalized leaving the spec IP position empty. Ex hypothesis, the domain of tone sandhi is contained within the IP, thus parsing zhe zhong jiu within or without the IP is tantamount to whether the T3 collocation is within the tone sandhi domain. One way of disambiguating the possible parses is though embedding, as in (2.3-19d). This forces the preverbal NP (in this case wo3 "I") to be in the spec (embedded) IP position, and hence within the sandhi domain, consequently must undergo tone sandhi.

(2.3-21)



mother believes I (am) very fat.

2.3.6. INTERIM SUMMARY

The use of inter-correspondence accounts for cyclic effects, crucially capturing the insight of structure sensitivity. The locus of alternation is determined by asymmetries in the ranking of ICT constraints, in this case, crucially the dominance of INTF-HD over the general INTF. However, guarantee that tone sandhi does not overapply comes from the restriction of the markedness constraint to within a domain, i.e. the phonological phrase in the case of Mandarin tone sandhi. This brings forth the question of how phonological phrases are determined and is answered by syntax~prosody interface constraints proposed in Selkirk (1995) and Truckenbrodt (1999). Building on Truckenbrodt's WRAP family of constraints, I propose the use of WRAP-IP to partition the topic from IP/S that follows it, thus blocking of tone sandhi application across the topic boundary. Under this account of Xiamen and of Mandarin, cyclicity is simply the result of how two markedness constraints (tone sandhi triggering constraints and NON-RECURSIVITY) interact with syntax~prosody interface constraints. Cyclicity is therefore simply the result of having recursive phonological phrases that may be obtained only when NON-RECURSIVITY is dominated by ALIGN XP, R, ALIGN XP, L and WRAP.

To wrap up this section, the constraints and the ranking hierarchies relevant to the interface between prosody and syntax are given below.

(2.3-22) Constraints relevant to syntax~prosody interface[9]

ALIGN-XP, R (from Selkirk 1995)

For each XP, there is a P (phonological phrase) such that the right edge of the XP coincides with the right edge of P.

ALIGN-XP, L (from Selkirk 1995)

For each XP, there is a P (phonological phrase) such that the left edge of the XP coincides with the left edge of P.

WRAP-XP (from Truckenbrodt 1999)

Each XP is contained in a P.

WRAP-IP

Each IP is contained in a P.

NON-RECURSIVITY (from Truckenbrodt 1999)

Any two P that are not disjoint in extension are identical in extension.

(2.3-23)a. Ranking for Mandarin Prosody

ALIGN XP, R   ALIGN XP, L   WRAP IP

NON-RECURSIVITY

WRAP XP

b. Ranking for Xiamen Prosody (Only relevant constraints shown)

ALIGN XP, R

NON-RECURSIVITY

WRAP XP

---

[9] For an alternative treatment on the Mandarin prosodic structures, see Lin (2002).

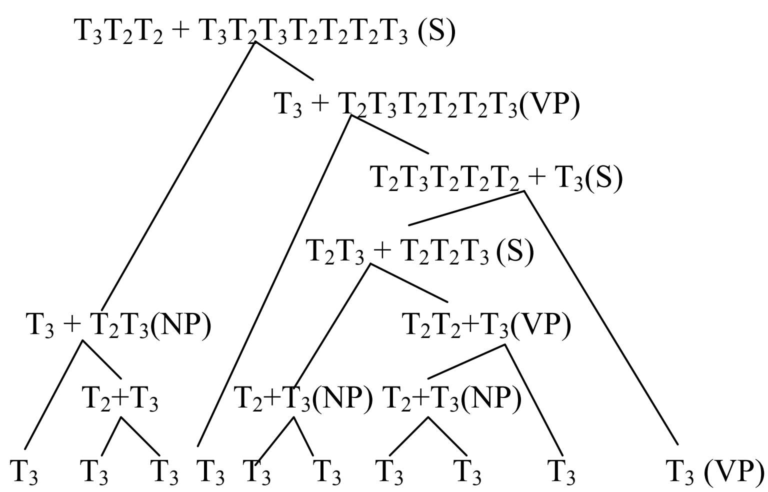
2.4. Prosody and prosodic structure

Having painted a fairly clear picture of Mandarin tonal alternations, this section returns to the matter on whether tone sandhi cycles on syntactic structures or on prosodic structures. Prima facie, the former seems more obvious, but earlier expositions have relied heavily on the assumption of the latter. Recall also the dilemma of whether Mandarin is iambic or trochaic given the contradictory suggestions of tone sandhi and neutralization.

2.4.1. Relevance of prosody for Mandarin tone sandhi

Kaisse (1985) believes that the tone sandhi rule simply cycles on the syntactic structure, which one may demonstrate with (2.4-1).

(2.4-1) A Complex Example[10]



Liu Zong-tong jiang Li Wu gan- jin zou hao.

Liu president say Li-Wu hurry-tight walk good

"President Liu says that LiWu is better off leaving quickly."

[10] I owe this example to Yan Xiuhong (p.c.).

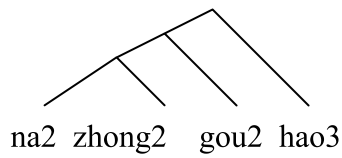
In (2.4-1) there is a series of ten T_3s. The phonetic realization of these tones is correctly predicted by simply cyclically applying (2.1-4) starting from the lowest constituents. At the root node, we have the subject NP with a T_3 at the right edge and a VP with a T_3 on the left edge. Here the two T_3s will be adjacent, and sandhi can apply again. Since the T_3 from the NP is the first of the two, it will change into T_2.

Liu (1980) differs from Kaisse in assuming that tone sandhi cycles on prosodic structure that is similar to the syntactic structure. Shih (1986, and 1997) agrees with Liu that tone sandhi cycles on prosodic structures. She departs from Liu and Kaisse in that for her, prosodic structures may or may not be identical to syntactic structures (See Selkirk 1984 as a standard reference to the relation between phonology and syntax). In Shih's proposal, for any given syntactic tree (such as those provided above) there is at least one prosodic structure that is identical to the syntactic structure. Other prosodic structures are also possible. I illustrate this with (2.4-2), adapted from Shih (1986). The numbers beside the syllable indicate the tonal category. Na3 'which' means na with T_3.

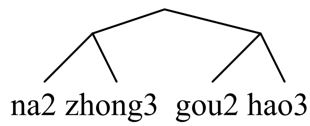
(2.4-2) na3 zhong3 gou3 hao3 → na2 zhong3 gou2 hao3
or na2 zhong2 gou2 hao3
which CL dog good
(means: which (breed of) dog is good?)

If Kaisse's view is to be taken strictly, the (2.4-2) must have two different syntactic structures, so as to explain the variation in tone sandhi. These two structures would look as follows.

(2.4-3) a.



b.



However, there is only one unique syntactic structure that corresponds to (2.4-2), and that structure is uniformly left-branching, i.e. (2.4-3a). If tone sandhi applies on prosodic structure, and that there may be more than one prosodic structure corresponding to a particular syntactic configuration (i.e. Shih's view), then the variation in (2.4-2) may be attributed to the prosodic structure being either (2.4-3a) or (2.4-3b). Cyclical application of (2.1-4) will thence produce different results.

An important point to note would be that with since Mandarin tone sandhi is regressive, prosodically recursively left-branching structures and flat binary foot structures yield different sandhi patterns. The former recursive structure produces counterbleeding effects while flat binary footing requires only odd-numbered syllables to undergo sandhi. Obviously also, uniformly right-branching structures and flat binary foot structures will produce identical sandhi patterns.

The relevance of prosody and the fact that tone sandhi in Mandarin is regressive warrant a discussion on the headedness of Mandarin prosody, itself an elusive topic. The difficulties surrounding the determination of the head in Mandarin prosody are already evident from the fact that in a disyllabic sequence neither the initial position (cf. third tone sandhi) nor the final position (cf. neutralization) is stable. Clearly then, an argument for the location of the prosodic head based on this would not lead anywhere. Without further ado, the following sub-sections present a discussion on the headedness of Mandarin prosody.

2.4.2. HEADLESS MANDARIN

A line of approach towards locating the head of Mandarin prosody, is to study the stress patterns and other phonetic effects of Mandarin. Presumably, prosodic heads carry stress, since heads are assigned grid marks for prominence eventually interpreted as stress (Hayes 1995:380). However, Mandarin stress is highly elusive, and speakers usually cannot feel stress in the language. There are also no pairs of words distinguishable by stress alone. While some have presented pairs consisting of neutral tones and full tones as evidence for stress in Mandarin (W. Li 1981 cited in Duanmu 2000), this is not convincing because their difference may be attributed to tone. As it is then, arguments constructed upon tonal stability may not be used to determine the location of prosodic heads, and Mandarin stress is so elusive that it may well be a stressless system, (a view held by researchers such as Gao and Shi 1963:68). Unable to determine the position of the prosodic head, one might be tempted to describe Mandarin prosody as headless.

2.4.3. MANDARIN PROSODY AS HEAD-FINAL

Despite the lack of clarity in the intuition of native speakers, Chao (1968:35) claims that the final syllable is stressed. Thus, if stress is taken to be indication of prosodic headship, then the prosodic head of Mandarin must be on the right. Wee (2000) further argues for this position by appealing to phonetic lengthening of the final syllable under emphasis (2.4-4).

(2.4-4) Under emphasis

> John is trying to tell Bill about a horse-drawn carriage and Bill who did not catch what John has said, requests for John to repeat.
>
> John says, "ma3 che1." (ma3che1 = horse-car 'horse-drawn carriage')
>
> Bill asks, "What did you just say?"
>
> John repeats, " ma3 **che1.**"

(2.4-4) parallels phonetic lengthening of English stressed syllables under emphasis. For example, if the situation in (2.4-4) were applied to the English word "banana", it is the second syllable that gets lengthened, yielding "banaaaaana". The second syllable in "banana" is the one that carries primary stress and is the head of the foot that contains it. By analogy, the second syllable of ma3che1 'horse-car (horse-drawn carriage)' is the head of the prosodic constituent that contains it. It is important to note that Wee's argument rests on the correlation between headship and the possibility of phonetic lengthening. It does not mean that heads must be phonetically longer.

Wee (2000) notes two instances where the final syllable does not undergo phonetic lengthening – (i) where the final syllable has a neutral tone and (ii) where contrastive focus is being applied to some other syllable. These instances are given below.

(2.4-5) Emphasis involving neutral tone

John is trying to tell Bill about a box and Bill, who did not catch what John had said, requests for John to repeat.

John says, "he2zi0" (he2zi0 = 'box')

Bill asks, "What did you just say?"

John repeats, "**he2**zi0 "[11]

(2.4-6) Contrastive focus

bu2 shi4 **qi4** che1, shi4 **ma3** che1.

NEG is motor-car, is horse car.

Not the car, the carriage.

(2.4-5) and (2.4-6) in an oblique way instantiate Wee's (2000) claim that the prosodic head must be on the right because it shows that phonetic lengthening by default can only apply to the syllable on the right it unless affected by factors such as neutralization[12] and contrastive focus. Wee took pains to further argue for his position by providing a list of disyllabic compounds to show that right-headedness is clearly prosodic and not semantic nor syntactic since many of these compounds have both elements belonging to the same syntactic or semantic category. This is given in (2.4-7), with syllables that allow phonetic lengthening is given in boldface.

[11] *zi0* is a toneless morpheme, it is not the result of neutralization.

[12] A syllable that has a neutral tone has a shorter articulation time and its surface tone is dependent on the syllable preceding it. This dependency may arguably explain why it cannot be lengthened.

(2.4-7)

Mandarin compounds	Gloss	Meaning
dian4**deng1**	electric light	Lamp
da4**ma2**	marijuana	marijuana
duo1**shao3**	more less	how much
mei3**li4**	beautiful beautiful	beautiful

Other than the possibility of final lengthening, Wee (2000) cites two other phenomena that favor the assumption of Mandarin as being right-headed – (i) meter from Tang poetry (cf. Chapter 1.4) and (ii) stability of the final tone in the nominal reduplication found in lesser variants of Mandarin.

First, consider Tang poetry, a literary form that was extremely popular in the Tang dynasty (618-907) with many modern poets still producing poetry of this genre. In the strictest form of Tang poetry, there are 4 lines of equal length to a stanza. Two lines form a couplet. Each line contains 5 or 7 syllables. (See Chen 1979, Wang 1979 and references therein for detailed analyses.) Not all lines in Tang poetry are well-formed. An important rule in forming lines relates to the tonal category of the even-numbered syllables. (2.4-8) exemplifies this with a line of seven syllables.

(2.4-8) $(\sigma_1\ \sigma_2)\ (\sigma_3\ \sigma_4)\ (\sigma_5\ \sigma_6)\ \sigma_7$

$\quad\quad\ \ T_a \quad\quad\ \ T_b \quad\quad\ \ T_a$

For the purposes of Tang poetry, tones are divided into two categories, even (E) and oblique (O). The first and second tones of Mandarin, T_1 and T_2, are considered to belong to the category E and the third and fourth tones, T_3 and T_4, belong to the category O. Their classification has historical origins irrelevant to our discussion. In Tang poetry, the odd-numbered syllables have a fairly large degree of freedom as to what tone they may bear. The even-numbered syllables however have to contrast, i.e. σ_2 must have a different tonal category as σ_4 and σ_4 must have a different tonal category as σ_6. Since there are only two categories, σ_6 will be the same as σ_2. In fact, a common rule of thumb found in old textbooks of Tang poetry states this generalization (though Wang 1979 warns that this generalization is no more than a useful mnemonic guide).

(2.4-9) yi1, san1, wu3 bu2 lun4, er4, si4, liu4 fen1 ming2.

One, three, five NEG discuss, two, four, six, divide clear.

The first, third and fifth (syllables) do not matter; the second, fourth and sixth (syllables) clearly contrasted.

The standard analysis of Tang poetry meter (again see Chen 1979 and references therein) is that each line is parsed into binary feet with the last syllable extrametrical. The feet are right-headed. Together with a principle that dictates the contrast of adjacent feet, the pattern in (2.4-8) is obtained.

It is conceivable that given a string like (2.4-8), one may construct trochaic feet with the first syllable being extrametrical. This line of attack is infeasible because:

(2.4-10) i. The last syllable is arguably not part of any foot since syllables in the same foot in the poem generally belongs to the same tonal category. Hence, syllable 1 and 2 are both of the same tonal category under default circumstances. They may disagree only if to save a violation of a higher rule in the poetics or when the poet desires to mark the line. The seventh syllable does not exhibit any such dependency on an adjacent syllable.

ii. The first syllable exhibits extreme dependency on the second syllable with respect to the amount of freedom it has as to what tone it may bear. If the second syllable is an O category tone, the first is usually O, though E is sometimes used. When the second syllable is an E category tone, the first syllable must be E unless the third is also an E. The dependency of the first syllable on the second strongly suggests that these two syllables belong to the same constituent.

It is to the iambic nature of Tang poetry that Wee (2000) appeals to for support in his claim that prosodic head of Mandarin is on the right.

Moving on to nominal reduplication in lesser variants of Mandarin, Wee (2000) noted that there is final tone stability. Among the Chinese community in Malaysia and Singapore (also among some Taiwanese people), pet forms of Mandarin names are obtained by making a copy of the final syllable of the first name. Hence a name such as "Chen Xiaoqiang" will become "qiangqiang". (Chinese names of the Han ethnicity typically have two or three syllables. The first syllable is the family name, though there are some disyllabic family names too. The remaining syllables are the first name.) Curiously, tone sandhi occurs with the second and third tones when under such reduplication.

(2.4-11)	a.	RED + T1	→	T1T1
	b.	RED + T2	→	T3T2
	c.	RED + T3	→	T2T3
	d.	RED + T4	→	T4T4

Notice that in all the cases above, it is the syllable on the right that bears the tone of the base. If there were any changes, it is the syllable on the left that changes.

It is unclear why there is sandhi involving T2 but not T1 or T4. One might speculate that it might be that low tones trigger sandhi, since both the second tone and the third tone starts with a low tone. Cheng (1968), cited in Shih (1997), reports that the third tone sandhi applies to a T3 before an English unstressed syllable, which is always read with a low pitch. T3 remains unchanged if it precedes a stressed syllable. Stressed syllables are read with a high pitch.

(2.4-12)	a.	hao2 professor	'good professor'
	b.	hao3 student	'good student'

In (2.4-12a), hao3 'good', with an underlying T3, undergoes sandhi to become T2 when it precedes an unstressed syllable. With the lack of alternation in (2.4-12b), this suggests that among all the properties that trigger sandhi, the relevant element would be the presence of a low tone.

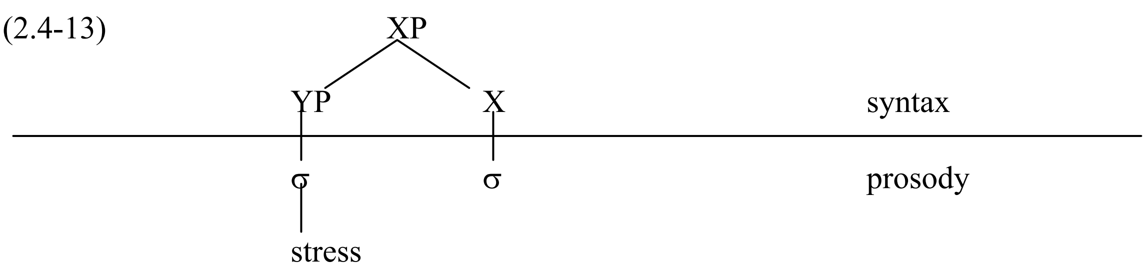
Neither poetic meter nor nominal reduplication argues conclusively for right-headedness. There is no a priori requirement that poetic meter must match linguistic prosody, as is evident from the mismatch between the iambic Shakespearean sonnets and the trochaic stress patterns of English (Chomsky and Halle 1968, Hayes 1995 especially p.88, Pater 1995 among many others). Likewise, there is no guarantee that variants of Mandarin match standard Mandarin in prosody. However, they do show an asymmetry that favors the element on the right. Such asymmetries support the idea that the prosody is right-headed.

2.4.4. Other head possibilities of Mandarin prosody

Wee's (2000) strongest claim to right-headedness thus resides in the possibility of phonetic lengthening on final syllables. This is not to be confused with arguments for right-headedness that say something to the effect of "final syllables are phonetically longer, and hence are heads" (for example, Chao 1968, Xu 1980 which may be supported by phonetic studies such as Lin, Yan and Sun 1984 and Yan and Lin 1988). Duanmu (2000) discounts the latter argument by citing three different studies. Firstly, Yan and Lin (1988) (cited in Duanmu 2000, not available to the author) found that although the final syllable has the greatest length, it is the initial syllable that has the greatest pitch range. Secondly, Yang (1992) shows that when words are read in isolation, despite the fact that the last syllable has the longest rhyme duration, the first syllable had the longest onset duration, the greatest amplitude and the highest F-0 peaks. Finally, Wang and Wang (1993) showed that given a target word, it is the initial syllable, not the final syllable, that has the longest duration, when the target word is read in a carrier sentence. In any case, Wee's argument apparently still stands, quite simply because it does not claim that final syllables are phonetically longer; it claims that final syllables can be lengthened.

But Wee's argument is but one argument for right-headedness - that is not convincing enough. Since a case cannot be convincingly made for no prosodic heads in Mandarin or for right-headedness in Mandarin prosody, a natural question to ask would be if a case could be made for left-headedness of Mandarin prosody. Duanmu (2000:pp.136ff) presents a hypothesis along this line. Essentially, his claim is that Mandarin prosody is trochaic, and that syntactic non-heads carry stress (see non-head stress in Cinque 1993). Thus,

(2.4-13)



Duanmu claims seven pieces of evidence in support of his idea. However, out of these seven, five pertain to the idea that stress exists in Mandarin, only two support the idea that prosody in Mandarin is trochaic. These two are, firstly the location of weak syllables and secondly, the restrictions on word length.

By the location of weak syllables, Duanmu alludes to the fact that neutral tones never occur at the initial position of a disyllabic sequence. However, this in itself is not convincing because one cannot be sure if the effect is due to a trochaic prosody or to some tone-reducing morphological suffixation. Also, by the same argument of tonal stability, third tone sandhi would argue for the opposite position. Thus, to repeat, tonal stability is not going to resolve the issue.

Moving on to the second piece of Duanmu's evidence which is the restriction of word length, consider the following pairs of synonyms and their collocations (data from Duanmu 2000:pp.140f), paying special attention to the syllabic length of the verb.

(2.4-14)	a.	i.	zhong	'plant'
		ii.	zhong-zhi	
	b.	i.	suan	'garlic'
		ii.	da-suan	
	c.	i.	zhong suan	'plant garlic'
		ii.	zhong da-suan	
		iii.*	zhong-zhi suan	
		iv.	zhong-zhi da-suan	

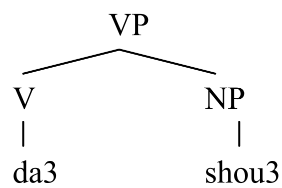
Notice that in (2.4-14), combination of the verb zhong or zhong-zhi 'plant' and the NP suan or da-suan 'garlic' to form a VP is possible except for (2.4-14ciii) when the verb is disyllabic and the object NP is monosyllabic. There is a restriction on the length of the verb. Duanmu's hypothesis provides an explanation to this by appealing to the weight-to-stress principle (Prince 1990). This principle would require that stress be assigned to the disyllabic V in (2.4-14ciii). However, the V is the syntactic head and the NP is the non-head, it follows the non-head stress hypothesis require the NP to be stressed. Stressing the NP would not be consistent with the weight-to-stress principle. This contradiction is Duanmu's explanation for the word length restriction. Since there are only two pieces of evidence for a trochaic claim, there is as little evidence for this position as there is for Mandarin being iambic.

Before discarding the idea that Mandarin is trochaic, it bears noting that in relation to the Mandarin third tone sandhi and neutralization, a trochaic claim, with or without appeal to the non-head stress requirement, appears to provide a handle for a unified analysis for the two phenomena. With neutralization, it is fairly straightforward - the non-initial syllables are unstressed and hence do not carry tones. With third tone sandhi, one may appeal to de Lacy's (1999, 2003) hypothesis that Designated Terminal Elements (DTE) (as did Yip 2002: Chapter 7), i.e. prosodic heads, must avoid low tones. Recall that T3 in Mandarin is arguably a low tone [L] (cf (2.1-1) and (2.1-2)). If Mandarin were trochaic, then in a T3T3 sequence, the first T3 would not be consistent with the requirement that DTEs must not have a low tone. To fulfill this requirement, one might envisage the insertion of a high tone [H] to the initial T3, changing it to a rising tone, which is T2. However, this approach will ultimately fail because by the same token, T3T1 sequences would be predicted to undergo tone sandhi, contrary to fact.

