LANGUAGE AND LINGUISTICS 9.1:127-160, 2008
2008-0-009-001-000250-1

Opacity from Constituency*

Lian-Hee Wee
Hong Kong Baptist University

Structural opacity often has derivation histories as deep as the number of structural tiers. This is implicit since the days of Lexical Phonology in the 1980s. However, with the advent of Optimality Theory (OT), the relationship between structural depth and opacity has become obscured due to the output-orientation of OT. This paper uses Mandarin third tone sandhi as a case study of structural opacity to develop, within OT, the Inter-tier Correspondence Theory (ICT) where structural configurations are taken into account by allowing for nonterminal nodes to reconstruct information of subordinate nodes. Since structures are built by GEN and selected by EVAL, information at the terminal nodes must come directly from the input string; information at non-terminal nodes would be derived by inter-tier correspondences. This asymmetry of terminal and non-terminal nodes allows ICT to marry the insights of both the Containment Approach and the Correspondence Approach to Optimality Theory. ICT further predicts that mere adjacency does not result in markedness, and consequently does not trigger alternation. Rather, it is to the constituency of units that markedness constraints apply. This is why derivation histories are rarely deeper than there are structural tiers.

Key words: opacity, constituency, correspondence, tone sandhi, Mandarin

1. Introduction

This paper explores structural opacity and how it might be accommodated in an output driven framework such as Optimality Theory (OT). It argues that any successful parallel OT account of structural opacity must be due to the information-bearing capacity of nonterminal nodes. The information comes from (violable) correspondence

* This paper developed out of chapter 2 of my PhD dissertation, Wee (2004). I am grateful to Akinbiyi Akinlabi, Alan Prince, Young-mee Yu Cho, Hubert Truckenbrodt, Mark Baker, and K. P. Mohanan for their guidance. Thanks also to Liang Yuan and Yan Xiuhong for the many fruitful discussions when we were colleagues at City University Hong Kong. I am also indebted to Andre Nuendel, Graham Horwood, Hsu Hui-chuan and the anonymous reviewers for their incisive comments, also Yiu Suet Yee for her painstaking work as my research assistant, without which the author would be embarrassed by his many flaws.

of information across structural tiers.

The structural opacity considered in this paper is that of cyclicity exhibited in Mandarin tone sandhi. Mandarin tone sandhi presents a case par excellence of structural opacity in that the number of cyclical applications of tone sandhi is constrained only by the number of structural tiers derivable from the morphosyntactic structure of an input string. In other words, depth of opacity equals depth of structural embedding. Though this has been well understood over decades of research, the central properties of Mandarin tone sandhi has remained elusive to modern phonological theory (which should become clear in §2.2).

Inter-tier Correspondence Theory (ICT) rises up to the challenges posed by Mandarin tone sandhi by the ranking between four kinds of constraints: (i) constraints that require the faithful correspondence of information between nodes that stand in immediate domination; (ii) interface constraints between prosodic structures and syntactic constituency; (iii) constraints militating against recursive prosodic structures; and (iv) constraints that mark certain collocations within the domains set by (ii). See Truckenbrodt (1999) and references cited therein for details on (ii) and (iii).[1]

2. Background

2.1 The cyclical character of Mandarin tone sandhi

The tonal inventory of Standard Mandarin is comprised of 4 tones: a high flat tone (T1); a rising tone (T2); the tone (T3) which has a dipping contour for some speakers and is a low flat tone for others; and a falling tone (T4). T3 is the focus of this paper, for this tone is systematically involved in the T3 sandhi process.

(1) T3 sandhi rule
T3 → T2[2] / __ T3

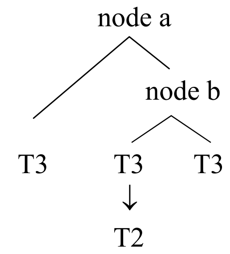
i.	/*zong3tong3*/	→ [*zong2tong3*]	'president'
ii.	/*lao3hu3*/	→ [*lao2hu3*]	'tigress'
iii.	/*hao3jiu3*/	→ [*hao2jiu3*]	'good wine'

[1] Essentially, cyclicity is possible when ALIGN-XP (from Selkirk 1995) and WRAP (from Truckenbordt 1999) dominate NONRECURSIVITY (from Truckenbrodt 1999). When NONRECURSIVITY is ranked high, cyclical effects disappear.