Even if one puts the absence of tone sandhi with T3T1 sequences aside, there are other problems with adopting Duanmu's idea for treat T3 sandhi. Zooming in to

Duanmu's theory that (i) non-syntactic heads are stressed and that (ii) trochees are built rightward, consider a disyllabic VP, such as the one below.

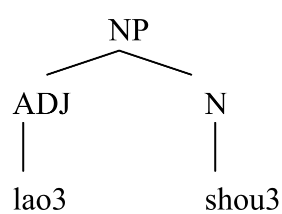
(2.4-15)



'hit hand'

By the non-head stress requirement, the NP should be stressed. However, by the requirement that trochees are built rightwards, the V should be stressed. Duanmu does not provide a way of resolving this. In any case, resolution by prioritizing one requirement over the other will only yield inconsistency in the location of the stressed syllable – iambic in some configurations and trochaic in others. This is exemplified below.

(2.4-16)



'old hand'

The syntactic head in (2.4-16) is the N. In this case, both Duanmu's requirements would place stress on the first syllable. Now if the trochaic requirement has priority, the non-head stress requirement would be redundant. This in turn creates trouble for Duanmu's observation on the restriction of word length (cf. (2.4-14)). On a different take, the prioritization of the non-head stress requirement would never yield a consistent trochee or iamb for both cases. This mixed situation is not desirable since the locus of tone sandhi and of neutralization is fairly stable. In a disyllabic sequence, tone sandhi always applies to the initial syllable and neutralization to the final syllable. It therefore appears that whether or not one buys Duanmu's treatment of Mandarin prosody, a trochaic assumption would find one caught in a tug-of-war.

Needless to say, any approach with mixed-headedness for Mandarin prosody will render prosody inapplicable to treating Mandarin tone sandhi or neutralization. By this token, Yip's (1980:147ff, esp 155) idea that Mandarin is trochaic when the structures are left-branching and iambic when right-branching, whether right or wrong, would simply have no bearing on the Mandarin situation at hand. This matter will finally receive treatment in Chapter 4.

2.5. Tonological matters of Mandarin Tone Sandhi

The ICT account for cyclic effects of Mandarin tone sandhi is in disagreement with those given Duanmu (2000) and Yip (2002). Duanmu and Yip assume that Mandarin is left-headed, while the solution proposed in the preceding sections assume that Mandarin is right-headed. In this respect, the motivations behind the tonal alternation differ. The solution to Mandarin tone sandhi in this chapter is thus in tonological disagreement with Duanmu and Yip.

With a left-headed approach, alternation must be due to satisfaction of a markedness constraint on heads. In such an approach, the initial T3, being L, is treated to be marked under the constraint that heads must have a high tone (De Lacy 1999, 2003). The right element which is a non-head under this analysis simply stays as it is. Under this analysis, it is immaterial if T3 is left-adjacent to any tone. As long as it is on the left, then it is the head, and consequently wants to acquire a H tone, making it to a rising contour. However, in Mandarin, T3 only alternates when left adjacent to another T3. While it may be possible to postulate additional devices to ensure that T3 does not alternate in any other condition except when with another T3, it does seem to miss the point. After all, the strongest piece of evidence that points to left-headedness is that the locus of neutralization is on the right element.

With a right-headed approach, the main idea is that the right element remains faithful by virtue of being the head. The left element is thus the one that alternates due to there being a marked collocation of tones (i.e. the OCP against adjacent T3 tones, but not others possibly due to ranking hierarchies of the kind: Special markedness » Faithfulness » General Markedness). This offers a natural account to why only T3 adjacency triggers alternation. All other collocations do not trigger alternation. In chapter 3, Tianjin provides additional support for this position. In Tianjin, tone sandhi is essentially triggered by OCP, which includes adjacency of L, R and F tones. In fact, the set of Tianjin tone sandhi rules is a superset of the Mandarin T3 sandhi rule. It is clearly desirable that two languages so similar in pattern should be analyzed in fundamentally the same way, rather than to have radically different accounts. However, I hasten to add that a right-headedness approach encounters challenges from neutralization. This is not impossible to circumvent, and shall be addressed later. Having said all the above, I believe that the correct reason behind tone sandhi in Mandarin lies in the OCP rather than a markedness requirement on heads.

2.6. Summary

This chapter is dedicated to the treatment of cyclicity through the use of ICT. Essentially, it is the recursive nature of structures that gives rise to cyclical effects, and for that matter other effects of repetitive rule applications such as that found in Xiamen tone sandhi. The chapter began with a detailed introduction of Mandarin, though only the tone sandhi is intimate to this chapter's focus. This was followed by an exploration on the nature of Mandarin prosody, laying the groundwork for understanding the asymmetry in decision when deciding which of the two adjacent third tones undergoes alternation. Though there is a lack of consensus of the location of the prosodic head, it is assumed here that Mandarin is right-headed, thus ex hypothesis, modification to the left constituent every time tone sandhi is triggered by an OCP against T3. The structure upon which tone sandhi cycles, is determined by a set of interface constraints between morphosyntax and phonology.

In the next chapter, ICT will be extended to cover a case of directionality, which like cyclicity, is repetitive rule application (to borrow convenient derivational terminology). The challenge offered by directionality is that it does not obviously relate to morphosyntactic structures, which are hierarchical, consequently potentially recursive. Directional effects appear to work linearly which confront the appeal to hierarchies so dear to ICT.

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

♠ This chapter had been reliant on the research supported by the Strategic Research Grant (Project No 7000990) and the Competitive Earmarked Research Grant (Project No 9040554) from the City University of Hong Kong. I am indebted to Matthew Chen, the principal investigator of this project, for permission to use data and recordings of Tianjin and Changting Hakka from these projects.

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 → T' / ___ T
where T is underlying and T' is sandhied.

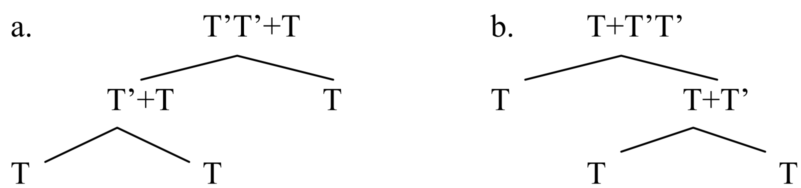
b.

```
   T + T'
  /    \
 T      T
```

T → 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

---

[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.

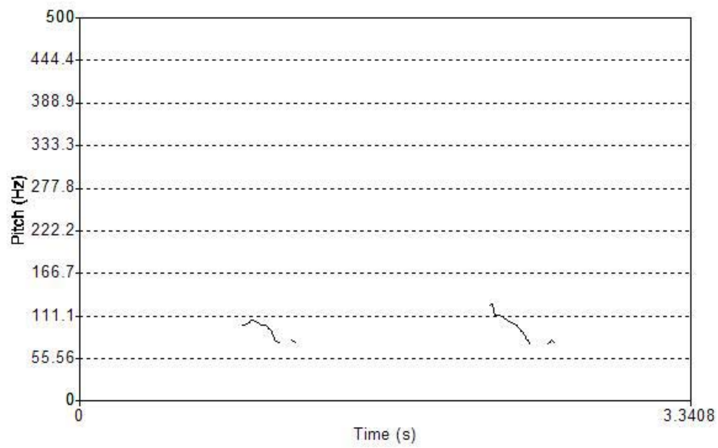
(3.1-1) Tones in Tianjin

	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)

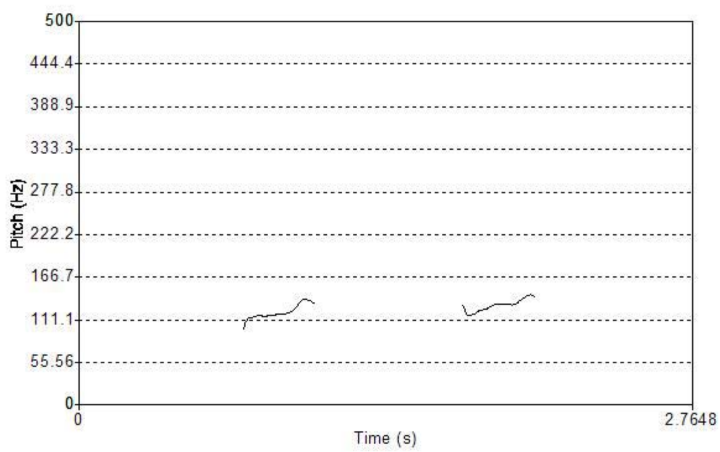
Like Mandarin, there is some discrepancy in the pitch value description of the T3. Chen (2000) bases the description on the experimental evidence of Shi (1990), and is hence quite reliable. Nonetheless, I follow the footsteps of Shih (1988) and offer the following pitch tracks, leaving it to the reader 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

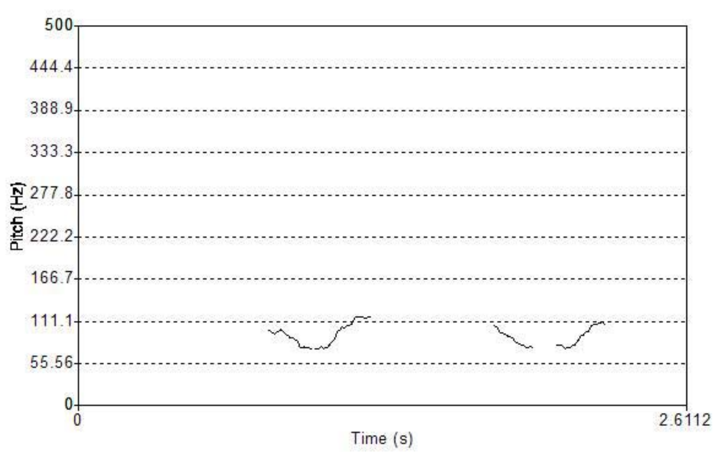
a. ma1 'mother'



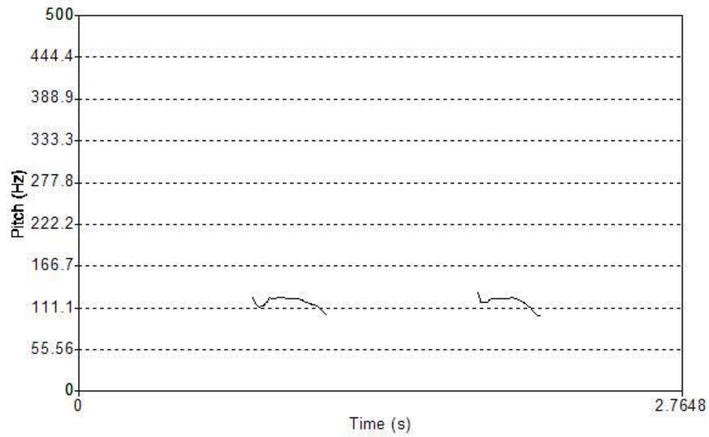
b. ma2 'hemp'



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).

---

[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'

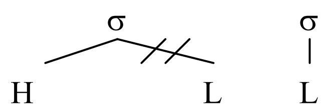
---

[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.

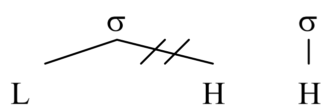
[5] This was communicated to me by Yan Xiuhong when we both assisted Matthew Chen in his research project on directionality at the City University of Hong Kong.

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 → T2 / T1, one may make the following observations.

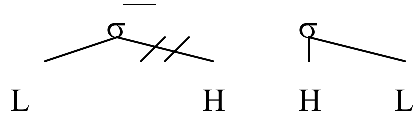
(3.1-6) a. F → H / __ L



b. R → L / __ H



c. R → 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) ← OCP[TC] applies here

tone feature tone feature (=h or l) ← 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

Input	R	R	R		L	L	L		F	L	L
TS at initial substring	H	|			R	|			H	|	
TS as final substring		H				R				R	
Result	H	H	R		R	R	L		H	R	L

b. Final substring first

Input	R	R	R		L	L	L		F	L	L
TS as final substring	|	H				R				R	
TS at initial substring	|										
Result	L	H	R		L	R	L		F	R	L

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].

---

[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/ $\rightarrow$ 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/ → [FLH] ([HLH] is another option)

b. /F**L**H/ → [HLH] (but never [FLH])

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

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

b. /F**F**H/ → [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. /$\underline{\text{RR}}$F/ (left to right)
↓
H$\underline{\text{RF}}$
↓
HLF

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

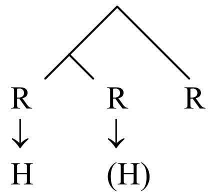
As far as I can tell the ambidexterity of these cases are not reducible to the interaction of the effects given from section 3.2.1 to section 3.2.5.

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

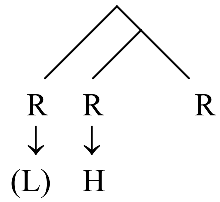
3.2.7. SYNTACTIC BLOCKING

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.p^{h}iŋ	ɕin.tɕia.p^{h}o
Step 1	Onset deletion	mau.ə.tuŋ	təŋ.au.p^{h}iŋ	ɕin.a.p^{h}o
Step 2	Schwa erasure	mau.__.tuŋ	-	-
Step 3	Coda deletion	mau.__tuŋ	tə.au.p^{h}iŋ	ɕi.a.p^{h}o
Step 4	Syllabification	mau.tuŋ	-	ɕia.p^{h}o
Step 5	Lax	-	tə.ɔ.p^{h}iŋ	-
	Output	ma.tuŋ	tə.ɔ.p^{h}iŋ	ɕia.p^{h}o

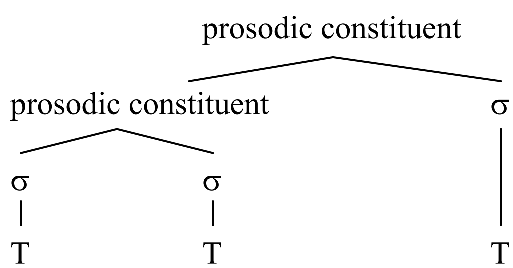
As may be seen in (3.3-6), the deletion of the medial onset and the initial nasal rime suggests certain proximity between the initial and the medial syllable. It is as if these two syllables are grouped together in the attempt to contract the trisyllabic sequence, presumably to make a disyllabic foot 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

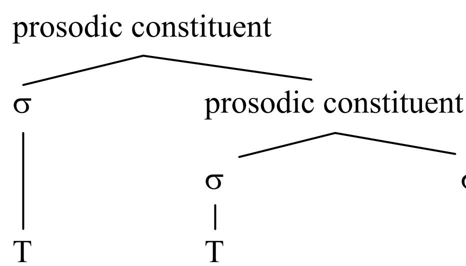


(3.3-7) does not make a claim if the tone-bearing unit is a syllable or something else. Instead, it serves merely to notate tonal association. This prosodic structure may be

[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.

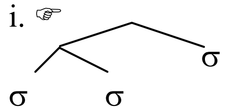
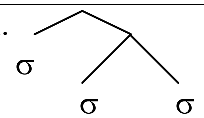
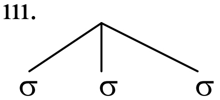
(3.3-9) Prosodic constraints active in Tianjin

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.

[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.

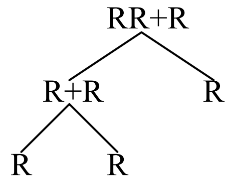
Consider now an input /RRR/ and the following (partial) set of candidates generated under inter-tier correspondence.

[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.

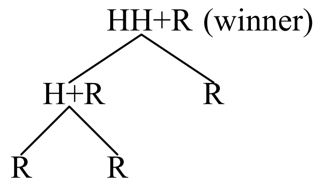
[19] Tianjin is assumed to be right-headed.

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

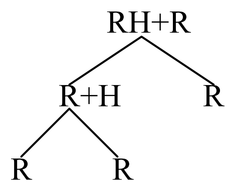
i.



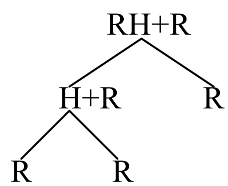
ii.



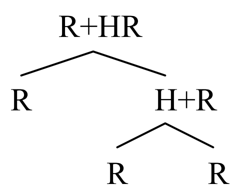
iii.



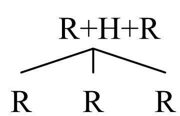
iv.



v.



vi.



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

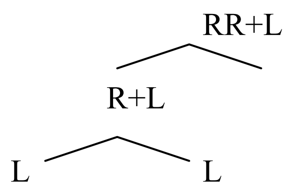
(3.4-3) Getting /RRR/ → HHR

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

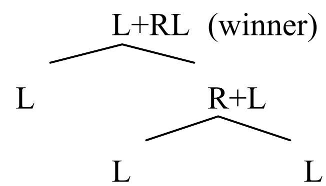
The applicability of ICT in (3.4-3) comes as little surprise. The more interesting case is to apply to /LLL/ and see if one still has a consistent ranking hierarchy. To this end, consider the following candidates generated from an input /LLL/.

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

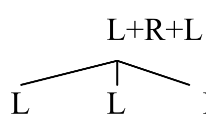
i.



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

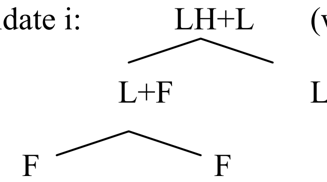
BINARY; WF-D INTF-HD

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

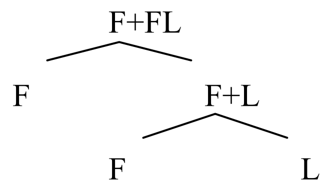
(3.4-9) P1: /FFL/ → [LFL]

Candidate i:

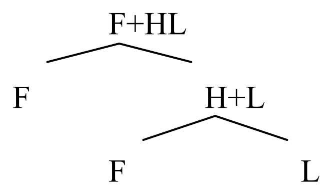


(winner)

Candidate ii:



Candidate iii:

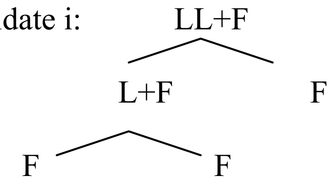


/FFL/ candidate	WF-D	WF-A	ALIGN LT	INTF
☞ i.			**	*
ii.	*!	*	***	
iii.			***!	*

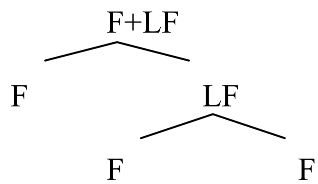
In (3.4-9) above, the difference between candidate (ii) and candidate (iii) is that the latter has an unfaithful percolation between the terminal nodes and the intermediate node. Candidate (iii) does not incur a violation of WF-A as WF-A is a root effective (only) constraint. Essentially, default left-branching 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]

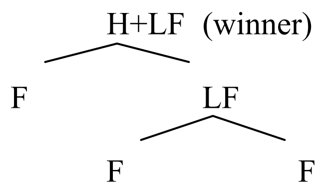
Candidate i:



Candidate ii:



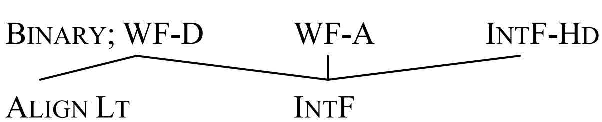
Candidate iii:



/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



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: RR+L

R+L L

R L

Candidate ii: H+RL (winner)

R RL

L L

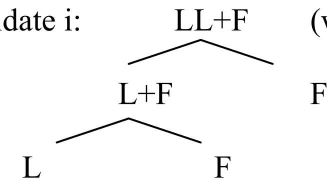
/RLL/ candidate	WF-D	Align Lt	IntF
i.	*!	**	**
☞ ii.		***	*

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.

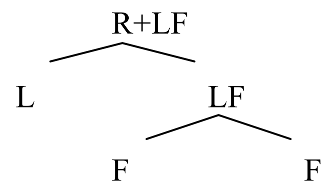
Now for P6 /LFF/ → [RLF], which case is exactly similar to P5.

(3.4-13) P6: /LFF/ → [RLF]

Candidate i: (winner)



Candidate ii:

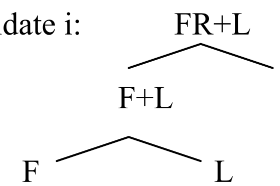


/LFF/ candidate	WF-D	ALIGN LT	INTF
i.	*!	**	**
☞ ii.		***	**

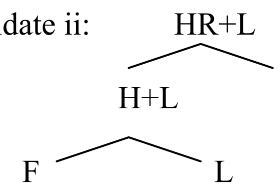
P7 /FLL/ → [FRL] is not difficult either, as it is the mirror of P1 (see (3.4-9) above), although with a curious twist.

(3.4-14) P7: /FLL/ → [FRL]

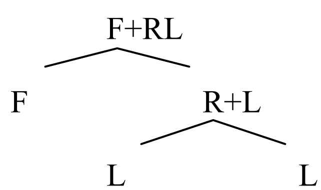
Candidate i: (winner)



Candidate ii:



Candidate iii:



/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

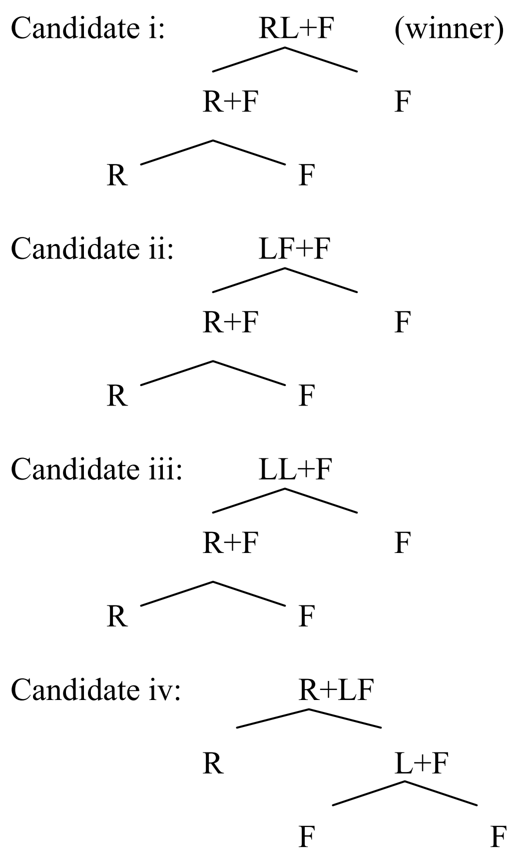
R RF

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 $\rightarrow$ L; L $\rightarrow$ R; R $\rightarrow$ 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.)

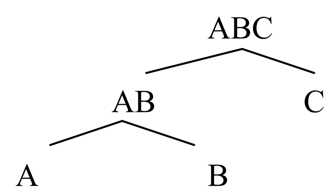
(3.4-19) Final Substring Satisfaction

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

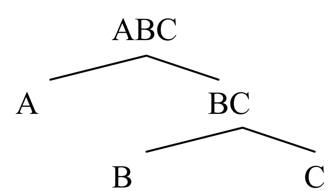
With (3.2-18), the explanation is straightforward. Emphasis is prosodically prominent, thus making any element that receives it a prosodic head. Heads are stable, and thus are exempt from tone sandhi. Because Tianjin ditonal sandhi is regressive, it follows that if “x” is head, then any element preceding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

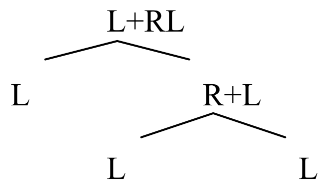
It does seem that ICT is capable of handling the bulk of the problems presented in Tianjin without many assumptions beyond that already needed for an account of Mandarin in Chapter Two. As such, considering ICT as a candidate for a unified account of iterative rule application (cyclical or directional)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

3.5. From the root to the leaves

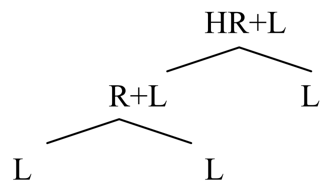
Thus far, in dealing with Tianjin, the chapter has alluded to a convenient version of WF-D and WF-A, defined in such a way that given some tone A, tone A may not alternate to tone C if such an alternation require an intermediary tone B. For example, given the way WF-D is defined, a tone like L may become 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/ → <u>DB</u>C → D<u>EC</u> → <u>FE</u>C)

Case 2: consistent target (i.e. /ABC/ → <u>AD</u>C → A<u>EC</u>)

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

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

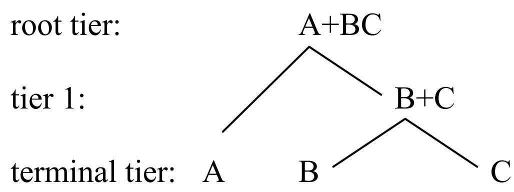
Legend: ✓ - allows; ✗ - disallows

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)



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

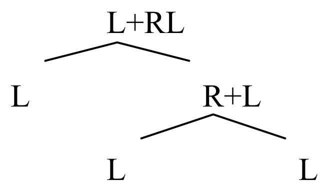
Given what has been presented on Tianjin, all three possibilities are attested. We have seen in Tianjin tritonal sequences cases belonging to (i), (ii) and (iii). Moving Window allows for such a possibility too without offering an explanation for the correlation between structures and the order of which 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.

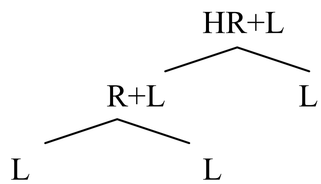
(3.5-6) Incorporating the One-Step Principle (cf. (3.5-1))

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	huang.dou	gong.lu
	'courtesy'	'soy bean'	'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"

R$\underline{\text{ML}}$
↓
$\underline{\text{RL}}$L
↓
R$\underline{\text{FL}}$
↓↓
* RRF (unattested derivation of /RML/)

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

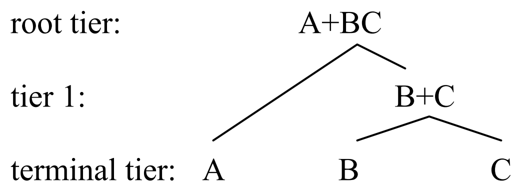
b. Failure of No Backtracking

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)



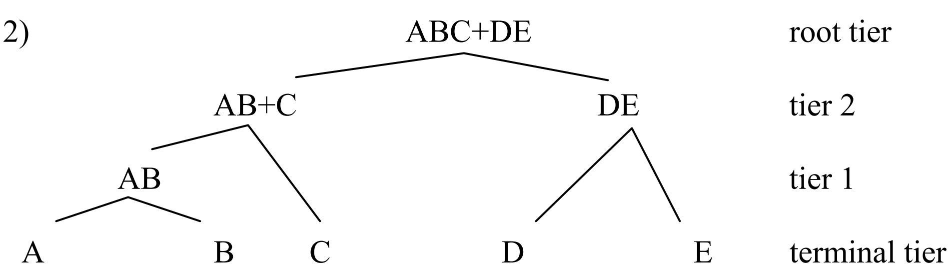
With this in mind, I propose the following constraint that will replace the OSP.

(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)



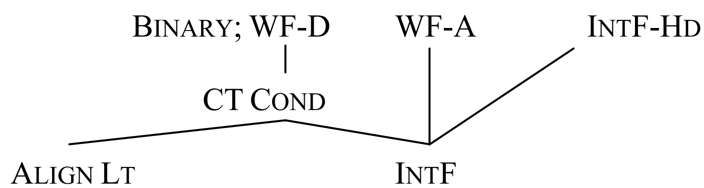
In (3.5-12), at tier 1, AB and DE are collocations that will be evaluated such that if any of these four elements do not correspond with the terminal tier, there is no violation of the CT COND. Moving on to tier 2, any unfaithful correspondence in A between tier 1 and tier 2 would constitute a violation 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 $R \rightarrow F / R \_\_$
FL rule $F \rightarrow L / F \_\_$

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.

Chapter Four

TONE NEUTRALIZATION, SANDHI SUSPENSION AND SELECTION

Previous chapters were devoted to expounding the tenets of inter-tier correspondence theory (ICT) and its usefulness in dealing with phenomena typically understood as iterative application of a set of rules. Nonetheless, a few questions remained unaddressed. Firstly, there is some need to compare the two main languages discussed (Mandarin and Tianjin), since tone sandhi in both languages are triggered by the OCP, with faithfulness to the identity of the right-edged tone. Chapters Two and Three assume that these languages are right-headed, thence the stability of the right-edged tone under sandhi. It remains to be seen if this position is viable when taking into consideration the fact that tone neutralization happens to the rightmost syllable (see Chapter Two, on Mandarin neutral tones).

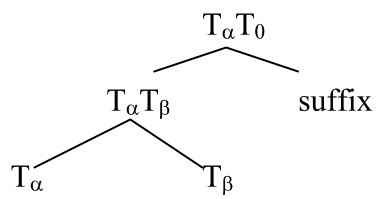
Secondly, Tianjin absorption clearly applies after dissimilation tone sandhi and applies in a once-and-for-all manner, which is acyclic. Why would Tianjin tolerate apparently marked environments manufactured by absorption? Finally, there is the matter on the selection of tones. The preceding chapters have not provided any account on how a given tone is mapped to another under alternation. Specifically, why did T3 $\rightarrow$ T2 in Mandarin, why did F $\rightarrow$ L, L $\rightarrow$ R and R $\rightarrow$ H in Tianjin dissimilation, but F $\rightarrow$ H and R $\rightarrow$ L in Tianjin absorption? This chapter shall be devoted to these residual questions. Section 4.1 begins with an explanation of Mandarin neutralization's compatibility with prosodic right-headedness, assuming that neutralization is triggered by suffixation. Section 4.2 goes on to support the right-headedness assumption by citing the parallels between Tianjin and Mandarin tone sandhi rules. Section 4.3 accounts for why Tianjin tolerates marked collocations generated by absorption by appeal to phonetic evidence that the sandhi triggering collocation is only apparent. Section 4.4 is a treatment of tone selection in Tianjin and Mandarin, essentially explaining that adjacency of identical tones is what prompts the mapping between underlying tones and sandhied ones. Section 4.5 appeals to the compatibility of comparative markedness theory and inter-tier correspondence so as to expand the account of tone selection to include larger structures. Section 4.6 explains that the Mandarin third tone, whether construed as low or dipping, requires no further assumptions because under both conceptions do sandhi application do not generate adjacent identical tone features. The chapter ends with a summary.

4.1. Mandarin neutralization

Recall that INTF-HD (with the further assumption that Mandarin and Tianjin are right-headed) was postulated in Chapter Two so that the stability of the final tone in Mandarin tone sandhi may be expressed. Apparently, a more direct approach might have simply been to assume a constraint such as INTF-R(ight) so that the rightmost element must percolate faithfully. The discomfort of postulating INTF-R, especially in the light of Nelson (1998), is that faithfulness to the rightmost element should be reduced to faithfulness to a head position. In fact, Nelson argues that constraints such as ANCHOR RIGHT (which in effect is the same as positional faithfulness to the rightmost element) is (i) not widely attested in reduplicated and/or truncated forms, (ii) pathological in predictions in that it would wrongly allow for a system that "anchors to the right edge of the base rather than to the stressed syllable, when the two qualities are not compatible" and (iii) unnecessary because effects of this constraint is attributable to other independently motivated constraints such as anchoring to the prosodic head.

This section argues that neutralization of the tone on the right edge can remain compatible with a right-headedness assumption. The essential idea is that neutralization on the rightmost tone happens because of suffixation of a tone reducing morpheme. This is illustrated in the following diagram.

(4.1-1)



Legend: T_α and T_β - tones
T_0 - neutral tone

The main idea in (4.1-1) is that if suffixation of a tone neutralizing morpheme happens at the root node, then tone sandhi may take place at lower nodes. This will produce the counterbleeding ordering effect found in the interaction between Mandarin tone sandhi and neutralization. Treatments along the lines of (4.1-1) allow for right-headedness (in this case T_β) that eventually gets neutralized (especially with CT COND, cf. Chapter 3: (3.5-11)).

If T_β is the head, then given a situation such as (4.1-1) where there is a tone reducing suffix, it would appear on the surface that the head is neutralized. I suspect it is this that is the cause for the controversy between whether Mandarin is prosodically right-headed or left-headed. Since the main thrust of the left-headed argument lies in neutralization, accounts along (4.1-1) resolves that controversy in favor of the right-headed camp. The appeal behind (4.1-1) is that the null suffix would have little bearing on the prosody (because it is null), but yet the interleaving between morphology and phonology would produce exactly the effect of the prosodic head appearing to be neutralized.

The crux of the challenge that underlies Mandarin neutralization is the combination of two things - firstly, the counterbleeding order of tone sandhi application prior to neutralization and secondly, the absence of tone sandhi under some cases. To refresh our memories, here are the key examples, repeated from Chapter 2: section 2.

(4.1-2) With tone sandhi

a.	i. da2shou3 /da3shou3/	'hit hand'	verb phrase
	ii. da2shou0	'bouncer, fighter'	noun
b.	i. zou2zou3 /zou3zou3/	'walk (emphatic)'	
	ii. zou2zou0	'take a short walk'	

(4.1-3) Without tone sandhi

a.	jie3jie0	'sister'
b.	nai3nai0	'granny'
c.	bao3bao0	'baby'
d.	gou3gou0	'doggie'

The most evident question in view of the above data is why tone sandhi occurs in (4.1-2) but not (4.1-3). A straightforward reply would be that in the reduplication of familiar terms such as (4.1-3), tones are not copied, thereby having no sandhi-triggering environment. As far as I can tell, this generalization appears to be correct and I shall state it as follows.

(4.1-4) Generalization on Mandarin familiar reduplication

Reduplication of familiar/familial terms in Mandarin does not involve copying of the base tone.

With (4.1-4), the neutral tones in (4.1-3) are really not the result of neutralizing an existent tone. The rightmost tone is in this case not there to begin with as it is not copied from the base. The next question would be how to capture the counterbleeding ordering effect in (4.1-2). After all, neutralization does bleed the sandhi-triggering environment by removing the T3 on the right. The solution to this is (4.1-1). Neutralization is assumed to be the result of suffixation of a tone reducing morpheme. Within the inter-tier correspondence framework, this would be perfectly compatible with a right-headed assumption. The following diagram exemplifies this.

(4.1-5)

da2shou0 'bouncer/fighter'

da2shou3 tone reducing suffix

da3 shou3

(4.1-5) shows how within ICT, the counterbleeding effect can be effectively captured by the same mechanism that accounted for the counterbleeding effect of left branching T3 sequences (cf. Chapter Two). All that remains is to see if there is any independent reason to believe that a tone reducing suffix is indeed present or if that assumption is merely a matter of convenience so that Mandarin may be assumed to be prosodically right-headed.

Examples like da2shou3 ‘bouncer/fighter’ suggest that there is some affixation of a null morpheme that lexicalizes what is otherwise a verb phrase. In fact, when one consults the list of examples cited as neutralization, it becomes clearer that some morphological processes are at work. Below is a sample list, repeated from Chapter Two (2.1-7).

(4.1-6) Examples of neutralization (data from Zhang 1977)

a.	i. sheng1xing4	‘nature of character’	noun
	ii. sheng1xing0	‘untamed’	adjective
b.	i. zhang4ren2	‘sir’	noun
	ii. zhang4ren0	‘father-in-law’	noun
c.	i. di3xia4	‘underneath’	adjective
	ii. di3xia0	‘underneath’	noun
d.	i. gao4shi4	‘relate, tell, proclaim’	verb
	ii. gao4shi0	‘notice, proclamation’	noun
e.	i. da2shou3 /da3shou3/	‘hit hand’	verb phrase
	ii. da2shou0	‘bouncer, fighter’	noun

Notice that with the exception of (4.1-6b), all of them involve a change in syntactic category, something typical of morphological processes. As such, it does seem rather reasonable to assume that there is a null morpheme suffix, without which one might be at a loss on providing an account to the relation between each data pair in (4.1-6).

Neutralization is just about the only problem a right-headedness approach faces. If it may be granted that neutralization is nothing other than a stem reducing suffix, controversy over the locus of the Mandarin prosodic head becomes less messy.

4.2. Comparing Mandarin and Tianjin

If neutralization in Mandarin may be accounted for with a segmentally null suffix that reduces the tone of the stem, then the position that Mandarin is prosodically right-headed becomes plausible. With reference to Tianjin, right-headedness in Mandarin has an additional advantage. To begin this exploration, the relevant Tianjin tone sandhi rules are repeated below.

(4.2-1) Alternation by identity (dissimilation)

a. $L \rightarrow R$ / __ L

b. $R \rightarrow H$ / __ R

c. $F \rightarrow L$ / __ F

Notice that (4.2-1a) is very similar to the Mandarin tone sandhi rule, given below.

(4.2-2) Mandarin tone sandhi

L → R / __ L (more commonly written as T3 → T2 / __ T3, where T3 is assumed to be L and T2 is R.)

The similarity between (4.2-1a) and (4.2-2) suggests that these two rules are really one and the same. Since both Tianjin and Mandarin are dialects of the Mandarin cluster, this is hardly surprising. The implication of this is as follows:

Any argument for Mandarin tone sandhi based on prosodic headedness must extend to Tianjin. To illustrate this, consider two hypotheses – firstly assuming that Mandarin is left-headed, thence by extension Tianjin is left-headed and secondly assuming that it is right-headed, thence by extension Tianjin too.

Assuming left-headedness requires that alternation L → R / __ L appeals to some markedness property obligatory of heads, conceivably that head elements should carry a high tone (de Lacy 1999). Putting aside problems already discussed in Chapter 2, section 2.5, this approach might work for Mandarin. However, extension to Tianjin would not be possible. This is because in Tianjin, there are cases like R → H / __ R and F → L / __ F. The initial tone R already has a high tone in it and so one is in need of finding a motivation for its alternation, especially when the result of that alternation is a tone relatively more simplex than the following tone. In F → L, the situation is worse. The initial tone is in fact losing the high tone. Tianjin makes appeals to headship on the left element unfeasible. Abandonment of this account for Tianjin would therefore require the same of Mandarin, given that the set of tone sandhi rules in Tianjin is a superset of the tone sandhi rule in Mandarin.

The second hypothesis that Mandarin is right-headed fares a little better. Assuming that Mandarin is right-headed would automatically account for the stability of the final tone. This can be extended naturally to Tianjin, since all final tones in Tianjin are stable.

While Mandarin and Tianjin headedness and tone sandhi rules are similar, there is some difference in the way tone sandhi rules apply. In Mandarin, tone sandhi applies to prosodic structures that parallels morphosyntactic configuration. Tianjin's prosodic structures are more divorced from morphosyntax by the high ranking of prosodic structural constraints such as BINARY AND ALIGN LEFT. This is essentially why Tianjin exhibit directionality effects that Mandarin do not. Another aspect in which the two languages differ is the number of active sandhi-triggering constraints (effect due to typologically different ranking relationships between faithfulness constraints the various OCP requirements on tone contour adjacencies[1]). Tianjin has more active OCP constraints at work than Mandarin. This is why Tianjin has the "direction flip" effect that Mandarin does not. Given the singular Mandarin tone sandhi rule, alternations can never lead to further sandhi triggering environments.

The next section moves on to discuss the absorption rules of Tianjin. As one may recall, ICT recognizes that constraints may be inter-tier effective or they may be root-effective. It is the latter that the next section explores.

---

[1] For Mandarin, the ranking would be OCP [L] » FAITH » OCP [R, F, H]. For Tianjin, OCP [R, F, L] » FAITH » OCP [H].

4.3. Tone sandhi suspension

Recall from Chapter Three that absorption rules apply only once to all applicable environments after dissimilation has taken its toll (relevant patterns repeated below).

(4.3-1) Patterns in Tianjin relevant to once-and-for-all effect

Pattern	Input	Dissimilation rightwards	Flip	Absorption	Output
P1	FFL	LFL	-	LHL	LHL
P3	FFF	LLF (via LFF)	FLF	HLF	HLF
P8	LRH	-	-	LLH	LLH
P9	LRF	-	-	LLF	LLF
P10	RRH	HRH	-	HLH	HLH
P11	RRF	HRF	-	HLF	HLF
P13	FRH	-	-	FLH	FLH
P14	FRF	-	-	FLF	FLF
P15	RFL	-	-	LHL	LHL

The question is: how is it that apparently sandhi-triggering environments (P8, P9, P13 and P14) are tolerated if they are the result of absorption?[2]

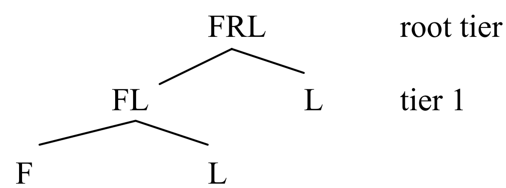
4.3.1. INDEX PRESERVATION

Given that absorption rules apply only once and that it applies only after dissimilation, it should be rather straightforward that this once-and-for-all effect must be attributed to the application of WF-A constraint being root-effective only (to use inter-tier correspondence terminology). However, this will not suffice, as the following example illustrates. Consider for example P9 (P8 and P9 present identical problems in this respect, solving

[2] The observant reader might notice that CT COND from Chapter Three, section 3.5.3 would effectively preempt the offending surface collocations of P8, P9, P13 and P14 from alternating. However, given P15 (see discussion in section 3.5.3), this approach is not feasible. P15 demands that WF-A outranks CT COND.

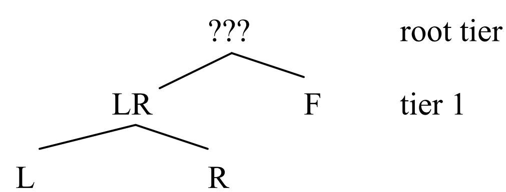
one would solve the other), where /LRF/ → [LLF], in conjunction with P7, where /FLL/ → [FRL]. Under inter-tier correspondence, P7 would be accounted for as in (4.3-2)

(4.3-2) Account of P7[3]



As a root-effective only constraint, WF-A does not apply at tier 1, thus keeping FL intact there without changing to HL. WF-D, with its inter-tier effectiveness, must apply to the root node, so that the medial L becomes R (thus bleeding application of FL → HL). With this in mind, WF-D applies to the root node of P9 also. In that case, WF-A would not have needed to apply (on grounds of faithfulness in correspondence). However, in the case of P9, WF-A must apply, implying that WF-D must NOT apply given the L adjacency. The crux of this conflict is shown below.

(4.3-3) Undetermined root node of P9



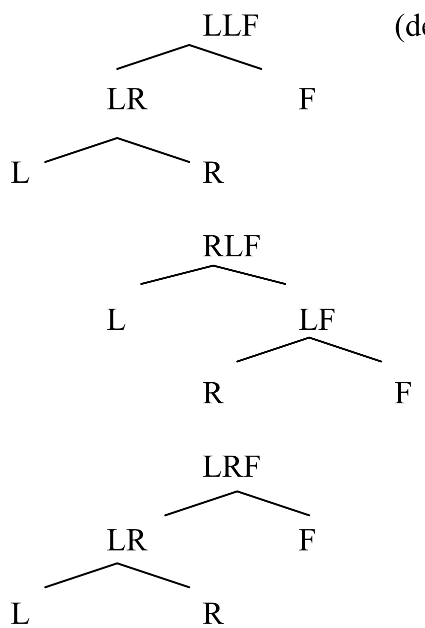
[3] A right-branching structure will not be more harmonic than this left branching one in this case because WF-A is root effective only, thus no violations with the FL adjacency at tier 1. While a right-branching structure in this case may do away with the stipulation that WF-A is root-effective only, it would bring about other problems as WF-A is crucially fed by results of WF-D.

The challenge is thus to resolve the conflict in such a way that one ends up with [LLF] for P9 rather than with anything else. To have a complete grasp of the picture, note at the onset that with a case like P9, one must make sure that WF-D does not result in a reconfiguration of the structure, something that has been shown to be possible in chapter 3, section 3.4 (specifically through the ranking of BIN over WF-D, see (3.4-5)). Reconfiguring the structure to be right branching would of course produce an unattested outcome. Having said this, the task at hand is to eliminate candidates (ii) & (iii) below[4].