[2] There is some controversy whether or not this rising tone is in fact the same as T2. While speakers of Mandarin do not seem to be able to tell them apart, researchers have reported that there are some phonetic differences (see, for example, Xu 1997).

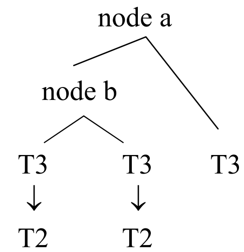
Given a regressive tone sandhi rule such as (1), tritonal sequence T3T3T3 would have two logical possibilities of tone sandhi: either (i) the medial T3 alternates to become T2 (i.e. bleeding order) or (ii) the initial and the medial T3s alternate to become T2 (i.e. counterbleeding order). Both effects are shown in (2), where tritonal sequences of various morphosyntactic configurations are considered.

(2) a.



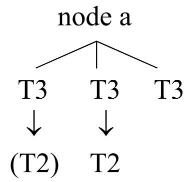
i. *hao3 zong2tong3* ‘good president’
ii. *mu3 lao2hu3* ‘tigress’
iii. *mai3 hao2jiu3* ‘buy good wine’

b.



i. *zong2tong2 hao3* ‘Hello, President!’
ii. *shou2jiao2 duan3* ‘short arms and legs’
iii. *zhan2lan2 guan3* ‘exhibition hall’

c.



i. *wu2jiu2wu3* ‘5-9-5’
ii. *ma2zu2ka3* ‘Mazurka’
iii. *hao2hao2hao3* ‘good, good, good’

In (2), tonal information for the Mandarin syllables is indicated by the numbers behind them, for example, *hao3* means the syllable *hao* with the tone T3. With the exception of right-branching constituencies, tritonal T3 sequences have tone sandhi applied to the initial and the medial positions. (2a) and (2b) taken together argue for cyclic application of the T3 sandhi rule, starting from the smallest constituent upwards until there are no more offending T3 adjacencies. Such a position is clearly simplistic in the light of (2c). Tritonal sequences such as those in (2) exemplify the problems well enough, and greater complexities found in longer sequences may easily be reduced to one of these the 3 types above.

A peculiarity that is noteworthy in (2a, b) is the morphosyntactic identity of the nodes labeled 'node b'. Notice that despite being identical morphosyntactically (e.g. *zong2tong3* and *zong2tong2* both means 'president'), their surface tones are different. This difference stems from (2b)'s need to avoid T3 adjacency at node a. This insight was captured by early treatments of Mandarin tone sandhi (Cheng 1973, Liu 1980, Kaisse 1985, and Shih 1986). However, given cases such as (3) where the tone sandhi patterns do not match syntactic constituencies (data from Shih 1986), it is now generally accepted that cyclicity applies to prosodic structures rather than syntactic ones. It just so happens that in Mandarin, there is always a prosodic parse that matches syntactic configurations, see (3) below and its syntactic structure in (4).

(3) /na3 zhong3 gou3 hao3/	→	[na2 zhong3 gou2 hao3]				
	or	[na2	zhong2	gou2	hao3]	
		which	CL	dog	good	
		'which (breed of) dog is good?'				

(4) (((na2 zhong2) gou2) hao3)

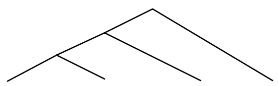
In a nutshell, the challenges that Mandarin T3 sandhi poses are its cyclic rule application effects on recursive and flat structures such as those in (2) such that variation is possible when different prosodic structures are obtainable from any given syntactic configuration.

2.2 Literature review

The combined transparency (2a) and opacity (2b) present interesting challenges for Optimality Theoretic (OT) approaches to the phenomena. On the one hand, parallel OT approaches are comfortable with transparent effects, while, on the other hand, numerous attempts have been successful to varying degrees with opaque ones. Most notable among the OT approaches to opacity are Sympathy Theory (McCarthy 1998, 2000a), Transderivational Faithfulness Theory (Benua 1995, 1997), Harmonic Serialism (Prince & Smolensky 1993[2004], McCarthy 2000b) and Stratal OT (Kiparsky, to appear). Specific to Mandarin T3 sandhi, Zhang (1997) presents interesting OT accounts that at once seek to address the matter of cyclicity and the issue of variability in TS sandhi with long tonal sequences.

Sympathy Theory captures opacity by appealing to a sympathetic candidate that exerts influence on the choice of an optimal output. The sympathetic candidate is typically the form intermediate in a derivation, though theoretically, this is purely accidental. An interesting characteristic of Sympathy Theory is the possibility of multiple sympathetic candidates, thus allowing for the possibility of deep opacity (see discussion on Yokuts in Kiparsky, to appear). At first blush, this seems to be a point of merit since by cycling on structures, Mandarin T3 sandhi could in principle exhibit very deep opacity. Consider for example (5):

(5)



zhan	lan	guan	xiao	'The exhibition hall is small.'
/T3	T3	T3	T3/	
↓	↓	↓		
T2	T2	T2		

(5) is a case of deep counterbleeding opacity[3] where the first 3 tones have undergone alternation in cycles starting from the lowest branching constituent. The difficulty of applying Sympathy Theory to Mandarin T3 sandhi lies in the fact that all the sympathetic candidates must be chosen by the same sympathetic constraint. Derivationally speaking, all the intermediate forms in (5) are cases where the same repair strategy was made to offending T3 collocations. In OT terms, this means that for any legitimate selector constraint,[4] only one candidate is identified as the sympathetic candidate. To see this more concretely, compare the following candidates for a given input like (5):

(6) Some potential sympathetic candidates for (5)
   a. T2 T3 T3 T3
   b. T2 T2 T3 T3
   c. T2 T3 T2 T3

[3] In studying (5), it is crucial to remember transparent cases like (2a). Otherwise, one might mistakenly analyze (5) as a case of alternation applying blindly to all nonfinal tone contours.

[4] De Lacy (1998) argues that Cairene Classical Arabic requires markedness selectors, but McCarthy (1998) argues that only faithfulness constraints may be selectors on the grounds that markedness selectors would overgenerate.

Notice that (6a) and (6b) are exactly what the first two intermediaries look like if the attested output for (5) were arrived at derivationally. If one ventures to assume that either of these are sympathetic candidates, (6b) will never be chosen on the grounds of faithfulness (recall that all selector constraints are faithfulness constraints (McCarthy 1998), thus robbing us of any further possibility of arriving at the opaque [T2T2T2T3] output. (6c) is a transparent candidate that could only be chosen as sympathetic if the selector were a markedness constraint.

Transderivational Faithfulness Theory (TFT, Benua 1995, 1997) offers new hope of grappling with Mandarin T3 sandhi by virtue of its structural sensitivity. By allowing each recursion to be sensitive to the output of the early recursion via the use of O-O constraints, TFT works perfectly with opacity that stems from recursive structures such as those found in Mandarin T3 sandhi. The only drawback is that TFT is confined to morphological structures and does not extend to larger syntactic units as is necessary when working on Mandarin T3 sandhi. Perhaps one might envisage enlarging the domain of TFT to include larger syntactic constituencies; but one must be careful not to be simplistic about such concessions since paradigmatic identity would have to be defined so loosely as to be uninformative. For example, there can be any number of different utterances that would be left-branching and tetrasyllabic; all could yield the same T3 sandhi output, but it hardly makes any sense to say that all these sentences are in the same morphosyntactic paradigm.

Harmonic Serialism (McCarthy 2000b) avoids the problems that plague Sympathy Theory and TFT since it allows any number of intermediaries without being confined within morphological domains. One crucial property of Harmonic Serialism is that the optimal candidate for each cycle must be an attested output. This runs afoul of flat structures like those in (2c). With flat structures like (2c), Mandarin T3 sandhi applies to all nonfinal tones. In order for Harmonic Serialism to work, sandhi must apply to starting from the leftmost tone at each cycle. However, since the structure is flat, the very first cycle has to include all the offending T3 collocations. One is thus back at square one of the problem—there is still no way of getting the opacity effects.

Stratal OT (Kiparsky, to appear) addresses opacity by appealing to strata such as ‘morphemic’, ‘lexical’, and ‘post-lexical’. In Stratal OT, each stratum has a specific constraint ranking hierarchy. Opacity is the result of each stratum taking the output of an earlier stratum as its input and then spitting out an output. Such a framework predicts opacity to a maximum depth of three steps and that within each stratum, there will only be no opacity between input and output. Clearly Stratal OT is incompatible with the opacity found in Mandarin tone sandhi. In Mandarin tone sandhi, opacity is as deep as there are embedded structures and they all occur within the same stratum.