(4.3-4) i. (desired optimal)

ii.

iii.



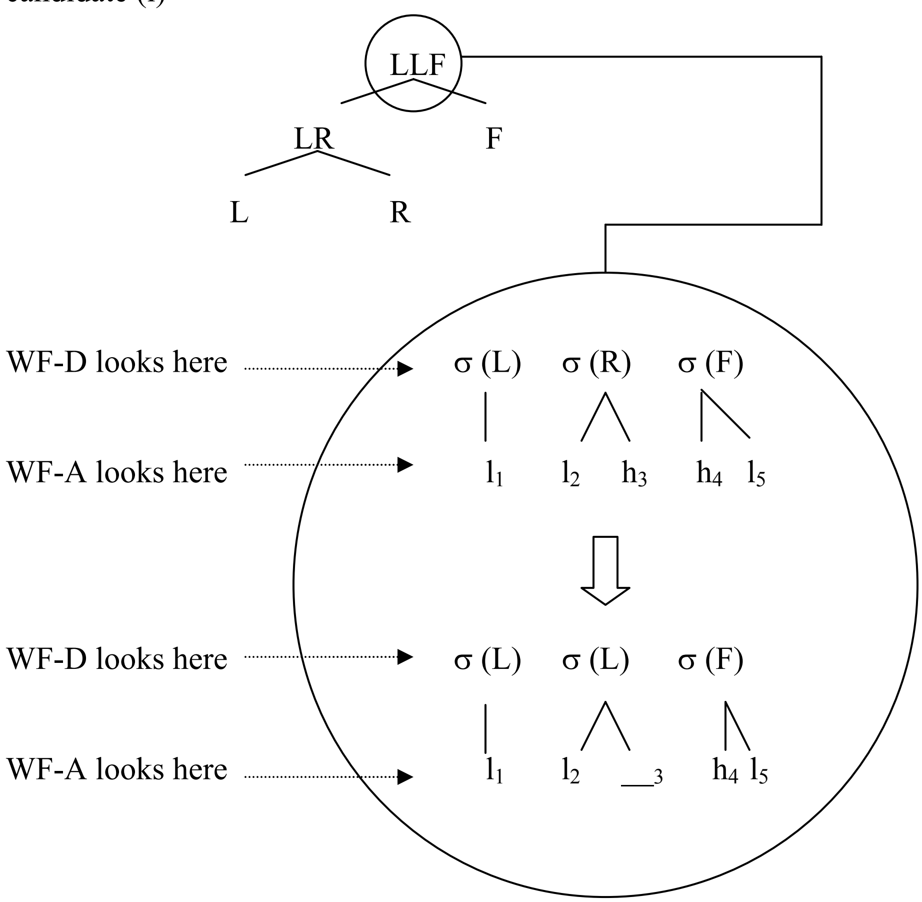
The simplest and most obvious way to the elimination of candidate (ii) and candidate (iii) would be to show that the LL sequence in candidate (i) is not of the same nature as that punishable under WF-D. That would automatically remove candidate (ii) because there will be no longer any motivation to pick a non-optimal structure (by the

---

[4] I am of course assuming that there are constraints limiting what each underlying tone can alternate to in response to either WF-D and WF-A. Exactly how to do this is not directly relevant now, but will be addressed later.

requirements of BINARY and ALIGN LEFT) and remove candidate (iii) by the requirements of WF-A (which disprefers RH and RF surface sequences). Evidently, assuming that the LL in candidate (i) is the result of sharing one L with two tone bearing units is not going to work. This is because there is no way to prevent such a move from extending to resolving other LL violations not triggered by WF-A. I thus propose that the reason behind the tolerance of the LL in P9 is the elimination of the constituent high tone of the underlying medial R without deletion of its index, i.e. having a floating high tone. To illustrate this, consider magnifying the root node of candidate (i) as follows.

(4.3-5) candidate (i)



Two crucial assumptions are needed for (4.3-5) to work. Firstly, WF-D applies as an OCP on the TBU that contains the entire tonal contour (in this case represented by the syllable) and secondly, WF-A applies as an OCP on the constituents of each contour. (These assumptions were implicit in treating WF-D and WF-A as different constraints anyway.) By preserving of the index from the constituent [h] in the medial R of P9, WF-D does not apply to the first substring of [LLH] derived from [LRH]. This is because the first substring no longer contains identical tonal contours now that the initial tone is a solitary [l] while the medial tone is a constituency of [l] and an empty element. The preservation of the index approach will work well for P8 too, where there is also an adjacency of L due to the application of WF-A. The matter is a little more delicate with respect to P13 and P14[5], but the general principle remains the same.

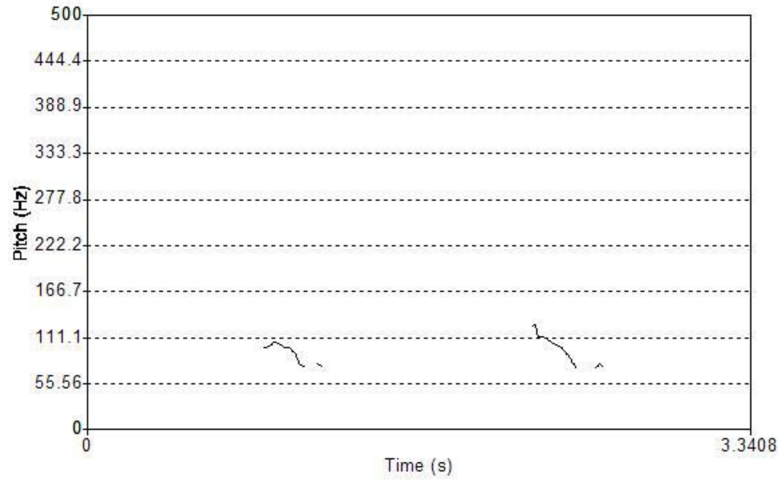
4.3.2. PHONETIC SUPPORT[6]

While index preservation works pretty well, it predicts that the L derived from the application of WF-A must be different from other Ls. We can thus imagine comparing three different kinds of Ls – the underived L (i.e. the L in LF); the L derived from WF-D (i.e. F $\rightarrow$ L / __ F) and; the L derived from WF-A (i.e. R $\rightarrow$ L / __ F). It is useful to recall here that the L tone in Tianjin has a falling contour. This pitch track is repeated from (3.1-2) here as (4.3-6).

[5] With P13 and P14, the matter is more delicate because the counterbleeding involves an FL sequence, which is relevant to WF-A rather than WF-D. However, when viewed with the fact that FR does not undergo sandhi, the crux of the matter appear to lie in finding an explanation for why /FL/ $\rightarrow$ [HL] but not /FR/ $\rightarrow$ [HR]. Once this has been accounted for, the index preservation approach would work with P13 and P14 too.

[6] All pitch tracks and spectrograms made here are taken from recordings of the research supported by the Strategic Research Grant from the City University of Hong Kong (Project No 7000990). I am grateful to Matthew Chen for permission to use these materials.

(4.3-6) Pitch track of the Tianjin Ma1 (Low tone)

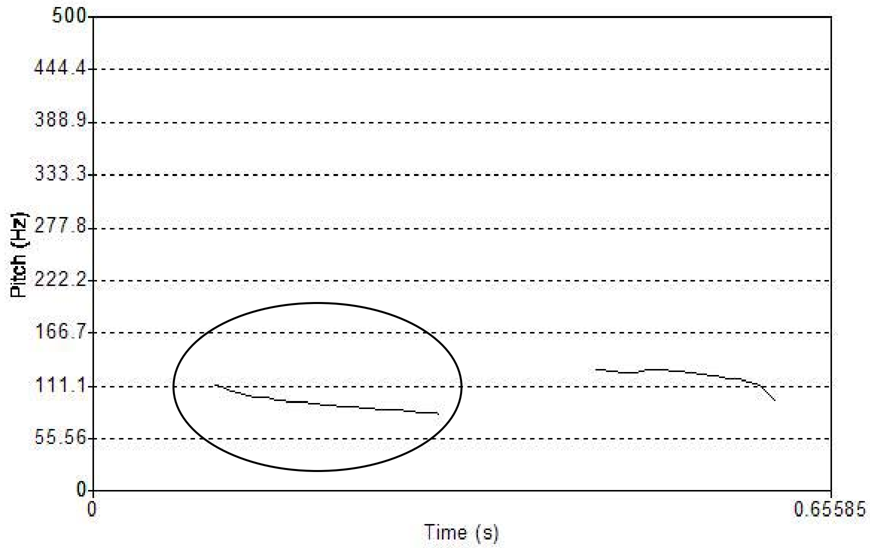


Thus, if the index preservation account is correct, then one would expect the L derived from R to be flatter in contour than the underived L. The following paragraphs will illustrate that this is indeed the case.

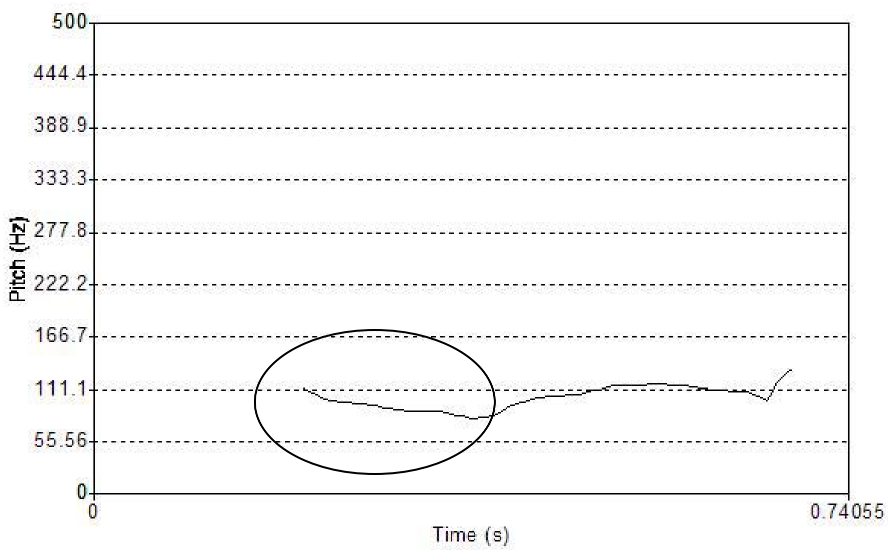
Using the recordings made by Chen et al (2003), one may compare 3 sets of pitch tracks, each set with three pitch tracks from the three different Ls. The first set of pitch tracks in (4.3-7) is for the underived L, the second set in (4.3-8) is for the L derived from WF-D. Finally in the third set (4.3-9) are pitch tracks for the L derived from WF-A. In all these pitch tracks, the part corresponding to the L tone in question is located at the first half. The second half belongs to the tone of the right adjacent syllable responsible for triggering any relevant alternation. In cases where the two syllables are separated by a voiceless consonant, a break may be observed in the pitch tracks. For convenience, the L part of each pitch track is circled.

(4.3-7) Underived L (or /LF/ → [LF])

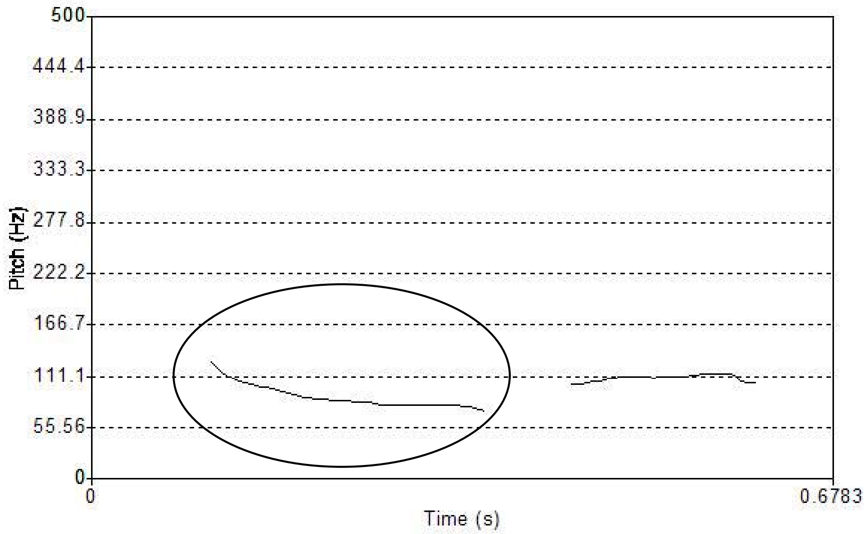
a. jinku 'gold vault'



b. xiwang 'hope'

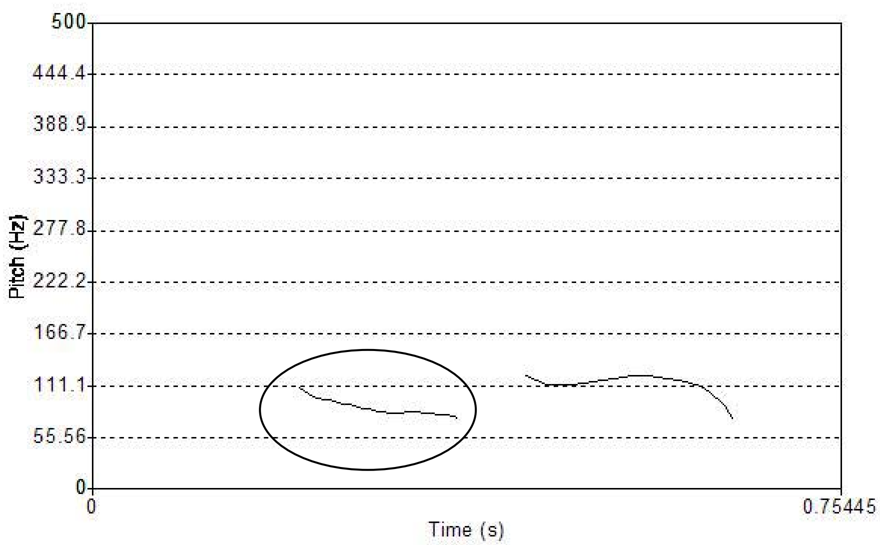


c. jianghua 'petrify'

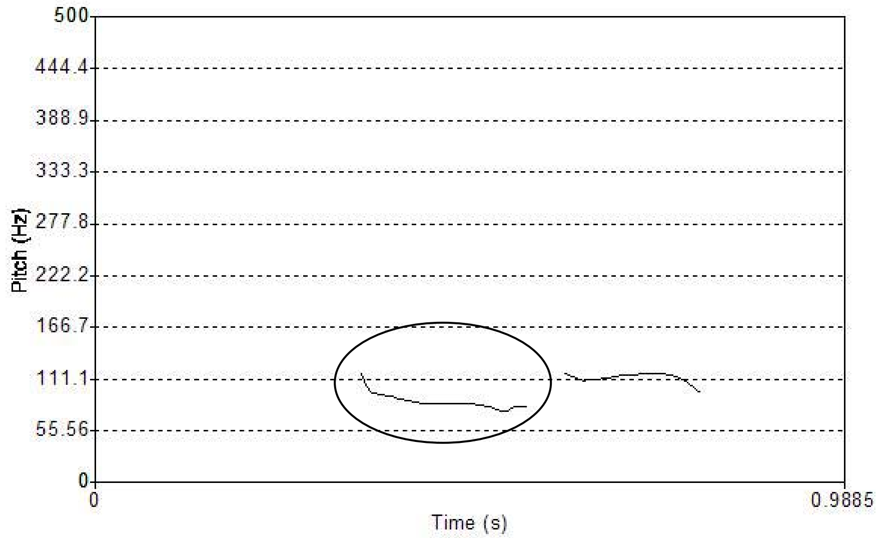


(4.3-8) L derived by WF-D (or /FF/ → [LF])

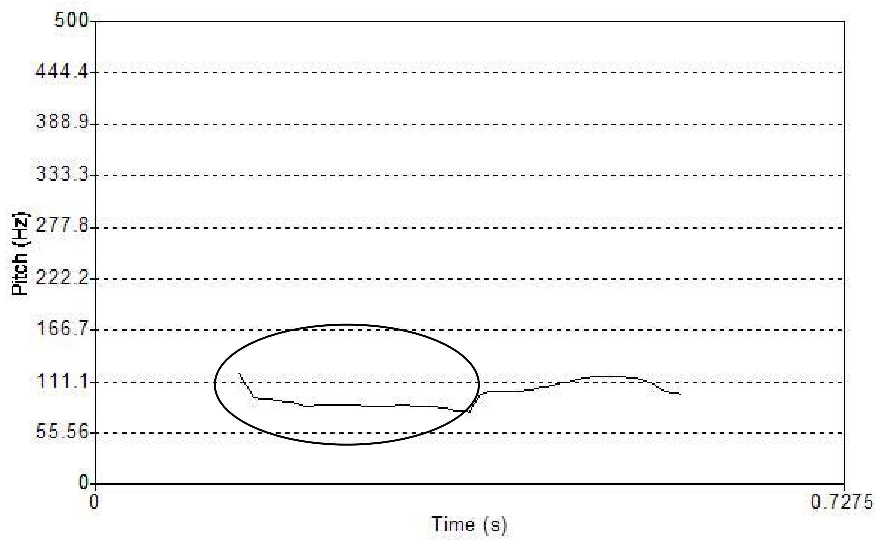
a. fugui 'wealth'



b. shijie 'world'

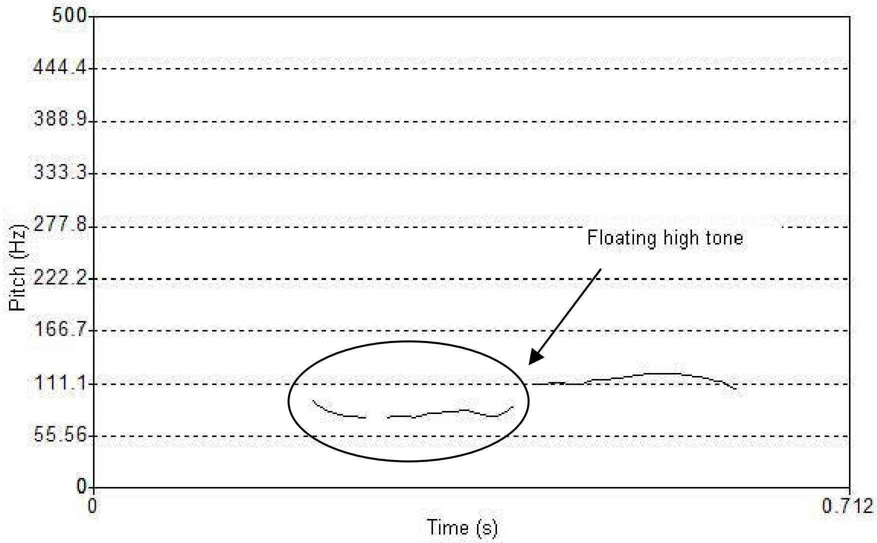


c. yundong 'exercise/campaign'

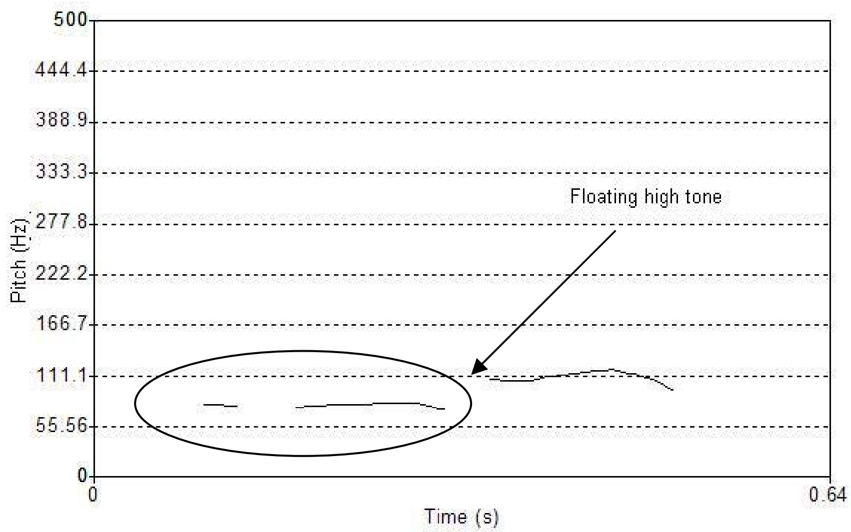


(4.3-9) L derived by WF-A (e.g. /RF/ → [LF])

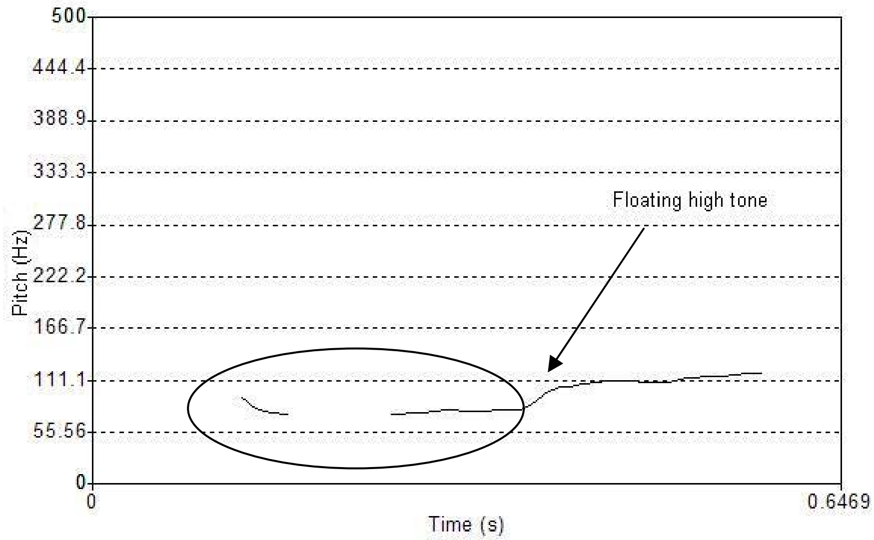
a. shouduan 'means/methods'



b. bandeng 'bench'



c. jianghua 'to speak'



Before making any comparisons, a few explanatory words are necessary. The break in the pitch track in (4.3-9c) is the result of some technical quirk, causing the machine to not pick up any frequency signals and has nothing to do with voicelessness. Otherwise, except for (4.3-7c) and (4.3-9c), segmental information varies. This is because such data pairs are unavailable from the recordings. Since it is the nature of the tonal contours that is of interest, this matter is trivial.