Zhang's (1997) treatment of Mandarin T3 sandhi tackled the problem by defining opacity out of the problem. Essentially, Zhang's approach was to identify a tone sandhi domain within which all nonfinal T3s undergo alternation to avoid offending adjacencies. There is thus no opacity involved since one operation takes care of the alternation of all nonfinal T3s. Zhang echoes the insight from Shih (1986) that tone sandhi domains are foot structures arrived at by interface constraints with syntax. Because opaque candidates are really tone sandhi operations to all nonfinal T3s, such an approach must stipulate what GEN can and cannot produce (inconsistent with the Freedom of Analysis property of GEN). For example, an input /T3T3T3/ within a tone sandhi domain, one must stipulate T3T2T3 to be an impossible candidate produced by GEN.[5] It is also unclear what one should do in cases where offending T3 collocations are not situated at the right edge of the domain, say for example /T3T3T2/. To be internally consistent, Zhang's approach would predict [T2T2T2] as optimal, contrary to fact.[6]

As may be seen from the above paragraphs, efforts have been made at two different levels to tackle structural opacity. At a more general level, various linguists have tried to develop theories that would capture opacity (cf. Sympathy Theory, TFT, Harmonic Serialism). At a micro-level, there have been efforts to reanalyze language specific opacity so as to define opacity out of the problem (cf. Zhang's 1997 treatment of Mandarin T3 sandhi).

If the above review is accurate, then one is left with a good understanding of Mandarin Tone Sandhi, but without a theoretical apparatus to account for it. Given the vast amount of research done in Mandarin T3 sandhi, it is impossible to review all of it. Generally, research has concentrated on three aspects: (i) obtaining the surface tone sequence; (ii) obtaining the variation allowed in the surface tone sequence; and (iii) obtaining the fact that the tone T3 (variously assumed to be dipping or low flat) undergoes sandhi to become a rising tone. In concentrating on these aspects, hierarchical structural relatedness is often underplayed, or even brushed aside.

This paper leans towards the enterprise of developing a theory for structural opacity. However, it is also necessary in the development of such a theory that domains of phonological processes be captured. This theory, Inter-tier Correspondence Theory (ICT), thus promises not only to capture all cyclic phenomena that is structural in nature but also predicts that marked adjacencies are tolerated when the offending elements belong to different domains.

5 Otherwise, the problem of opacity persists.

6 Chen (2000:306-374) uses the same strategy to get out of the opacity problem and encounters similar challenges.

3. Inter-tier correspondence and structural opacity

Orgun (1996a, b)[7] envisaged a model where, given a hierarchical structure, nonterminal nodes reconstruct the content information of its daughter nodes. Such a model, Orgun argues, effectively captures derivational effects if the reconstruction of information at every node is allowed to deviate from that contained in the daughter nodes. In other words, the structure is capable of encoding derivation history. Wee (2000) independently developed a similar idea to tackle cyclicity, differing with Orgun's in one respect—Wee's model allows structural mismatches across dimensions of phonology, syntax, and semantics. Both Orgun's and Wee's ideas are not novel. In fact they echoed those of Shieber (1986), Pollard & Sag (1994), and also the percolation that is common in X-bar syntactic theories.

Based upon these ideas, this paper argues that a solution to the cyclicity problems exemplified by Mandarin T3 sandhi must be founded upon the following theory:

(7) Inter-tier Correspondence Theory (ICT)

a. **Carriage of information**
   All nodes (terminal or nonterminal) are information-bearing.

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

c. **Violability of correspondence**
   Correspondence of information between nodes is not necessarily perfect.

3.1 From asymmetry of correspondence to derivation history

Prima facie, ICT is vertically symmetrical with respect to how information across nodes corresponds. However, asymmetry sets in when one considers the fact that linguistic inputs are often linear strings and that their structures are derivable via formation constraints or templates. In other words, information at the terminal nodes will, as a result, be primary.

Consider for example an input string of phonological segments /sandi/ and its syllabification into two syllables [san.di].

[7] But also see Goldrick (2000).

(8) /sandi/

σ σ

san di

Well established constraints of syllabification will derive (8), given the string of segments. It is easy to extrapolate from (8) to include other phenomena. What this means for ICT is that information from terminal nodes would be "preset", because it comes from the input. In other words, content information in nonterminal nodes are secondary to information from terminal nodes. To understand the implication of this property of ICT, consider two different inputs *fen3chang3* 'graveyard' /T2T3/ and *fen2chang3* 'flour mill' /T3T3/. Within ICT, one has to consider the following representations:

(9) a. /fen2chang3/ 'graveyard'

fen2chang3

fen2 chang3

b. /fen3chang3/ 'flour mill' (perfect correspondence)

*fen3chang3

fen3 chang3

c. /fen3chang3/ 'flour mill' (imperfect correspondence)

fen2chang3

fen3 chang3

In (9), the nonterminal nodes get their content information from the terminal nodes via inter-tier correspondence (recall (7b)). The interesting case is (9b) where the percolation of information results in the offending collocation of two T3s. (9c)'s correspondence is imperfect. In this case, /fen3/ has the unfaithful correspondent [fen2]. ICT does allow for this as stated in (7c). (9c), where /fen3/ → [fen2], avoids a marked form, and hence is the output for /fen3chang3/ 'flour mill'. (10) and (11) below illustrate how this may be done with a set of ICT constraints and a markedness constraint that triggers tone sandhi.

(10) ICT Constraints and OCP

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.

INTF

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

OCP [T3][8]

Do not have adjacent T3 within a phonological phrase (P-phrase).

(11) Input: /T3+T3/ e.g. *fen3 chang3* 'flour mill'

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

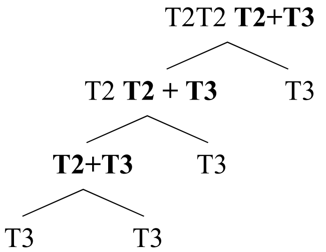
Looking at (10), OCP [T3] applies only within phonological phrases the domain for tone sandhi. This domain is derivable from the interface between morphosyntax and prosody (§3.2 and §4) and is minimally disyllabic. INTF-HD and INTF are inter-tier positional faithfulness constraints dictating the faithful correspondence across tiers in a structural configuration. These faithfulness constraints are the ICT equivalent of the IDENT constraints found in McCarthy & Prince (1995) and Beckman (1997). However, ICT does not apply faithfully because of OCP [T3]. If one assumes that Mandarin is right-headed, then it would follow that the offending T3 tone from the left constituent undergoes sandhi, as shown above. (Discussion on the right headedness of Mandarin in §3.3.) To achieve such an effect, the following ranking hierarchy is needed.

8 Following Bao (1999). The exact nature of this is not a main concern at this point.

(12) Ranking of the constraints
OCP [T3]; INTF-HD » INTF

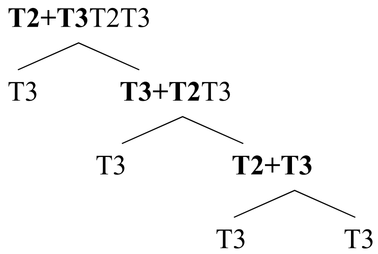
Having seen how ICT works for simple disyllabic sequences, counterbleeding opacity of the kind witnessed in Mandarin T3 sandhi is simply the avoidance of T3 adjacency at the each nonterminal node, as illustrated in (13) (boldface indicates where sandhi took place).

(13) ICT and counterbleeding



By the same token, ICT predicts transparency in Mandarin T3 sandhi with right branching structures, as shown in (14).

(14) ICT and bleeding[9]



Being capable of feats like (13) and (14), ICT effectively encodes derivation history by virtue of the asymmetry in the correspondence of information across tiers in a structural representation. ICT also presents itself as the most direct way out of the problems faced by Sympathy Theory, TFT, and Stratal OT.[10]

---

[9] As observed by a reviewer, ICT would predict that [T3 [T3 X]] should yield [T2 [T3 X]] when the T3s become adjacent at the higher constituent. This prediction is borne out.

[10] However, to avoid the drawbacks found in Harmonic Serialism and Zhang's (1997) poly-syllabic sandhi domain approach, ICT needs to work with other constraints that define the tone sandhi domain.

The next step is to establish the structures upon which the constraints in (10) apply.

3.2 Phonological structures through interface

By recalling syntactically flat structures such as that in (2c) and mismatched cases such as (3), it must be clear that tone sandhi applies to (prosodic) structures rather than to morphosyntactic ones. Yet, Shih (1986) and Wee (2004) noted that with the exception of flat morphosyntactic structures, any given string of Mandarin T3s will always have one sandhied output that perfectly reflects the morphosyntactic constituency. If one were only interested in such cases, the solution is relatively straightforward. What one needs is a set of faithfulness constraints that will align all morphosyntactic edges with prosodic edges. In that context, ICT will yield the sandhi output quite easily.[11] Selkirk (1995) and Truckenbrodt (1999) provide us with exactly these constraints.