Recall that underived L and L derived from WF-D triggers WF-A (since WF-D feeds WF-A, e.g. P1 and P3), one would expect these two Ls to be similar. By this token, since the L derived via WF-A does not trigger any further sandhi, this L would be different from the other two. Thus, one would expect the pitch tracks in (4.3-7) and (4.3-8) to be similar with respect to the L tone, but (4.3-9) to be different.

Comparing the pitch tracks[7], two things are striking – firstly, L derived by WF-A tends to be flat (in contrast to the falling L of the other two kinds) and; secondly, the L

[7] Pitch tracks for /LH/ and /RH/ though not included here, show similar contrasts between L derived from WF-A and other Ls.

derived from WF-A never begins at a point higher than the 111Hz frequency line (in contrast to the L beginning at minimally that pitch for the other two kinds). These two observations hold true for all the nine cases above. Although 9 is hardly a figure large enough to be meaningful in statistics, the convergence is quite striking. Thus this gives phonetic support to the proposal that the L adjacency tolerance is due to index preservation. Index preservation here is the same kind of floating tone effect frequently found in Benue-Congo languages where the effect of the deleted tone is left behind (Clements and Ford 1979, Pulleyblank 1986, Clark 1992, Odden 1995, Yip 2002 among others).

As mentioned earlier, the challenge posed by P8 is identical to P9, and so does not warrant any further discussion. P13 and P14, involves marked collocations that apparently pertain to WF-A, but since these collocations are derived, they too may arguably not have the sandhi triggering structure under the index preservation account. Verification would require a comparison between derived FL against underived FL (P13 and P14 have WF-A triggers on the surface) phonetically. This requires substantial work in phonetics that stretches the bounds of this dissertation and thus awaits future research.

4.4. Tone selection

This section moves on to discuss the residue matter on tone selection. Although the main thrust of this dissertation pertains to the application of sandhi on windows AB and BC in some given ABC sequence, what A, B or C alternates with (i.e. tone selection) has not been addressed. This section devotes itself to matters on tone selection, but it does not present itself as an inherent part of inter-tier correspondence theory (rather only as a complement to the theory), nor does this section present itself as a general theory on tone selection. It only takes into consideration the tone selection involved in Mandarin and Tianjin.

Recall that tone sandhi may be grouped into two categories – those involving dissimilation (Mandarin tone sandhi and Tianjin WF-D types of tone sandhi) and those involving absorption (Tianjin WF-A types of tone sandhi).

(4.4-1) a. Alternation by identity (dissimilation, WF-D)[8]

$F \rightarrow L$ / __ F

$L \rightarrow R$ / __ L (Mandarin tone sandhi shares this with Tianjin)

$R \rightarrow H$ / __ R

b. Alternation by partial identity (absorption, WF-A)

$F \rightarrow H$ / __ L

$R \rightarrow L$ / __ H

$R \rightarrow L$ / __ F

While OCP constraints on contours (OCP[TC]) and on features (OCP[TF]) may be invoked as triggers to these processes (see Chapter 3, section 3.1), they do not explain

[8] Working on tone shifts in Chinese languages, Hirayama (1984 and 1991) argues that the pattern would be $F \rightarrow L \rightarrow R \rightarrow H \rightarrow F$, thus completing a circle such that complex tones are reduced by taking from the left edge and simplex tones are contoured by adding features to the right edge. Yan Xiuhong (p.c.) however reports that at least in Hakka languages, the arrows would point in a variety of directions. As such, I shall refrain from making arguments for these tone mapping patterns from a historical perspective.

why, for example, L → R and not anything else. The problématique is pictorially described below.

(4.4-2) Mapping relations

Underlying tone	Mapping under WF-D or WF-A	
F = [hl]	[lh]	✗
	[hl]	✗
	[h]	✓
	[l]	✓
L = [l]	[lh]	✓
	[hl]	✗
	[h]	✗
	[l]	✗
R = [lh]	[lh]	✗
	[hl]	✗
	[h]	✓
	[l]	✓

In (4.4-2), ✗ refers to unattested mapping while ✓ refers to an attested mapping. The matter on tone selection is thus essentially the distribution of ✗ and ✓. The pattern behind the mapping becomes clear when presented as the following:

(4.4-3) a. Mapping of F

$$\text{hl} \rightarrow \begin{cases} \text{(i)} & \text{h / \_\_ l} \\ \text{(ii)} & \text{l / \_\_ hl} \end{cases}$$

b. Mapping of L

$$\text{l} \longrightarrow \text{(i)} \quad \text{lh / \_\_ l}$$

c. Mapping of R

lh → (i) l / __ h

lh → (ii) h / __ lh

(4.4-3) shows evidently, that the mapping must result in a collocation that is free from adjacency of identical tone features (i.e. satisfies OCP[x.x]). It is for this reason that F and R has two mapping possibilities depending on the tone feature that follows it. For example, with /hl/ (=F), [l] is deleted if the following tone feature is [l] (as in (i)) and [h] is deleted if the following tone feature is [h] (as in (ii)). The same logic applies to /R/. With L, avoidance of adjacent [l]s is done by inserting [h]. In essence, the selected tone for mapping must not result in an OCP[x.x] violation.

4.5. Comparative markedness and tone selection

The application of OCP[x.x] as a key to tone selection calls to mind its exact position in the ranking hierarchy. In Chapter Three, section 3.1, it was first mentioned that WF-A is really OCP[xy.y], a special kind of OCP[x.x] (i.e. a constraint on adjacent identical tone features). WF-A addresses such alternations as /RH/ → [LH] (= /lh.h/ → [l.h]) which has an offending [h] adjacency. The difference between WF-A and OCP[x.x] is that the latter punishes also collocations such as /HF/, /HH/ and /LR/. These collocations however do not trigger tone sandhi. Consequently, it must be that OCP[xy.y] » FAITH » OCP[x.x]. At first blush, this ranking hierarchy works. Consider all the ditonal sandhi patterns as predicted in all six tableaux below.

(4.5-1) Dissimilation tone sandhi

a. /FF/ → [LF] or hl.hl → l.hl

/hl.hl/=FF Candidate		WF-D	WF-A	INTF	OCP[x.x]
i.	hl.hl = FF	*!			
ii.☞	l.hl = LF			*	
iii.	h.hl = HF			*	*!
iv.	lh.hl = RF		*!	**	*

b. /LL/ → [RL] or l.l → lh.l

/l.l/=LL Candidate		WF-D	WF-A	INTF	OCP[x.x]
i.	l.l = LL	*!			*
ii.☞	lh.l =RL			*	
iii.	hl.l = FL			*	*!
iv.💣[9]	h.l = HL			*	

c. /RR/ → [HR] or lh.lh → h.lh

/lh.lh/=RR Candidate		WF-D	WF-A	INTF	OCP[x.x]
i.	lh.lh = RR	*!			
ii.☞	h.lh =HR			*	
iii.	l.lh = LR			*	*!
iv.	hl.lh = FR		*!	**	*

[9] This candidate is not as on par with the desired optimal as it appears on this tableau. It drastically changes the identity of the input tone from L to H, involving simultaneously a deletion of the L and the epenthesis of H. The desired optimal involves only epenthesis of H. The desired optimal is therefore more faithful.

(4.5-2) Absorption tone sandhi

a. /FL/ → [HL] or hl.l → h.l

/hl.l/=FL Candidate	WF-A	INTF	OCP[x.x]
i. hl.l = FL	*!		
ii. l.l = LL		*	*!
iii. ☞ h.l = HL		*	
ii. lh.l =RL		**!	

b. /RH/ → [LH] or lh.h → l.h

/lh.h/=RH Candidate	WF-A	INTF	OCP[x.x]
i. lh.h =RH	*!		
ii. h.h = HH		*	*!
iii. ☞ l.h = LH		*	
iv. hl.h = FH		**!	

c /RF/ → /LF/ or lh.hl → l.hl

/lh.hl/=RF Candidate	WF-A	INTF	OCP[x.x]
i. lh.hl =RF	*!		
ii. h.hl = HF		*	*!
iii. ☞ l.hl = LF		*	
iv. hl.hl = FF		**!	

(4.5-1) and (4.5-2) do not consider candidates where the final tone contour alternates (i.e. no examples of A → A'/ A __ type) since Tianjin tone sandhi is strictly regressive. This property is taken care of by the right-headedness assumption that keeps the tone contour on the right edge stable. INTF is the inter-tier faithfulness constraint that is used here to evaluate for faithful preservation of tone features.[10]

Such an account however does not stand up to scrutiny. The appeal to OCP[x.x] as key to tonal selection for dissimilatory sandhi cases fails the moment one considers

[10] Counting INTF violations in terms tone features does not adversely affect the way the constraint was used in Chapter Three as it is just a refinement on the representation of contour tones.

/RRR/ or /FFF/. As an illustration, consider the situation with /FFF/ below. (For details on /FFF/, see Chapter Three, section 3.4.3.)

(4.5-3) P3: /FFF/ → [HLF] violations:count

Candidate i: hl.+h.hl (= [FHF]) OCP[x.x]:1

hl h.hl OCP[x.x]:1 INTF:1

hl hl

Candidate ii: h+l.hl (= [HLF]) INTF:1

hl l.hl INTF:1

hl hl

/FFF/ candidate	WF-D	INTF	OCP[x.x]
💣 i.		*	**
⚐ ii.		**	

⚐=desired optimal 💣=predicted optimal

In (4.5-3), candidate i violates of OCP[x.x] as prevention for subsequent violations of INTF as one moves up each tier. Thus, candidate i is erroneously preferred over the attested candidate ii. Note that OCP[x.x] does not apply at the intermediate tier because as part of the WF-A family, it has root-effectiveness only. Even if this was relaxed, it would not help. Also, reranking of OCP[x.x] and INTF(MAX) is not viable since not OCP[x.x] does not trigger alternation. Either ways, appeal to OCP[x.x] for tone selection for dissimilation cases makes the wrong predictions. A similar situation may be constructed with P2: /RRR/ → [HHR].

To solve this conundrum, it is important to recognize that while OCP[x.x] are often tolerated with underived tones, it is never tolerated with derived tones. This calls to mind the insight behind comparative markedness theory (McCarthy 2002). Under comparative markedness, markedness constraints belong to two different kinds – one that punishes underived marked forms ($*M_O$, i.e. old marked environment) and another that punishes derived marked forms ($*M_N$, i.e. new marked environment). These two sides of the same coin interact with faithfulness constraints producing four possibilities, all of which are explained below.

(4.5-4) Typology: comparative markedness with faithfulness

i. $*M_O$; $*M_N$ » FAITH

All surface forms contain no marked environments.

ii. FAITH » $*M_O$; $*M_N$

All surface forms are identical to underlying forms.

iii. $*M_O$ » FAITH » $*M_N$

Derived marked environments are tolerated, but not underived ones.

iv. $*M_N$ » FAITH » $*M_O$

Underived marked environments are tolerated, but not derived ones.

In terminal based OT accounts (that is, any OT account that does not use inter-tier correspondences), the expression of comparative markedness appears awkward because of its reference to derivations. However, this notion is natural with inter-tier correspondence representations because information in a dominating node would be "derived" from its constituent nodes (details, see Chapter One). Therefore, only unfaithful upward percolation could result in a violation of *M_N. So, in fact, all one needs is an OCP_N[x.x] that applies to all derived environments, with a ranking of the type in (4.5-4iv.) This is shown below, again using P3 /FFF/ as an example.

(4.5-5) P3: /FFF/ → [HLF] violations:count

Candidate i: hl.+h.hl (= [FHF]) OCP[x.x]:1

hl h.hl INTF:1
OCP_N[x.x]:1

hl hl

Candidate ii: h+l.hl (= [HLF]) INTF:1

hl l.hl INTF:1

hl hl

OCP_N[x.x] Mismatched inter-tier correspondences (in other words, unfaithful inter-tier correspondence) may not have adjacent identical tone features.

/FFF/ candidate	OCP_N[x.x]	WF-D	INTF	OCP[x.x]
i.	*!		*	*
☞ ii.			**	

OCP_N[x.x] does not adversely impact on the ditonal cases as none of the optimal cases involve a derived [x.x]). Given the way OCP_N[x.x] is formulated, the adjacent [h] at the root node of candidate i does not constitute a violation. This is because this collocation is inherited from the constituent nodes rather than derived. Taking this cue, ICT is actually indispensable for an account in tone selection. To see the importance of ICT in dealing with tone selection, consider now P2: /RRR/ → [HHR]. Notice the adjacent Hs in the initial substring. Since these two Hs are derived, would not that constitute a violation of $OCP_N[x.x]$?

(4.5-6) P2: /RRR/ → [HHR] violations:count

Candidate i: l+h.lh (= [HLF]) IntF:1

l.lh lh $OCP_N[x.x]$:1
IntF:1

lh lh

Candidate ii: h+h.lh (= [HHR]) IntF:1

h.lh lh IntF:1

lh lh

$OCP_N[x.x]$ Mismatched inter-tier correspondences (in other words, unfaithful inter-tier correspondence) may not have adjacent identical tone features.

/RRR/ candidate	$OCP_N[x.x]$	WF-D	IntF	OCP[x.x]
☞ i.	*!		**	*
ii.			**	*

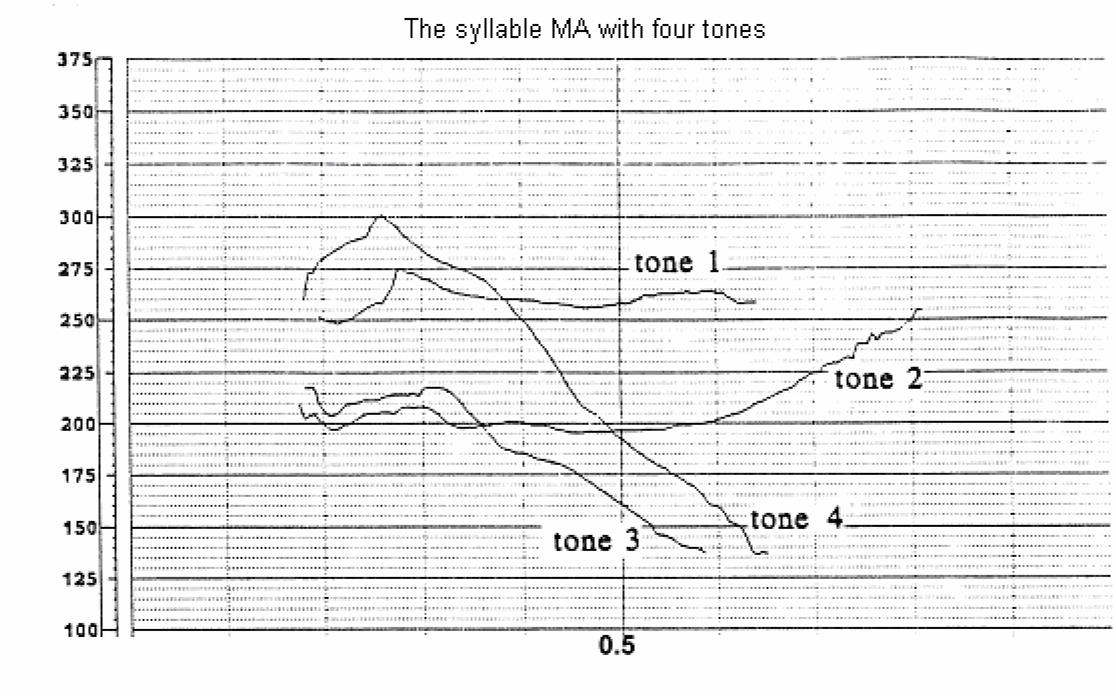
Notice that in (4.5-6) candidate ii, there is a [h] adjacency at the root node. If $OCP_N[x.x]$ applies without reference to inheritance from lower tiers, then candidate ii would be share all the violations of candidate i, thus predicting optionality between the two candidates. Breaking this tie requires that $OCP_N[x.x]$ applies only when unfaithful percolation results in identical tone features being adjacent. This cannot be formulated without reference to structures since a terminal-based treatment (see Chapter One) would view the [h] adjacency as derived.

4.6. Dipping or low tone in Mandarin

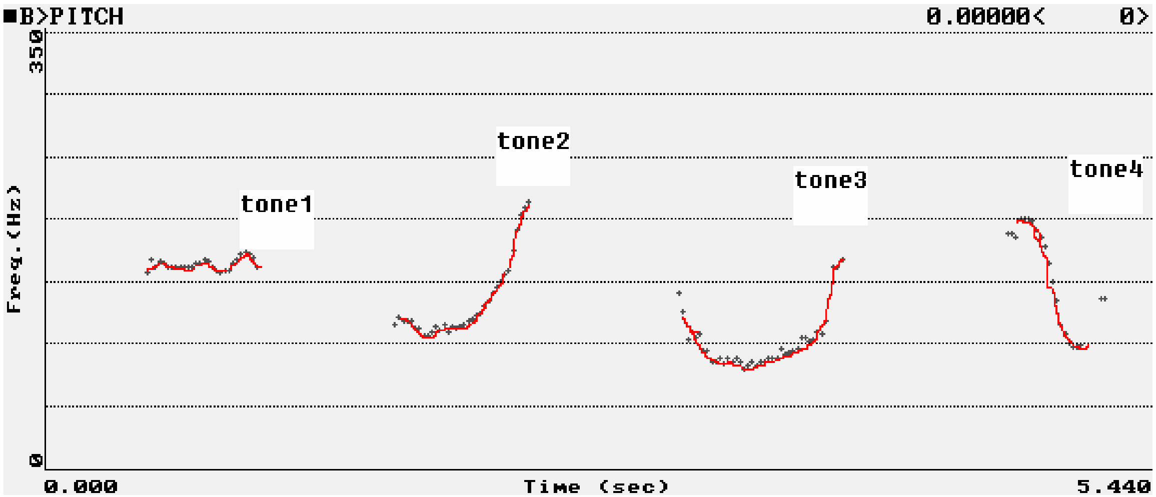
The above discussions have concentrated mostly on Tianjin making hardly any reference to Mandarin. This indulgence is granted based on the observation that the Mandarin tone sandhi rule (T3 → T2 / __ T3) is a subset of the Tianjin rules (since Mandarin T2 is R and T3 is arguably L). This view of Mandarin tone sandhi puts the spotlight on a long-standing debate about the nature of the T3 as well as the sandhied T2.

As noted in Chapter Two, T3 is Mandarin varies phonetically across speakers. For some speakers, it is a low tone (see pitch track from Shih 1988) where for some, it is a dipping tone (see pitch track as articulated by the writer).

(4.6-1) a. Pitch Tracks of the Mandarin Tones from Shih (1988)



b. Pitch Tracks of the Mandarin Tones articulated by the writer



Many accounts of Mandarin tonal inventory describes T3 as [214] (following the tone letter system where 1 = lowest and 5 = highest). Speakers of Mandarin whose articulation of T3 matches Shih's description are mostly from the south. Speakers who articulate T3 as [214] are often from the north. So, let us call these two groups of speakers the southern-speakers and the northern-speakers.

Even though the phonetic nature of T3 varies across speakers, both Shih speakers and textbook speakers share the same tone sandhi target in that T3 alternates with a rising tone. Now, the discussion on tone selection in the earlier section is clearly compatible with the Southern speakers as it fits squarely with /l/ → [lh] / __ l. Recall that for Southern speakers, T3 is a low tone.

The matter becomes a little more complicated with northern speakers. This is because if T3 is construed as [214], then it certainly is not a case of L adjacency, but rather collocation of two dipping tones. Triggering alternation here is not a problem, since an OCP on tone contour (i.e. OCP[TC]) would suffice. Thus the Mandarin ranking hierarchy for triggering tone sandhi would be (4.6-2) regardless of the dipping quality of T3.

(4.6-2) OCP[T3]; FAITH » OCP [T1, T2, T4]

That said, one can concentrate on obtaining a rising tone out of a dipping one? The most obvious approach would be to either remove the high bit on the left edge of the dipping contour, thus making a [14] out of [214] or remove the middle bit, thus making [24] out of a [214]. Now, the pitch description for T2 is [35] (see Chapter Two, section 2.1). This would mean that both approaches predict that the rising tone produced by T3 sandhi (be it [14] or [24]) is not the same as T2 (which is also rising). At this point, there are two issues to address – (i) does this affect the earlier analysis on tone selection and (ii) is there any phonetic evidence to show the difference between sandhied T3 and regular T2.

Addressing (i) first, recall that central to the treatment on tone selection is the requirement that derived tones do not have adjacent identical tone features. Thus even for northern speakers of Mandarin where T3 is [214], T3 adjacency does not have any OCP[x.x] violations since the initial tone ends in a [h] (= […4]) and the final tone begins with [l] (= [2…]). Moving on to (ii), Yin (2002) argues that the rising tone derived from T3 sandhi is different from T2. In fact, Yin cites phonetic studies from Xu (1997) that the sandhied tone is more akin to [14] than to the [35] of T2. As explained above then, the account on tone selection accommodates both views of Mandarin tone sandhi, regardless of the precise description of T3.

4.7. Summary

This chapter addresses neutralization in Mandarin, absorption in Tianjin and the mapping of underlying tones to sandhied tones in these two languages. These are residual issues not directly related to the inter-tier correspondence theory (ICT), but are nonetheless crucial for a complete account of the two languages in question. This is because these issues relate to phenomena that either (i) threaten ICT as an account for the derivational effects or (ii) do not require inter-tier correspondence as a tool. Phenomena pertaining to (i) include neutralization in Mandarin which creates more change than the structural configuration apparently allows and absorption in Tianjin which seem to undo certain dissimilatory processes. In response to Mandarin neutralization, the main idea is to assume a tone reducing suffix, thus giving the representation as many tiers in structures as needed for all the alternations to occur. This move also makes a right-headed assumption of Mandarin prosody viable because the rightmost syllable which tone is reduced is no longer head at the higher tier where suffixation occurs. On Tianjin absorption, tolerance of certain collocations is explained the fact that these collocations are in reality not the same ones that trigger tone sandhi. Essentially, phonetic evidence shows that tones derived via absorption are different from those that trigger sandhi.