(15) Constraints for the interface between morphosyntax and prosody
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 (from Truckenbrodt 1999)[12]
Each XP is contained in a P-phrase.

---

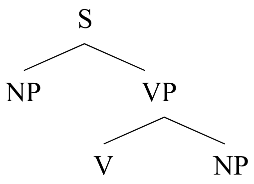
[11] However, it is often the case that for a given input string, a number of tone sandhi outputs are possible (Shen 1994, Zhang 1997, Wang 2002, and Liang & Wee 2004). This variation is not something that can be captured in this paper. Zhang (1997) proposes unranked constraints to allow for variation in optimal structures. Liang & Wee (2004) adopt a similar strategy and attribute the deciding constraint to the alignment of the right edge of syntactic XPs to the edge of prosodic feet.

[12] In Truckenbrodt (1999), WRAP-XP does not include functional projections but only lexical projections, thus IP and CP would not need to be contained in P-phrases by this constraint. And, on this note, a reviewer rightly queried about the motivation for WRAP-IP since IP is a functional projection. As will be seen later in (18), this is necessary in order to account for why tone sandhi does not extend beyond the IP into the CP. If this move is correct, it would predict that IPs could serve as prosodic domains in patterns of other languages, which, I submit, makes intuitive sense. Within an utterance, it is easier to insert pauses at IP boundaries, which is a prosodic effect. Future research into other Chinese tone sandhi patterns might also bear on the relevance of the IP as a sandhi domain.

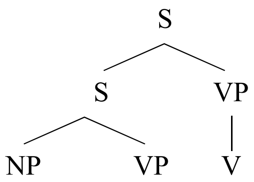
WRAP-IP (from Wee 2004)
Each IP (Infl phrase) is contained in a P-phrase (phonological phrase).
NONRECURSIVITY (from Truckenbrodt 1999)
Any two P-phrases that are not disjoint in extension are identical in extension.

The effects of the constraints listed in (15) may be illuminated by considering the following two syntactic representations.

(16) a.



b.



Given syntactic configurations such as those in (16a, b), one could envisage a number of candidates of P-phrase constituency. Candidates relevant to the workings of the analysis here are provided in the tableaux in (17).

(17) Evaluation of P-phrase structures corresponding to (16)

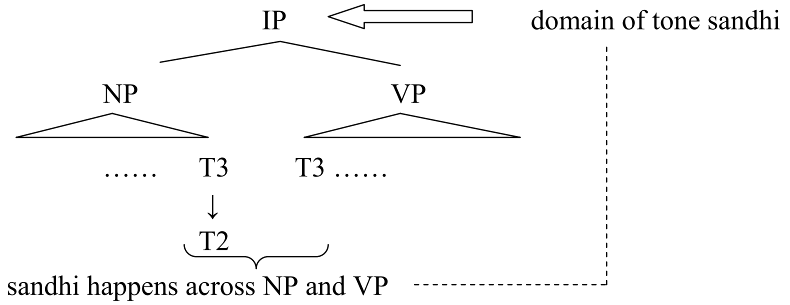
Input: (16a)	ALIGN -XP, R	ALIGN -XP, L	WRAP IP	WRAP XP	NON RECURSIVITY
i. [NP] [V [NP]]			*		*
ii. [NP V NP]	*	**			
iii. [NP] [V NP]		*	*		
iv. [NP] V [NP]		*	*	*	
v. [[NP] [V [NP]]]					***
Input: (16b)	ALIGN -XP, R	ALIGN -XP, L	WRAP IP	WRAP XP	NON RECURSIVITY
vi. [NP] [VP] [VP]			*		
vii. [NP] [VP VP]	*	*	*		
viii. [[NP] [VP] [VP]]					*