The phenomena pertaining to (ii) would be on the mapping between underlying tones and sandhied tones, which apparently does not call for the elaborate inter-tier correspondence notation. This is because, ditonal sandhi simply does not produce a OCP[x.x] situation (i.e. a situation where two adjacent tone features are identical). This however does not extend very well to longer strings such as /FFF/ and /RRR/. To accommodate these cases, it turns out that inter-tier correspondence is after all necessary so that certain derived OCP[x.x] are not punished while others are. This makes the ICT more important and necessary in providing a complete account to Mandarin and Tianjin than just capturing the opaque and derivational effects discussed in the preceding chapters.

Chapter Five

A GENERAL THEORY OF CYCLICITY

Inter-tier Correspondence Theory (ICT) addresses cyclicity as exhibited in Mandarin and Tianjin. Its general claim to a theory of cyclicity beyond Chinese tonology remains to be seen. This chapter attempts to justify that claim by extending it to other phenomena of cyclicity in relation to analyses constructed by earlier theorists. It does not purport to supercede these theories, but rather to locate its central claims amidst the landmarks that others have built in terra-phonologiae. As such, this chapter has the added function of being a literature review as well.

Beginning with Cole (1995), the main components of a theory of cyclicity are laid out so that ICT may be compared to them. This is followed by a discussion on English stress, chosen to exemplify Benua's (1997) Transderivational Faithfulness Theory as well as to check the usefulness of ICT on stress systems. Moving on to overapplication in Tiberian Hebrew, McCarthy's (1998, 2000) Sympathy Theory is presented as with the extension of ICT to opacity effects in segmental phonologies. Yokuts come next, so that the insights of Kiparsky's (2002 and to appear) Stratal OT (and by its formulation, Lexical Phonology) are showcased.

5.1. Components of an account to cyclicity (Cole 1995)

Let us begin by considering what components any phonological theory of cyclical phenomena must have. Cole (1995) argues quite convincingly such a phonological theory must include three components. These are listed below.

(5.1-1) Cole's (1995) components for an account of cyclicity

a. A sub-theory of domains

This constructs domains for the application of certain phonological rules on the basis of morphological structure. The domains are not necessary isomorphic to that structure.

b. A constraint on monomorphemic environments

This restricts certain rules from applying in monomorphemic environments.

c. A interaction mechanism

This models the interaction that can occur between rules applying in cyclic domains and those applying in the larger domains defined by word and phrase structure.

Motivation behind these requirements is obvious enough. One must have some means of determining a domain and its internal structure upon which "rules" cycle. By the same token, an interaction mechanism is required locate where the cyclical effects stop and where they begin. The constraint on monomorphemic environment is chiefly motivated by empirical needs. After all, cyclic rules are rarely, if ever, observed to apply in monomorphemic environments, and hence some way of preventing this is required.

ICT as a theory of cyclicity is promising because it satisfies the requirements outlined by Cole (1995). Necessary in the inter-tier correspondence account is the need for a set of interface constraints between prosody and syntax, thus satisfying the requirement of having a theory of sub-domains. The interface constraints determine the kinds of prosody structures within which cyclicity applies.

The constraint against monomorphemic environments is built into the ICT account simply because the terminal nodes themselves do not constitute environments for any application. It is the percolation (or rather the inter-tier correspondence) that results in collocation of elements that constitute triggering environments.

Finally, the interaction mechanism is available to ICT in two ways – either constrained by non-recursivity (which would in fact change the nature of the domains in question) or by the definition of the wellformedness (i.e. markedness) constraints.

Under ICT, cyclicity can thus be understood as the requirement for well-formed collocations at each tier (i.e. constituents), such that the collocation is due to the percolation of information. The domains within which these requirements must be satisfied are determined by the interface between morphosyntactic structures (in the case of Mandarin and Tianjin, the syntactic structure) and phonological structures. The effects of cyclicity are observed when non-recursivity is violated, so that domains are recursively embedded.

5.2. English stress

The matter of cyclicity in relation to English warrants first and foremost the distinction of affixes in English into two classes: (I) e.g. -al, -ate, -ic, -ity, -ous, etc; and (II) e.g. -ness, -ful, - ist, -er, etc (Siegel 1974). Class I affixes attract stress while Class II affixes do not.

(5.2-1) Main Stress in Affixed Words (taken from Benua 1997)

a. Class 1 affixation		b. Class 2 affixation	
órigin	oríginal(*óriginal)	obvious	óbviousness(*obvíousness)
párent	paréntal	párent	párenthood
úniverse	univérsal	sórdid	sórdidness
pópular	populárity	inhábit	inhábitable
contínue	continúity	artículate	artículator
grámmar	grammárian	astónish	astónishingly
ópera	operátic	wónder	wónderfulness

Notice in (5.2-1) that stress shifts rightwards when a class I suffix is added, e.g. órigin → oríginal. With Class II affixes the stress stays where it was in the stem. What relates English stress to cyclicity pertains to Class I affixes. Consider the following paradigm.

(5.2-2) a. órigin

b. oríginal

c. orìginálity

In (5.2-2), the main stress is always located at the syllable containing the penultimate mora after assuming that the final syllable is extrametrical. Construed this way, shift in the main stress in itself does not constitute cyclicity. However, when the secondary stress is taken into account, the secondary stress placement in (5.2-2c) oríginálity cannot be easily located without reference to (5.2-2b) oríginal.

Having established why English stress shift is cyclical, an account for English stress must therefore minimally (i) capture the stress shifts with Class I affixes while (ii) exempting stress shifts with Class II affixes.

5.2.1. Tranderivational Faithfulness Theory (Benua 1997)

Rising up to this challenge, Benua (1997) develops the Transderivational Faithfulness Theory (TFT). In TFT, forms belonging to the same paradigm are required by O-O constraints to be identical, although the identity may be overridden by wellformedness requirements. Benua (1997) summarizes such transderivational (output-output) correspondence with the following schema.

(5.2-3) Transderivational (output-output) correspondence

$$
\begin{tikzcd}
{[\mathrm{root}_i]} \arrow[r, "\text{OO-Correspondence}"] & {[\mathrm{root}_i\mathrm{+affix}]} \\
{/\mathrm{root}/} \arrow[u, "\text{IO correspondence}"] & {/\mathrm{root+affix}/} \arrow[u, "\text{IO Correspondence}"']
\end{tikzcd}
$$

Notice that in (5.2-3), there is identity in the output of the root form and the output of the affixed form. This identity is denoted by the subscripted index. For example, ‘origin’ is the root that is found in the word ‘original’. OO-correspondence then requires the first three syllables of ‘original’ to be identical to ‘origin’. With cyclical phenomenon, (5.2-3) is extended to include the OO correspondence between [root+affix] and [[root+affix]+affix] with recursive evaluation. The stress shifts with Class I affixes could then be obtained with the following constraints and their ranking.

(5.2-4) Multiple Affixation

	OO Correspondence		
órigin →	oríginal	→	orìginálity
↑	↑		↑ IO Correspondence
/origin/	/origin+al/		/origin+al+ity/

Recursion (A)

/origin/	NON FINAL	ALIGN HD RT	OO-IDENT	ALIGN HD LT	IO IDENT	»
a. o.(rí.gin)	*!			*		
b. (ó.ri)gin		*				
c. (ó.ri)gin		*				
d. ☞ (ó.ri)gin		*				

Recursion (B)

»	/origin+al/	NON FINAL	ALIGN HD RT	OO-IDENT	ALIGN HD LT	IO IDENT	»
	a'. o(rí.gi)nal		**		*		
	b'. (ó.ri)gi.nal		***!	*			
	c'. o(rí.gi)nal		**	*	*		
	d'. ☞ o(rí.gi)nal		**	*	*		

Recursion (C)

»	/origin+al+ity/	NON FINAL	ALIGN HD RT	OO-IDENT	ALIGN HD LT	IO IDENT
	a". o.(rì.gi)(ná.li)ty		**		*	
	b". (ò.ri)gi(ná.li)ty		**			
	c". (ò.ri)gi(ná.li)ty		**	**!		
	d".☞ o(rìgi)(ná.li)ty		**	*	*	

Legend:
. – syllable break; **( )** – feet boundary

NON-FINAL – Final syllable should not be footed.
ALIGN HD LT/RT – Align feet to left/right.
OO-IDENT – Have identical correspondences of this candidate to an immediately earlier output.
IO IDENT – Have identical correspondences of this candidate with the input.

The next thing is to find some means of exempting Class II affixes from the cyclicity. To this end, Benua separates O-O faithfulness constraints for Class I (O-O_1) and Class II (O-O_2) affixes, thus expressing that asymmetry in stress shifts with the ranking hierarchy O-O_2 » Markedness » O-O_1. This ranking ensures that paradigmatic identity applies without exceptions to Class II affixes in terms of stress assignment, since O-O_2 is undominated. Benua (1997) does not actually define the O-O_1 and O-O_2 constraints, even with respect to English stress. However, it is at least evident that the O-O constraint must make as much reference to the class of the affixes as they do to the stems, making the statement something along the lines of "be (paradigmatically) faithful to stem X when affixed with morpheme Y". Unless there is some other way to conceptualize this, such a formulation presupposes some way of distinguishing the stems (albeit by contextual reference to the affix class), making the account sound strangely circular. O-O_1 and O-O_2 cannot be formulated independently of the stems.

Striking in the recursions in (5.2-4) is that some candidates look identical. Also, the candidates that are given the same letter corresponds to one another, that is (a) corresponds to (a') and (a"). Candidates deemed non-optimal in earlier recursions are knocked out in subsequent recursions, so their evaluation in subsequent recursions is ignored. This is the case of (a', a" and b"). Hence only the set of candidates that survive earlier recursions are fed into subsequent recursions. OO-IDENT then requires the candidates in subsequent recursion to correspond to the earlier recursion. After three cycles of recursion, candidate (d") surfaces as optimal for 'originality'. Notice that in each recursion, there is only one OO-IDENT constraint. This constraint has to be formulated such that it only sees the output of the immediately preceding recursion. Also, subsequent recursions may only take place if there were optimal outputs in earlier recursions so that OO-IDENT may use it as a target for correspondence.

I provide in (5.2-5) below, a list of the salient characteristics of Benua's TFT.

(5.2-5) Key features of Benua's TFT

a. morphological relatedness

b. earlier recursions' foresight of total number of recursions

c. having recursions

d. OO constraints must see and only sees the result of an immediately earlier recursion

e. dependency of later recursions on the grammatical output of earlier recursions.

Depending on how insistent one needs to be on the features in (5.2-5), one may evaluate the usefulness of TFT differently. For example, since Chinese tone sandhi applies across words, it is clear that (5.2-5a) makes TFT inapplicable to the Chinese data. To extend TFT to Mandarin, one needs to relax this assumption. Another point to note is that foresight of earlier recursions to number of future recursions is necessary so that the correct number of identical candidates may be generated. In fact, when formulated within the framework of TFT, some form of foresight must be necessary since inputs of each cycle are outputs of an immediately preceding cycle.

By relaxing the criterion on morphological relatedness, one can envisage how TFT addresses the Mandarin cyclical problem as follows:

(5.2-6) Getting the Mandarin Tone Sandhi with TFT

Recursion (A)

/T3T3/	OCP [T3]	IDENT-R	OO-IDENT	IDENT [T]	»
a. T3T2		*!			
b. T2T3				*	
c. T2T3					
d. ☞ T2T3				*	

Recursion (B)

»	/T3T3+T3/	OCP [T3]	IDENT-R	OO-IDENT	IDENT [T]	»
	a'. T3T2T3				*	
	b'. T2T3T3	*!			*	
	c'. T3T2T3			**!		
	d'. ☞ T2T2T3			*	*	

While TFT may work with Mandarin cyclicity, it suffers from the inability to handle directional reversals of the kind found in Tianjin. There is no apparent way of expressing the flip condition in TFT without awkward apparatus. This is because TFT relied almost solely on morphological structures as that on which applications cycle. Languages like Tianjin point to phonological structures as structures where cyclicity happens.

Implicit in TFT is that it requires optimal candidates of intermediate recursions to be actual surface outputs forms. This is not empirically supported as may be seen in cases of loanwords. An example from Tianjin would illustrate this.

(5.2-7) Yi da li transliteration of "Italy"

/F F F/ → H L F (cf. P3)

The problem is that neither yida nor tali are attested surface forms in the paradigm of yidali related forms. Hence, if one were to use TFT in the Tianjin derivation of yidali, the O-O IDENT constraints would be inactive. This is one important difference between TFT and ICT. TFT is recursive such that earlier cycles are more important than later cycles[1]; ICT is not (but rather the global collective pooling of marks).

5.2.2. ICT ON ENGLISH STRESS

Although, TFT was not developed with Chinese tonology in mind, it contains insights useful for an account such as the Inter-tier Correspondence Theory (ICT). ICT shares with TFT a certain reliance on forms generated by earlier cycles. Now, we have seen how ICT deals with Mandarin and Tianjin. It allows cyclical effects to stretch beyond the confines of morphology by treating cyclicity as applicable to phonological structures. Where cyclicity applies is where the phonological structures are recursive such that certain markedness constraints have bearing in those domains. Intermediate forms may therefore either be attested or not depending on both phonotactics as well as morphosyntax. Hence with (5.2-7) yi.da.li “Italy”, the intermediate phonological forms may not be actual attested morphosyntactic forms.

It is now necessary to see if there is some way of applying ICT to English stress. At first blush, this seems straightforward. One simply recasts each candidate in its morphosyntactic structures with footing information percolating across tiers.

---

[1] Importance of outputs from earlier cycles also limits Harmonic Serialism (McCarthy 2000) in its usefulness to tone sandhi in Tianjin. It too requires intermediate forms be attested.

(5.2-8) **NON FINAL**

Word final syllables are not footed.

ALIGN HD RT

The head of a prosodic word is aligned at the right edge of a prosodic word.

ALIGN HD LT

The head of a prosodic word is aligned at the left edge of a prosodic word.

INTF-FT

If node A immediately dominates node B, then the foot structure of B must correspond to that in A.

/origin+al+ity/	NON FINAL	ALIGN HD RT	INTFT	ALIGN HD LT
a. o.(rì.gi)(ná.li)ty o(rì.gi)nal ity o(rí.gin) al	 *!	** ** *		*** * *
b. (ò.ri)gi(ná.li)ty (ó.ri)gi.nal ity (ó.ri)gin al		** *!** *		***
c. (ò.ri)gi(ná.li)ty o(rí.gi)nal ity (ó.ri)gin al		** ** *	* *!	*** *
d. ☞ o(rìgi)(ná.li)ty o(rígi)nal ity (óri)gin al		** ** *	 *	*** *

ICT seems to have no problems in deriving the stress pattern of “órigin”, “oríginal” and “orìginálity”, but for two pressing questions. First, there is the matter of bridging the gap between morphosyntactic and prosodic structures. Thus far, ICT has relied on prosodic structures obtainable via interface constraints. In the case here, the cycle appears to be on morphosyntactic structures, with prosodic information percolating through it. For ease of reference, I will call this the Interface problem. Second, there is the problem circumventing cyclical stress shifts with Class II affixes, which I will call the Circumvention problem

Starting with the Interface problem, note first off that ICT is not restricted to prosodic structures. While it advocates independence across phonological and morphosyntactic representations, percolation is not the sole prerogative of phonology (recall in fact, that syntax uses percolation extensively, including the percolation of focus which manifests itself as stress on the focused entity). So the main thrust of the problem lies in getting foot structures to be accessible to morphosyntactic structures, so that the interleaving between the two levels of representation can generate the effect of cyclical stress shifts over morphological concatenations. This assumption is made explicit below.

(5.2-9) Cross-representation accessibility assumption

Prosodic structural information is accessible to morphology and vice versa.

It necessary to note that (5.2-9) is not the same as interface constraints. Interface constraints allows for the calculation of some structure, say prosodic ones, given a particular morphosyntactic configuration. (5.2-9) ensures that the prosodic information is visible to morphology. (5.2-9) is in fact implicit in the treatment of many morphosyntactic phenomena. Recall for example (i) the percolation of stress (prosodic structural information) in focused constituents (a morphosyntactic representation) and (ii) the allowance for English codas to have four segments dependent on the existence of morpheme boundaries e.g. “text” [teksts]. In fact, there is an abundance of evidence that phonology and syntax interact to each other, allowing information in one to influence possibilities in the other. On the one hand there is ample evidence to divorce prosody from syntax (since many cyclic applications, say that in Tianjin, work in prosody independently of syntax) and on the other, cases like English stress where morphology is so intimately glued to the stress assignment.

Back to the case of English stress, the morphological structures may be taken for granted as part of the input, the only thing that remains to be done is to use this input to generate the foot structure that is accessible to the morphology. What the grammar needs to do here is simply generate a varied set of footing for each phonological form “origin”, “original” and “originality”, so that each foot structure may be accessible to each node in the morphosyntactic representation. The constraints in (5.2-8) would select the best footing in relation to the morphological configuration.

On the Circumvention problem, Class II affixes apparently do not affect the stress assignments of stems. It is almost as if they were extrametrical – this idea being not very different from the traditional hypothesis that stress is assigned prior to their affixation. I will take that stance here, and assume that Class II suffixes are lexically specified to be barred from stress assignment. This can be done with a constraint along the lines of ***STRESS ON CLASS II**. This will prevent any percolation from shifting stress to Class II suffixes. To illustrate this, consider the paradigm consisting of “care”, “careless” and “carelessness”.

(5.2-10) cárelessness

cáreless ness

cáre less

NON FINAL would certainly prevent “-less” from receiving stress in “careless”. However, this would not suffice at the next tier since now “-ness” is the one that NON FINAL bars from receiving stress. This is where *STRESS ON CLASS II comes in, because it will prevent “-less” from receiving stress even at this top tier. And so, Inter-tier Faithfulness constraints can continue to keep the stress on “care”.

5.3. Overapplication in Tiberian Hebrew

ICT has relied heavily on morphosyntax for much of its account on derivational opacity. However, there are some cases where opacity in phonological alternations has little relation to morphosyntactic structure. Among them is the case of Tiberian Hebrew vowel epenthesis into final consonant clusters and word-final glottal stop deletion, shown below.

(5.3-1) Tiberian Hebrew (Marlone 1993, cited in McCarthy 2000)

a. Epenthesis into final clusters: C → CV / __ C#

e.g. /melk/ → melex 'king'

b. ?-deletion outside onsets: ? → ∅ / __ #

e.g. /qaraʔ/ → qara 'he called'

c. Overapplication:

e.g. /deš?/ → deše? → [deše] 'tender grass'

epenthesis ?-deletion

In Tiberian Hebrew phonological rules overapply. This is because application of ?-deletion suffices to bleed the application of epenthesis. In traditional derivational frameworks, this state of affairs is accounted for by the counterbleeding ordering of epenthesis before ?-deletion, thereby producing the attested candidate [deše] via an intermediate form deše?, which exists neither in the lexicon nor the surface phonology as indicated by the grey shading in (5.3-1c).

5.3.1. Sympathy Theory (McCarthy 1998, 2000, Jun 1999)

This section will employ essentially the ideas of McCarthy (1998, 2000) in explaining the application of Sympathy Theory on the opacity effects seen in Tiberian Hebrew. The main idea is that opacity can be accommodated into OT: selecting a failed candidate, called the sympathetic candidate, to influence the output, and exercising that influence through a sympathy relation between the sympathetic candidate and the output. Below is a list of constraints and an OT tableau for sympathy theoretic analysis.

(5.3-2) Constraints for a Sympathy Theoretic Account

***COMPLEX**

Do not allow consonant clusters.

MAX-C

Underlying consonants must surface.

DEP-V

Surface vowels must have underlying correspondences.

CODA COND

Do not allow ʔ in codas.

❀CUMUL

A candidate under evaluation (E-Cand) is cumulative with respect to the sympathetic candidate (❀-Cand). That is, ❀-Cand has a sub-set of E-Cand's faithfulness violations.

❀DIFF

Every IO faithfulness violation incurred by E-Cand is also incurred by ❀- CandF.

Fixed Universal Ranking

❀CUMUL » ❀DIFF

/dešʔ/	CODA-COND	*COMPLEX	❀CUMUL	❀DIFF	★MAX-C	DEP-V
a.☞deše				*	*	¡*
b.☜deš			*!	*	*	
c. ❀dešeʔ	*!				✓	*
d. dešʔ	*!	*!	*!	*	✓	

In (5.3-2), the sympathetic candidate selected by the selector[2] ★MAX-C is ❀deše?. This candidate influences the ultimate choice of the optimal candidate through a sympathetic constraint ❀CUMUL which in this case requires that the vowels from the sympathetic candidate are preserved in the output. For convenience, the tenets of sympathy theory are given below.

(5.3-3) Tenets of Sympathy Theory

a. Harmonic evaluation

The sympathetic candidate is the most harmonic member of the subset of candidates available under Confinement to $C_{<+F>}$

b. Confinement to $C_{<F+>}$

Selection of the sympathetic candidate $\aleph_F$ is confined to $C_{<+F>}$, the subset of candidates that obey the IO faithfulness constraint F (i.e. the selector).

c. Invisibility of sympathy constraints

Selection of sympathetic candidates is done without reference to sympathy constraints.

While sympathy theory has been useful as a solution to Tiberian Hebrew in terms of producing counterbleeding ordering opacity effects, its application to the structure sensitive cyclicity of Mandarin appears limited. Sympathy allows for only one intermediate candidate while Mandarin cyclicity is as deep as there are embedded recursive structures. The relevant case in Mandarin tone sandhi to look at is the left-branching cases. Consider the data presented in (5.3-4).

[2] Choice of selectors is language particular.

(5.3-4) [[zong3tong3] hao3] → zong2 tong2 hao3

president good (means: Hello, Mr. President.)

Recall that with cases like (5.3-4) the tone sandhi rule is counter-bled, which is why there is over-application of the rule. Changing the middle syllable would have satisfied the OCP [T3] constraint, but instead, both the first and the second syllable were changed.

To achieve this result under sympathy theory, one would have to find a sympathetic candidate given the input in (5.3-4). It should be clear that the sympathetic candidate should be as in (5.3-5).

(5.3-5) Sympathetic Candidate for (5.3-4)

zong2tong3hao3

The candidate in (5.3-5) is a failed candidate and it is the one to which the target in (5.3-4) must sympathize. Since the first syllable in (5.3-5) has T2, the optimal candidate will be one that looks like it. To satisfy also the markedness constraint OCP [T3], the optimal candidate will be one that changes the second syllable to tong2. With this in mind, the next tableau illustrates that in order for the correct sympathetic candidate to be chosen, the selector constraint has to be IDENT RT.

(5.3-6) Identifying the sympathetic candidate

OCP [T3]

Do not have adjacent T3.

IDENT RT

An input must have an identical correspondent in the output if it is on the right edge of a branching constituent.

IDENT LT[3]

An input must have an identical correspondent in the output if it is on the left edge of a branching constituent.

Input: $((T_3T_3)T_3)$	★IDENT RT	OCP [T3]	IDENT LT
i. ❀$T_2T_3T_3$ ~ ii. $T_3T_3T_3$		W	L
i. ❀$T_2T_3T_3$ ~ iii. $T_2T_2T_3$	W	L	
i. ❀$T_2T_3T_3$ ~ iv. $T_3T_2T_3$	W	L	L
i. ❀$T_2T_3T_3$ ~ v. $T_2T_3T_2$	W	L	
i. ❀$T_2T_3T_3$ ~ vi. $T_3T_3T_2$	W		L
i. ❀$T_2T_3T_3$ ~ vii. $T_2T_2T_2$	W	L	

As may be seen from the above comparative tableau, the only way for the desired sympathetic candidate to be chosen is to use IDENT RT as the selector, together with a ranking hierarchy where OCP [T3] outranks IDENT LT. Any other constraint as selector will produce a different sympathetic candidate. On this basis, ❀CUMUL may then step in to identify the optimal candidate. It is the candidate that shares all the faithfulness violations of the sympathy candidate plus some faithfulness violations of its own, i.e. candidate (iii) T2T2T3. In fact, among all the available candidates, this is the candidate that is least different (hence most sympathetic) to the sympathy candidate, since on top of

[3] I have experimented with a general IDENT constraint on tonal identity to disastrous effects. It appears that the most straightforward way of ensuring a sympathy account to work is to somehow allow the optimal candidate to compare with the sympathetic candidate on the faithfulness violation of the left-edge tone.

having all the same faithfulness violation as the sympathy candidate, it only has one additional violation of IDENT RT, shown below.

(5.3-7) Identifying the optimal candidate

Input: $((T_3T_3)T_3)$	OCP [T3]	★IDENT RT	❀CUMUL	IDENT LT
i. ❀$T_2T_3T_3$	*!			*
ii. $T_3T_3T_3$	**!		*	
iii.☞ $T_2T_2T_3$		*		*
iv. $T_3T_2T_3$		*	*!	
v. $T_2T_3T_2$		*!		*
vi. $T_3T_3T_2$	*!	*	*	
vii. $T_2T_2T_2$		**!		*

Problems arise when one considers left-branching inputs with four T3s. With /(((T3T3)T3)T3)/, the required sympathy candidate would have to be T2T2T3T3, but the selector does not seem to pick it out.

(5.3-8)

Input: $((T_3T_3)T_3)T_3)$	OCP [T3]	★IDENT RT	❀CUMUL	IDENT LT
i. $T_2T_2T_3T_3$	*!	*		*
ii. ❀$T_2T_3T_3T_3$	*!*			*
iii. ⚐$T_2T_2T_2T_3$		**		*
iv. 💣$T_2T_3T_2T_3$		*		*

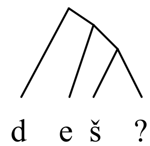
With T2T3T3T3 as the sympathetic candidate, then given ❀CUMUL, a few other candidates can be considered as the optimal output. Consider first (i) T2T2T3T3, which has all the faithfulness violation of T2T3T3T3 plus one more IDENTR violation of its own. One can rule this candidate out if ❀CUMUL is ranked below OCP [T3]. This move however will not yield the desired (iii)T2T2T2TT3, because there is still candidate (iv)T2T3T2T3. This candidate (iv) not only satisfies OCP [T3], it is on par with candidate (ii) as far as ❀CUMUL is concerned. There is no way one could get the desired candidate (iii) since (iii) is harmonically bound by (iv). So far as the attempt here represents the application of sympathy theory, Mandarin cyclicity limits its usefulness. This is because sympathy theory provides only one intermediate step of the cyclical derivation. In cyclicity of the kind exhibited in Mandarin, sometimes more than one intermediary is required to reach the actual output.

5.3.2. ICT ON OVERAPPLICATION IN TIBERIAN HEBREW

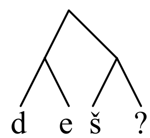
An important insight Sympathy Theory has on Tiberian Hebrew is an explanation of the status of the intermediate form of opaque derivations. This form is a failed candidate. For ICT to be comparably useful, it too has to capture the overapplication effect in Tiberian Hebrew while explaining why the intermediate form deše? is not attested in the language.

Given an input like /deš?/, under ICT, a set of possible phonological structures could be generated. Among them are the following, each grouping is some kind of a phonological constituent (i.e. syllable, coda, onset, rime, etc):

(5.3-9) a.



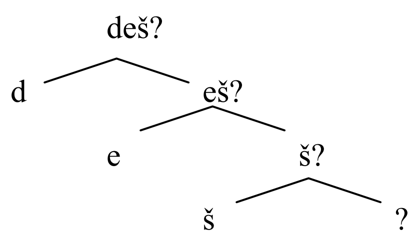
b.



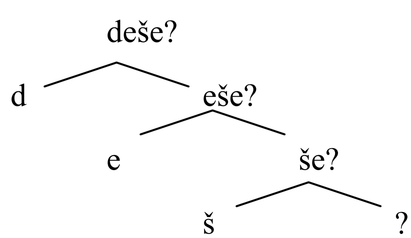
A representation like (5.3-9a) would treat deš? as one syllable but (5.3-9) would potentially give the effect of two syllables. By ICT, each non-terminal node would have information corresponding, in varying degree, to the nodes it dominates. We can thus imagine a set of candidates corresponding to each structure varying in the kinds of information that is percolated.

(5.3-10) Candidates for /deš?/

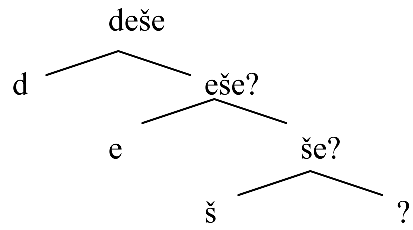
i.



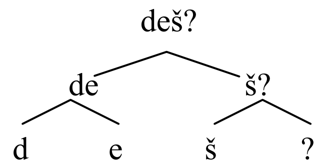
ii.



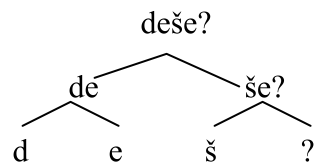
iii.



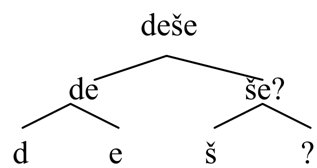
iv.



v.



vi.



With a set of candidates as above, either the selection of candidate (ii) or (vi) suffices to produce the optimal output. Candidate (iii) nonetheless is weird in that it appears to claim dese as monosyllabic, contrary to sonority peak requirements. As such we shall assume candidate (vi) as the attested optimal.

That said, a comparative tableau[4] is used below to figure out the ranking hierarchy. Constraints are similar to those given in McCarthy (1998), modified to match ICT terms.

(5.3-11) Constraints for Tiberian Hebrew

Syllable structure (**SYLL STRUC**)

A syllable must have only one sonority peak.

***CC**

Do not allow consonant clusters (word finally).

INTF-V

Vowels correspond across tiers.

INTF-C

Consonants correspond across tiers..

CODA COND (ROOT EFFECTIVE)

Do not allow ? in codas.

/deš?/	**CODA COND**	***CC**	**INTF-V**	**INTF-C**	**SYLL STRUC**
Candidate (vi) ~ (i)	W	W	L	L	
Candidate (vi) ~ (ii)	W			L	W
Candidate (vi) ~ (iii)					W
Candidate (vi) ~ (iv)		W	L	L	
Candidate (vi) ~ (v)	W			L	

[4] Actual tableau given here. Note that except for CODA COND, all are evaluated at every tier.

/deš?/	**CODA COND**	***CC**	**INTF-V**	**INTF-C**	**SYLL STRUC**
(i)	*!	***			
(ii)	*!		*		**
(iii)			*	*	*!*
(iv)		*!*			
(v)	*!		*		
☞ (vi)			*	*	

It is important to note that except for the CODA COND, all constraints are evaluated with inter-tier effectiveness. The CODA COND is crucially assumed here to be root-effective only.

Recall that Tiberian Hebrew's challenge to ICT calls for more than picking out the attested form. It also requires a statement to be made about derivationally intermediate forms like deše? which appears nowhere in the language. To the second question, ICT's answer is that nowhere in the optimal candidate does deše? appear as a single constituent. The question therefore does not arise and is in fact predicted not to exist in the language.[5]

There is no doubt that treatment on Tiberian Hebrew here is simplistic, resting in fact on cases of the type CVCC, where the final C could be the glottal [?], illustrated with /deš?/. The treatment has also not paid attention to an important aspect of vowel-epenthesis in Tiberian Hebrew. In Tiberian Hebrew, stress is on the ultimate syllable unless that syllable is the result of epenthesis[6], i.e. epenthesis displaces stress. Under ICT, the layers of percolation potentially makes the epenthetic status of [e] invisible at higher tiers, with the consequence that the ICT analysis presented above would never correctly predict the location of stress for cases such as /deš?/. This problem can be easily resolved by assuming that epenthesis really inserts an empty vowel slot between [š] and [?] to become [š_?]. The melodic content is filled in at the root node when stress assignment also takes place. This guarantees the visibility of the epenthetic status of [e]. Evidence for this move comes from the fact that the choice of epenthetic vowels varies between [a] and [e].

---

[5] This might be a good example to show that ICT is unlike traditional derivations. Surely the tiers here do not match the procedural steps of traditional derivations.

(5.3-12) deše ← melodic content of epenthetic vowel and stress done here

de š_?

d e š ?

As may be seen in (5.3-12), the empty slot will ensure the visibility of the epenthetic status of the vowel, so that at the root node, one can still have constraints that prevent stress from being assigned to it, thereby producing the effect of stress displacement by such vowels.

The point here is that opacity effects pertaining to segmental phonology may not be beyond the reach of ICT. In the case of Tiberian Hebrew, it is done by recognition of the fact that segments together constitute phonological constituencies too, such as syllable, coda, onset, rime and so on.

5.4. Yokuts rounding, lowering and shortening

The vowel system of Yokuts (Yawelmani) exhibits phonological opacity involving three different processes: rounding harmony, lowering and shortening (Kiparsky to appear, citing Newman 1944, Kuroda 1967 and other antecedent works.). Because this section shall be discussing Stratal OT, discussion in this section relies heavily on Kiparsky (to appear)

[6] Thanks to Alan Prince (p.c.) for pointing this out.

(5.4-1) Yokuts vowel alternation rules (from Kiparsky to appear)

a. Rounding Harmony

Rounding spreads rightwards between vowels of the same height.

e.g. /cu:m-i:n/ → [co:mon] "will devour"

(with lowering, see below)

b. Lowering

Long vowels become mid vowels.

e.g. /cu:m-al/ → [co:mal] "devour (dubitative)"

c. Shortening

Long vowels are shortened in closed syllables.

e.g. /do:s-hin/ → [doshin] "report (aorist)"

Opacity effects emerge when one considers cases where potentially all three rules above can apply, such as the one below.

(5.4-2) /cu:m-hin/ → [comhun] "devour (aorist)"

Derivation:

/cu:m-hin/
↓ Rounding Harmony
cu:mhun
↓ Lowering
co:mhun
↓ Shortening
[comhun]

As may be seen in (5.4-2), ordering of the rules in any other way will not produce the correct results. It is also clear that the rules are applying in counterbleeding order, for example, Lowering could bleed Rounding Harmony. The application of all three “rules” is attested in a vast number of words in the language of all morphological categories, in derived environments and morpheme internally (Kiparsky to appear).

5.4.1. Stratal OT (Kiparsky 2000, 2002, to appear)

Stratal OT is a serial model where constraints are layered into various strata, thereby marrying the insights of Lexical Phonology (LP) (Kiparsky 1982a, b, Mohanan 1986, Hargus and Kaisse 1993 and many others) and parallel OT models (Kiparsky 2000, 2002, to appear). Opacity could therefore result when the markedness requirements at one stratum is different from the next. Each stratum corresponds to a level in LP.

(5.4-3) Model of Stratal OT

Stem phonology ➔ Word phonology ➔ Postlexical Phonology

(LP’s Level 1) (LP’s Level 2)

By layering constraints as in (5.4-3), the opacity effects of Yokuts are captured in Stratal OT in the following way:

(5.4-4) a. Constraints (from Kiparsky to appear)

IDENT-σ_1(ROUND)

A segment in an initial syllable must have the same value for [round] as its I/O correspondent.

ID [RD]

A segment must have the same value for [round] as its I/O correspondent.

ID [HIGH]

A segment must have the same value for [high] as its I/O correspondent.

MAX-μ

Preserve input syllable weight in outputs.

αHI/βRD

Every path including [αhigh_i] includes [βround_j]. (Successive vowels of the same height have the same rounding).

***[+RD]**

No vowel is [+round].

***[HIVV]**

Do not have long high vowels.

***[μμμ]$_\sigma$**

Do not allow trimoraic syllables (*VVC)

b. Tableaux

Stem level

/cu:m-hin/	MAX-μ	ID [HI]	ID-σ1(RD)	αHI/βRD	*[+RD]	ID [RD]
i. co:mhun		*!			**	*
ii. co:mhin		*!			*	
iii. ☞cu:mhun					**	*
iv. cu:mhin				*!	*	
v. cumhun	*!				**	*
vi. cimhin			*!			*

Word level

/cu:mhun/	*[HIVV]	MAX-μ	ID [RD]	αHI/βRD	*[+RD]
i. ☞co:mhun					**
ii. cu:mhun	*!				**
iii. co:mhin			*!		*
iv. cu:mhin	*!		*	*	
v. cumhun		*!			**

Postlexical level

/co:mhun/	*[μμμ]σ	MAX-μ	ID [HI]	ID [RD]
i. ☞comhun		*		
ii. cumhun		*	*!	
iii. co:mhin	*!		*	
iv. comhin		*		*!
v. cu:mhun	*!		*	
vi. co:mhun	*!			

Notice that in the Stratal OT account, inputs to each layer is dependent on the output of the antecedent layer. Further, constraints in the different layers have different rankings. This ensures that at each layer, different alternation processes yields greater harmony.

The limiting case for Stratal OT would be opacity within a single stratum. Its reliance on outputs of antecedent layers makes it vulnerable to cases where opacity effects occur within a single layer. In the case of Mandarin, cyclic effects are observed in the postlexical (even lexical) layer since tone sandhi applies recursively over the structures. This is true in the case of Tianjin too. In Tianjin, borrowed words like yi.da.li

"Italy" (recall Transderivational Faithfulness Theory, section 5.2.1) also stretch the limits of Stratal OT. Recall that this monomorphemic form requires tone sandhi to apply opaquely first to the initial ditonal substring before applying to the final ditonal substring.

This situation puts even Lexical Phonology (LP) to the test. Monomorphemic forms are not environments for cyclicity in LP (Non-derived Environment Blocking (NDEB), Kiparsky 1982b). ICT makes no such restrictions because in treating Tianjin and Mandarin, cyclicity was not operational on morphosyntactic structures but rather on prosodic structures (an insight well-argued in Inkelas 1993). This does not mean that ICT allows cyclicity to apply freely in monomorphemic forms. The main idea behind the NDEB is that certain cyclic effects apply to morphosyntactic structures, wherein indeed cyclical effects are not possible within monomorphemic environments. This harks back to the discussion on English Stress in section 5.2, which ICT addresses by recognizing that inter-tier correspondence applies as much to morphosyntax as it does to phonology. Thus when applied to morphosyntax, NDEB falls out as a natural consequence because monomorphemic items are at the terminal nodes where cyclical effects cannot possibly apply (terminal nodes offer no room for opacity effect under the OT set-up used here). On the other extreme, the cyclic effects observed in Mandarin and Tianjin apply to sentential domains which are post-lexical (therefore post-cyclic). Unless LP relaxes this requirement to allow to cyclic processes to apply at the post-lexical level, it is hard to see how it may be applicable to Mandarin and Tianjin.

5.4.2. ICT on Yokuts

Yokuts presents an interesting challenge to ICT. Using /cu:m-hin/ as an example, notice that there is only one morpheme boundary, effectively giving us the morphosyntactic structure in (5.4-5)

(5.4-5)

cu:m hin

With such simple structures, how can ICT evoke three ordered alternations within one percolation? The problem of opacity persists. An interesting parallel between Stratal OT and ICT may be observed here. Both cannot capture (deep) opacity – Stratal OT fails when opacity occurs within a single stratum while ICT fails when opacity happens within relatively simplex structures.

To wriggle out of this conundrum, note that Stratal OT and ICT do not stand in conflict with each other. ICT is a theory about structural representations of candidates while Stratal OT is a theory about the configuration of the EVAL module. There is no a priori reason why one cannot cross Stratal OT with ICT. If we allow for there to be strata, and for ICT-enriched representations of candidates, then neither Yokuts nor Tianjin present any problems. Once this allowance is made, the analysis of /cu:m-hin/ may be recast into ICT would look something like the following:

(5.4-6) Crossing Stratal OT with ICT

Stem level

/cu:m-hin/	INTF-μ	INTF [HI]	INTF-σ_1(RD)	αHI/βRD	*[+RD]	INTF [RD]
i. co:mhun cu:m hin		*!			**	*
ii. co:mhin cu:m hin		*!			*	
iii. ☞cu:mhun cu:m hin					**	*
iv. cu:mhin cu:m hin				*!	*	
v. cumhun cu:m hin	*!				**	*
vi. cimhin cu:m hin			*!			*

Needless to say, beyond the stem level, there are two other levels as laid out by Stratal OT. The combination of these two theories appears to be trivial, because they address separate issues. Enriching the representations in Yokuts appears to have a vacuous effect other than making Stratal OT useful for phenomena found in Mandarin and Tianjin. Likewise, ICT does not gain much from this cross-breeding other than becoming compatible with Yokuts data. However, the facts of the languages (Mandarin, Tianjin and Yokuts) demand that any account must separate out the different levels (due to the depth of Yokuts opacity given simple structures) and the different tiers (due to the depth of tone sandhi opacity determined by structural depth), falling short of which would make the facts incomprehensible.

Another way of accommodating Yokuts into ICT is to actually assume as many structures on the representation of /cu:m-hin/ as there are strata, such as below.

(5.4-7)

(5.4-7)	comhun	postlexical level
	co:mhun	word level
	cu:m-hun	stem level
	cu:m hin	

(5.4-7) is in fact not as far-fetched as it may look. Recall in Chapter Four that Mandarin neutralization is assumed to have suffixation of a null morpheme. If Kiparsky is right about the various strata, then structures like (5.4-7) is in fact allowed. This will provide enough structure for ICT to describe the opacity effects observed in Yokuts.

Looking at (5.4-4b), and especially at tableaux for Word Level and Postlexical Level, notice that *[$_{HI}$VV] is responsible for selecting [co:mhun] at the Word Level while *[μμμ]$_{\sigma}$ finally selects the optimal candidate at the Postlexical Level. Given (5.4-6), all one needs to do is to stipulate the tier at which these two constraints apply[7], and Inter-tier Faithfulness will guarantee the correct results by allowing no other modifications be made from cu:m-hum where rounding harmony has applied.

5.5. Summary

Various interface constraints provide domains for cyclicity as well as sufficient structures for depth in opacity. Uner ICT, terminals (usually monomorphemic) would therefore not constitute certain marked collocations. Thus, ICT relates itself to the components necessary to a general theory of cyclicity laid out by Cole (1995). Sensu stricto, ICT does not limit enriched structural representations to phonological ones, and so may capture cyclicity in stress systems such as English. Opacity found in segmental phonology is not beyond the reaches of ICT because segments themselves organize to make phonological constituents such as onset, rimes, nuclei and codas. This was demonstrated with Tiberian Hebrew and to some extent Yokuts. Yokuts data highlight a shortcoming of ICT in that there is opacity which depths do not match morpho-phonological structures, but this is resolvable by a trivial combination with Stratal OT.

[7] One may not reduce the number of tiers or allow for both *$[_{\text{HI}}$VV] and *$[\mu\mu\mu]_\sigma$ to apply at the same level. This is because the effects of these two constraints stand in counterbleeding orders.

CONCLUSION

Inter-tier Correspondence Theory (ICT) is a theory of candidate structure. By appealing to the percolation of information across nodes that stand in immediate domination, ICT captures effects of opacity and transparency all in one fell swoop. This is especially important and useful in analyzing languages such as Mandarin and Tianjin where both opaque and transparent derivational effects are simultaneously attested.

ICT requires that GEN produces candidates with all the relevant structures. This in itself is not new, since GEN is responsible for generating the optimal structural configuration given any linear input. What is new here is that each node in the structure carries information that corresponds to lower nodes, albeit imperfectly when warranted by high-ranked markedness requirements. Under ICT, mere adjacency does not count as marked collocations, it is constituency that does. Because of this property, terminal nodes always match the input string. This naturally yields the Non-Derived Environment Blocking effect required in traditional derivational frameworks. With the terminals stable (as they are not marked environments), faithful or unfaithful correspondences at higher nodes are determined by markedness.

The stability of terminals and their percolation upwards across tiers has the consequence of marrying both the containment and correspondence approaches of optimality theory. The effect of each candidate containing the input is captured in the terminals while the matter of correspondence is done across tiers. The containment approach to optimality theory easily captures opaque phenomena by way of preservation of input alternation-triggering environments. In ICT, this is possible because the triggering environment is “ordered” in the way hierarchical structures are layered. ICT is therefore more restrictive because opacity cannot occur freely, it necessarily depends on structural configuration. Unlike the containment approach, the correspondence approach to optimality theory comfortably deals with transparent effects. This is because, under the correspondence approach, all alternation-triggering environments must be at the surface and must be resolved. It removes the awkwardness of expressing how one entity may simultaneously contain its previous carnation. To see this, imagine an alternation where /+voice/ → [-voice], which under containment would require opposite specifications of a feature to contain each other. Under the correspondence approach, the two features simply correspond. ICT preserves the merits of correspondence theory in the most straightforward way – the correspondence of information across tiers. There is, however, one difference between ICT and the traditional correspondence approach. The traditional view of correspondence is global, i.e. between inputs and outputs with nothing in between. ICT’s correspondence does not leap from terminals to root, but happens via all the nodes in between. In that sense, inter-tier correspondence is local.

Correspondences of information across tiers lead to the appearance of encoding derivational histories, with intermediate tiers as intermediate steps of derivations. If this were true, then ICT is no more than a translation of derivations into optimality theoretic terms, which is not true. The appearance of derivation history in ICT comes from the hierarchical structures, not from derivations. Tianjin unambiguously illustrates this as it is the selection of prosodic structures that account for the “direction flip”. Tianjin tritonal sandhi directionality cannot be a comparison of derivational histories simply because (i) transparent derivation histories would always be more “faithful/economical” (depending on whether one uses parallel or serial terminology) while being equally unmarked and (ii) there is simply no well-established reason for such a framework. Tianjin's directionality effect really stems from selection of the most harmonic prosodic structures under satisfaction of OCP. Therefore, ICT cannot be a matter of encoding derivational history. That said, there can be no question on what status is attributed to intermediate tiers. Traditional theories not devoid of structures, and ICT views intermediate tiers the same way as traditional theories do. That intermediate tiers carry information is not comparable with the intermediate steps in derivational theories except by way of convenient analogy.

A logical consequence of ICT is that root nodes look like the output string in traditional theories (derivational or optimality theoretic). However, to think of the root node as an output is to misconstrue each structural representation as a derivation. In fact, each structure is simply a way of organizing the input string, such that certain constituencies have certain correspondence relation with their mothers and daughters. To see the point from a somewhat different perspective, let us assume a traditional non-ICT structural representation. Is that structure an output? Does the output contain the structure? If yes, then it shares the same view with ICT – the physical acoustic signal may be devoid of structures, but the linguistic reality of it is not. If no, then traditional view must have some means of removing all that structure to leave only a linear string behind, which to be fair, so can ICT.

Perhaps a good way to view ICT is to consider a multi-layered club sandwich. In the making, layers are put in order, but in the eating, it hardly matters.

REFERENCES:

Bakovic, Eric. 2002. Vowel harmony and stem identity. PhD dissertation, Rutgers University. ROA#540.

Bao, Zhi-ming. 1990. On the Nature of Tone. PhD dissertation, MIT, Cambridge, Massachusetts.

Bao, Zhi-ming. 1999. The Structure of Tone. New York: Oxford Univ. Press.

Beckman, Jill. 1998. Positional Faithfulness. PhD dissertation, UMASS, Amherst, MA: Graduate Linguistic Student Association. ROA#234.

Beijing Univeristy, Department of Chinese languages and literature. 1995. Hanyu Fangyan Cihui. (A lexicon of Chinese dialects). Beijing: Yuwen Chubanshe. (In Chinese).

Benua, Laura. 1997. Transderivational Identity: Phonological Relations Between Words. PhD dissertation, UMASS, Amherst, MA: Graduate Linguistic Student Association, ROA#259.

Chao, Yuen-Ren. 1930. A System of Tone Letters. La Maître phonétique. 45:24-27.

Chao, Yuen-Ren. 1968. A grammar of spoken Chinese. Berkeley: Univ. of California Press.

Chen, Matthew Y. 1979. Metrical Structure: Evidence from Chinese Poetry. Linguistic Inquiry 10:371-420.

Chen, Matthew Y. 1984. Unfolding latent principles of literary taste - poetry as a window into language. In The Tsing Hua Journal of Chinese Studies, 1984. Taiwan.

Chen, Matthew Y. 1985. Tianjin tone sandhi: erratic rule application? Ms., Univ. of California, San Diego.

Chen, Matthew Y. 1986. The paradox of Tianjin tone sandhi. CLS 22:98-154.

Chen, Matthew Y. 1987. Introductory remarks to a symposium on Tianjin tone sandhi. Journal of Chinese Linguistics 15:203-227.

Chen, Matthew Y. 2000. Tone Sandhi: Patterns across Chinese dialects. Cambridge Univ. Press.

Chen, Matthew Y. 2002. Changting Hakka tone sandhi. Paper presented at the Eighth International Symposium on Chinese Languages and Linguistics. Academia Sinica, Taipei.

Chen, Matthew Y, Xiuhong Yan and Lian-Hee Wee. 2003. Hakka tone sandhi: Corpus and Analytical Challenges. Monograph 413 pp. City University of Hong Kong.

Cheng, Chin-Chuan. 1968. Mandarin Phonology. PhD dissertation, Univ. of Illinois at Urbana-Champaign. [Published as A Synchronic Phonology of Mandarin Chinese. The Hague: Mouton, 1973.]

Chomsky, Noam. 1957. Syntactic Structures. The Hague, Mouton.

Chomsky, Noam. 1970. Remarks on Nominalization. In Jacobs and Rosenbaum (eds), English Transformational Grammar. 184-221.

Chomsky, Noam. 1981. Lectures on Government and Binding: the Pisa lectures. Mouton de Gruyter. Berlin, New York.

Chomsky, Noam and Morris Halle. 1968. The Sound Pattern of English. New York: Harper and Row.

Cinque, Guglielmo. 1993. A Null Theory of Phrase and Compound Stress. Linguistic Inquiry 24 : 239-298.

Clark, Mary M. 1992. Representation of downstep in Dschang Bamileke. In Harry van der Hulst and Keith Snider eds. The Phonology of Tone: The Representation of Tonal Register. Mouton de Gruyter. Pp. 29-74.

Clements, George N. and Kevin C. Ford. 1979. Kikuyu tone shift and its synchronic consequences. Linguistic Inquiry 10:179-210.

Cole, Jennifer. 1995. The cycle in Phonology. In Goldsmith (1995) pp. 70-113.

Crowhurst, Megan and Mark Hewitt. 1995. Directional footing, degeneracy, and alignment. Ms., UNC Chapel Hill and Brandeis Univ. ROA#65.

De Lacy, Paul. 1999. Tone and Prominence. Ms., UMASS Amherst.

De Lacy, Paul. 2003. The interaction of tone and stress in optimality theory. Phonology 19:1:1-32.

Duanmu, San. 1989. Cyclicity and the Mandarin Third Tone Sandhi. Ms., MIT.

Duanmu, San. 1990. A Formal Study of Syllable, Tone, Stress and Domain in Chinese Languages. PhD dissertation, MIT.

Duanmu, San. 2000. The phonology of standard Chinese. Oxford Univ. Press.

Duanmu, San. 2002. Two theories on onset clusters. In Chinese Phonology vol. Special edition. Association of Chinese phonology, Taiwan.

Gao, Mingkai and Shi, Anshi. 1963. Yuyanxue Gailun. [Introduction to linguistics]. Beijing: Zhonghua Shuju. (In Chinese).

Goldsmith, John (ed). 1995. The handbook of phonological theory. Cambridge: Blackwell.

Grimshaw, Jane. 1991. Extended Projections. MS. Brandeis Univ.

Halle, Morris, James W. Harris and Jean-Roger Vergnaud. 1991. A reexamination of the stress erasure convention and Spanish stress. Linguistic Inquiry 22:141-159.

Hargus, Sharon and Ellen M. Kaisse eds. 1993. Phonetics and phonology – studies in lexical phonology. San Diego, CA: Academic Press.

Hayes, Bruce. 1995. Metrical Stress Theory: Principles and Case Studies. Univ. of Chicago Press.

Hirayama, Hisao. 1984. Jianghuai fangyan zudiaozhi gouni he beifang fangyan zudiaozhi chu tan. YuYan 1984(1):185-199. (In Chinese).

Hirayama, Hisao. 1991. Hanyu shengdiao qiyuan kuitan. [A preliminary study of the genesis of Chinese tone]. YuYan 1991(1):145-151. (In Chinese).

Horwood, Graham. 2000. Anti-Identity and Taiwanese Tone Sandhi. Ms., Rutgers Univ.

Hsu, Hui-chuan. 2002. More on One Step Principle in Tonal Derivation. Ms., National Chiao Tung University. Taiwan.

Hung, Tony. 1987. Syntactic and Semantic aspects of Chinese Tone Sandhi. PhD dissertation, Univ. of California, San Diego. [Indiana Univ. Linguistic Club.]

Hyman, Larry and Kenneth van Bik. 2002. Output problems in Hakha Lai – or: What's (not) Chinese about Directional Tone Sandhi. Draft of paper prepared for the 8th International symposium on Chinese Languages and Linguistics, Institute of Linguistics, Academia Sinica.

Inkelas, Sharon. 1993. Deriving cyclicity. In Hargus, Sharon and Ellen M. Kaisse, eds. 1993.

Itô, Junko. 1986. Syllable theory in prosody phonology. PhD dissertation, UMASS, Amherst [published 1988, Garland: New York].

Itô, Junko. 1989. A prosodic theory of epenthesis. NLLT 7:217-60.

Jackendoff, Ray. 1972. Semantic interpretation in generative grammar. Cambridge, Mass., MIT Press.

Jackendoff, Ray. 1977. X'-syntax: a study of phrase structure. Cambridge, Mass: MIT Press.

Jesperson, Otto. 1924 The philosophy of grammar. London: Allen and Unwin.

Jun, Jongho. 1999. Generalized Sympathy. NELS 29. ROA#297.

Kager, René. 1994. On eliminating directional foot parsing. In H.P. Kolb ed, GLOW 32:31.

Kager, René. 1995. The metrical theory of word stress. In Goldsmith 1995: 367-402.

Kager, René. 1999. Optimality Theory. Cambridge Univ. Press.

Kaisse, Ellen M. 1985. Connected Speech: the Interaction of Syntax and Phonology. Orlando: Academic Press.

Kenstowicz, Michael. 1994. Phonology in Generative Grammar. Cambridge, Mass. and Oxford, UK: Blackwell.

Kiparsky, Paul. 1982a. From cyclic phonology to lexical phonology. In H. van der Hulst and N. Smith eds. The structure of phonological representations vol 1. 131-175. Dordrecht: Foris.

Kiparsky, Paul. 1982b. "Lexical Phonology and Morphology." In Linguistics in the Morning Calm. Seoul: Hanshin. 3-91.

Kiparsky, Paul. 2000. Opacity and Cyclicity. The Linguistic Review 17:351-367, 2000.

Kiparsky, Paul. 2002. Syllables and moras in Arabic. In C. Fery and R. Vijver (ed.) The Syllable in Optimality Theory. Cambridge University Press, 2002. In press.

Kiparsky, Paul. To appear. Opacity and Paradigm Effects. Stanford: CSLI.

Kuroda, S.-Y. 1967. Yawelmani Phonology. Cambridge, Mass.: MIT Press.

LaCharité, Darlene and Carole Paradis. 1999. Derivational Residue: Hidden Rules in Optimality Theory. In Dekkers, Joost, Frank van der Leeuw and Jeroen van de Weijer (eds). OptimalityTheory. Oxford Univ.Press. pp. 211-233.

Li, Weimin. 1981. Shi lun qingsheng he zhongyin. [A preliminary discussion on stressless and stressed syllables]. ZhongGuoYuWen 1981:1:35-40. (In Chinese).

Li, Xingjian and Sixun Liu. 1985. Tianjin fangyan de liandu biandiao [Tone Sandhi in the Tianjin dialect]. ZhongGuoYuWen 76-80. (In Chinese).

Liberman, Mark. 1975. The intonational system of English. PhD diss., MIT. Distributed by IULC.

Liberman, Mark and Alan Prince. 1977. On stress and linguistic rhythm. Linguistic Inquiry 8:249-336.

Lieber, R. (1980). On the organization of the lexicon. PhD dissertation, MIT.

Lin, Hui-shan. 2002.Constraint reranking and Mandarin tone sandhi. In Chinese Phonology vol 11 (special issue) on "Glide, Syllable and Tone". Taipei: Association of Chinese Phonology,

Lin, M-C, Jingzhu Yan and Guohua Sun. 1984. Beijinghua lianzizu zhengchang zhongyin de chubu shiyan [Experimental explorations in the normal accentuation of disyllabic constructions in Beijing]. FangYan 57-73. (In Chinese).

Liu, Feng-Hsi. 1980. Mandarin Tone Sandhi: A Case of Interaction between Syntax and Phonology. Ms., Univ. of Iowa.

Lu, Jilun. 1997. Tianjin fangyan zhong de yizhong xin de liandu biandiao. [A new tone sandhi in the Tianjin dialect]. Tianjin Shifan Xuebao 1997 vol. 4. pp. 67-72. (In Chinese).

Marlone, Joseph L. 1993. Tiberian Hebrew Phonology. Winona Lake, IN: Eisenbrauns.

McCarthy, John 1979. Formal problems in Semitic phonology and morphology. PhD dissertation, MIT [published 1985, NewYork:Garland].

McCarthy, John. 1998. Sympathy and Phonological Opacity. ROA#252.

McCarthy, John. 2000. Harmonic Serialism and Parallelism. ROA#357.

McCarthy, John. 2002. Comparative Markedness. ROA#489.

McCarthy, John and Alan Prince. 1993. Generalized Alignment. In Geert Booiji and Japp van Marie eds. Yearbook of morphology 1993. Dordrecht: Kluwer. 79-153. Technical Report #7, Rutgers Univ. Center for Cognitive Sciences, 1993. ROA#7.

McCarthy, John and Alan Prince. 1995. Faithfulness and Reduplicative Identity. In Jill Beckman, Laura Walsh Dickey and Suzzane Urbanczyk eds. Univ. of Mass. Occasional Papers in Linguistics 18: Papers in optimality theory. 249-384. Also in René Kager, Harry van der Hulst and Wim Zonneveld eds. The prosody morphology interface. ROA#60.

Mester, Armin and Jaye Padgett. 1993. Directional syllabification in Generalized Alignment. In Jason Merchant, Jaye Padgett and Rachel Walker eds. Phonology a Santa Cruz 3:79-86. Santa Cruz, LRC. ROA#1.

Milliken, S., G-P. Zhang X-Y. Zhang, Z-Q. Li and Y. Lü. 1997. Resolving the paradox of Tianjin tone sandhi. . In Wang Jialing and Norval Smith eds. Studies in Chinese Phonology. Mouton de Gruyter. New York. 53-80.

Mohanan, K.P. 1986. Lexical Phonology. PhD dissertation, MIT.

Mohanan, K. P. 1995. The Organization of the Grammar. In J. Goldsmith (ed.), The Handbook of Phonological Theory (pp.24-70). Blackwell..

Myers, Scott. 1991. Persistent Rules. Linguistic Inquiry 22:315-344.

Nelson, Nicole. 1998. Right anchor, aweigh. Ms., Rutgers Univ. ROA#284.

Newman, Stanley. 1944. Yokuts language in California. (Viking Fund Publications in Anthropology 2.) New York: Viking Fund.

Odden, David. 1995. Tone: African Languages. In Goldsmith 1995: 444-475.

Odden, David. 2000. Ordering. Ms., Ohio State Univ.

Orgun, Orhan C. 1996a. Sign-based morphology and phonology with special attention to optimality theory. PhD dissertation, Univ. of California, Berkeley. ROA#171.

Orgun, C Orhan. 1996b. Sign-based morphology: a theory of phonology-morphology interleaving. MS. Univ. of CA. Berkeley. ROA#122.

Pater, Joe. 1995. On the nonuniformity of weight-to-stress and stress preservation effects in English. MS., McGill Univ. ROA #107. Published as “Nonuniformity in English Stress: the role of ranked and lexically specific constraints” in Phonology 17:2:237-274.

Pollard, Carl and Ivan Sag. 1994. Head-driven Phrase Structure Grammar. Chicago: University of Chicago Press.

Pulleyblank, Douglas. 1986. Tone in Lexical Phonology. Dordrecht: Reidel Publishing Company.

Prince, Alan. 1990. Quantitative consequences of rhythmic organization. In CLS 26 (Chicago: Chicago Linguistic Society 1992):355- 98.

Prince, Alan and Paul Smolensky. 1993/2002. Optimality Theory: Constraint Interaction in Generative Grammar. MS: Rutgers Univ. and Univ. of Colorado, Boulder. ROA#537.

Radford. Andrew. 1988. Transformational Grammar: A First Course. Cambridge Univ. Press.

Rice, Karen. 1987. On Defining the Intonational Phrase: Evidence from Slave. Phonology Yearbook 4:37-59.

Rooth, Mats. 1992. A theory of focus interpretation. Natural Language Semantics 1. 75-116.

Rooth, Mats. 1996. On the interface principles for intonation focus. In Proceedings of SALT VI.

Selkirk, Elizabeth O. 1984. Phonology and Syntax: the relation between sound and structure. MIT Press.

Selkirk, Elizabeth O. 1995. The Prosodic Structure of Function Words. In Univ. of Massachusetts Occasional Papers: 18 in Optimality Theory. pp. 77-136. Amherst, MA: Graduate Linguistic Student Association.

Shi, Feng. 1988. Shi lun Tianjin de shengdiao ji qi bianhua [On Tianjin tones and their sandhi behavior]. Zhongguo Yuwen 351-360.

Shi, Feng. 1990. Zai lun Tianjin de shengdiao ji qi bianhua [Tianjin tones and their sandhi behavior-revisited]. YuYan 2 (Reprinted in S. Feng, Studies in Tone and Stops. Beijing Univ. Press, 101-117, in Chinese).

Shieber, Stuart. 1986. An introduction to unification-based approaches to grammar. Stanford: CSLI publications.

Shih, Chi-Lin. 1986. The Prosodic Domain of Tone Sandhi in Chinese. PhD dissertation, Univ. of California, San Diego.

Shih, Chi-Lin. 1988. Tone and Intonation in Mandarin. In Nick Clements ed. Working Papers of the Cornell Phonetics Laboratory 3.

Shih, Chi-Lin. 1997. Mandarin Third Tone Sandhi and Prosodic Structure. In Wang Jialing and Norval Smith eds. Studies in Chinese Phonology. Mouton de Gruyter. New York. 81-124.

Siegel, Dorothy. 1974. Topics in English Phonology. Published by New York: Garland. 1979.

Steriade, Donca. 1982. Greek prosodies and the nature of syllabification. PhD dissertation, MIT.

Tan, Fu. 1986. Ye tan Tianjin fangyan de liandu biandiao. Zhongguo Yuwen 6:447-450.

Truckenbrodt, Hubert. 1999. Syntactic Phrases and Phonological Phrases. Linguistic Inquiry. Vol 30(2) pp. 219-255.

Wang, Jialing. 1997. The neutral tone in Putonghua. In Wang Jialing and Norval Smith eds. Studies in Chinese Phonology. Mouton de Gruyter. New York. 157-183.

Wang, Jing and Wang, Lijia. 1993. Putonghua duo yinjie ci yinjie shichang fenbu moshi. [The types of relative lengths of syllables in polysyllabic words in Putonghua]. ZhongGuoYuWen 1993:2(233):112-16.

Wang, Li. 1979. Shi ci gelü gaiyao. [Essentials of verse]. Bejing Chubanshe: Beijing. (In Chinese).

Wang, Jialing. 2002. Youxuanlun he tianjinhua de liandu biandiao ji qingsheng. [OT and the tone sandhi and tone neutralization in Tianjin dialect. ZhongGuoYuWen 4 (289):363-371. (In Chinese).

Wee, Lian-Hee. 2000. Faithfulness as Percolation – Evidence from Tone Sandhi in Mandarin. In Horwood and Kim eds, Ruling 2, 2001, Rutgers Univ.

Wee, Lian-Hee, Xiuhong Yan and Matthew Y Chen. 2004. Tianjin Fangyan Liandu Biandiao: Zonghe Baogao. (Tianjin Tone Sandhi: A Final Report) Monograph in Chinese 235 pp. City University of Hong Kong.

Xu, Shirong. 1980. Putonghua yuyin zhishi. Beijing: Wenzi Gaige Chubanshe. [Phonology of Standard Chinese]. (In Chinese).

Xu, Yi. 1997. Contextual tonal variations in Mandarin. Journal of Phonetics 25:61-83.

Yan, Jingzhu and Lin, Maocan. 1988. Beijinghua sanzizu zhongyin de shengxue. [Acoustic characteristics of the stressing Beijing trisyllabic sequences]. Fangyan, 1988:3:227-37. (In Chinese).

Yan, Xiuhong, Jilun Lu and Lian-Hee Wee. 2003. Tianjin Fangyan de Tunyin Xianxiang. [Swallowing sounds in Tianjin]. Ms., Shantou Univ., Tianjin Normal Univ. and Rutgers Univ. (In Chinese).

Yang, Shun'an. 1992. Beijinghua duoyinjie zuhe yunlü tezheng de shiyan yanjiu. [An experiment on the prosody of polysyllabic sequences in the Beijing dialect]. Fangyan, 1992:2:128-37. (In Chinese).

Yin, Hui. 2002. Faithfulness and makredness in Mandarin tone sandhi. Paper presented at The Eighth International Symposium on Chinese languages and linguistics, Academia Sinica, Taipei.

Yip, Moira. 1980. The Tonal Phonology of Chinese. PhD dissertation, MIT, Cambridge, Massachusetts. Published 1991, New York: Garland Publishing.

Yip, Moira. 1995. Tones in East Asian Languages. In Goldsmith (1995) pp. 476-494.

Yip, Moira. 2002. Tone. Cambridge Univ. Press.

Yuan, Jiahua. 1956. Hanyu Fangyan Gaiyao [A General Survey of Chinese Dialects]. Beijing: Wenzi Gaige Chubanshe. 2nd ed. 1989.

Zhang, Ning. 1997. The Avoidance of Third Tone Sandhi in Mandarin Chinese. Journal of East Asian Linguistics 6:293-338.

Zhang Xiao-yu. 1977. Qingsheng Bianyi Juli [Minimal Pairs of Tonal Reduction]. Xuehai Chubanshe, Taiwan. (In Chinese).

Zoll, Cheryl. 2003. Optimal Tone Mapping. Linguistic Inquiry. 34(2):225-268.