In (17), P-phrases are indicated in the square brackets. Candidate (17ii) incurs one violation of ALIGN-XP, R because the right edge of its first NP does not have a coinciding P-phrase boundary, likewise for the medial VP of (17vii). Candidate (17ii) has two counts of ALIGN-XP, L violations because the left edge of the VP and the left edge of the complement N are not aligned to a P-phrase boundary. Similar violations are found in (17iii, iv, vii). With Wrap-IP, the violations are straightforward. Since the inputs in (16) are sentences (IP), any candidate that does not have a P-phrase overarching the entire structure violates this constraint (candidates 17i, iii, iv, vi, vii). Candidate (17iv) violates WRAP XP because the VP is not contained within a P-phrase. Finally, NONRECURSIVITY is violated by candidate (17i) because the P-phrase containing the complement NP is in turn contained by a larger P-phrase wrapping the VP. One can see in (17) that ranking these constraints undoubtedly yields very different P-phrase structures.[13]

Armed now with a way to derive prosodic structures given morphosyntactic configurations, viability of ICT as a solution to Mandarin T3 sandhi may only be established if it is possible for the constraints to be ranked with respect to each other so that ICT produces the attested results. For the most part, this is relatively easy. Liang & Wee (2004) note that all sandhi variations conform to ALIGN-XP, R, so we know that this must be an active and important constraint for any analysis of Mandarin T3 sandhi. For the purposes of this paper, it will suffice to concentrate on the fact that all nonflat morphosyntactic structures yield a sandhi output that appears to have the tone sandhi rule cycle on the morphosyntactic structure. As syntactic structures are hierarchical, obtaining a similarly hierarchical P-phrase structure requires that the interface alignment constraints dominate NONRECURSIVITY. This ensures that P-phrases recur structurally upwards as syntactic XPs are embedded in higher phrases. That way, P-phrases stack up so that the highest P-phrase is to be the domain within which OCP[T3] applies. Since Mandarin T3 sandhi applies across subject NPs and its VP sister, the IP must be a domain of T3 sandhi (as is shown in (18)). This means that WRAP-IP outranks NONRECURSIVITY. In other words, IPs would be contained in P-phrases at the expense of NONRECURSIVITY violations.

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

(18) The syntactic IP as a domain for tone sandhi



Looking back at (16) and (17), ranking WRAP-IP above NONRECURSIVITY ensures that candidate (17v) is favored over the others when given an input like (16a). The ranking hierarchy for Mandarin is thus as in (19).

(19) Ranking hierarchy for Mandarin syntax~prosody interface
ALIGN-XP, R; ALIGN-XP, L » WRAP-IP » NONRECURSIVITY; WRAP-XP

With (19), treatment for the opaque effects in Mandarin T3 sandhi would be complete if not for the opacity also observed in morphosyntactically amorphous structures. Recall that this was one of the motivations for phonological structures in treating tone sandhi. All (19) has done is to say that one can derive the right phonological structures for morphosyntactically structured strings, but it remains to be seen how to derive flat morphosyntactic ones. Any flat prosodic structure should in principle have no need for counterbleeding rule operation to avoid collocation of T3s. Evidently, the answer lies in the determination of prosodic structures independent of morphosyntactic configurations. The next subsection sets out to determine the prosodic structure of Mandarin when reliance upon interface with morphosyntax is not an option.

3.3 Prosodic headship and binarity

Duanmu (2000:136ff) argues for Mandarin prosody by claiming that stress exists in the language. Moreover, this stress is trochaic, though feet become iambic when sanctioned by 'nonhead stress'.[14] Duanmu's claim to trochees is founded on two assumptions about Mandarin T3 sandhi. Firstly, Duanmu assumes that T3 is a low flat tone (rather than a dipping tone) and secondly, Duanmu assumes the applicability to

[14] This rule is inspired by Cinque (1993) and requires that nonsyntactic heads receive stress. For example, the NP complement in a VP will be the stressed unit since the head of the VP is a V. Since Mandarin VP has the NP-complement to the right, it follows from "nonhead" stress that such a situation would be iambic under Duanmu's (2000) conception.

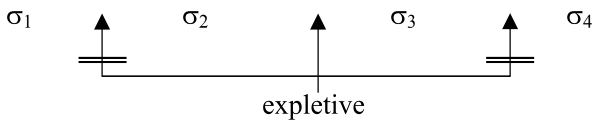
Mandarin, de Lacy's (2002) claim that heads of prosodic units must carry a high tone. Duanmu's account runs afoul of that variety of Mandarin where T3 is dipping in contour (where there are high tonal elements). In this variety of Mandarin (in fact, this is the variety that is considered standard by most accounts), T3 sandhi would have been predicted by Duanmu not to apply, contrary to observation. Further, it must be remembered that only adjacent T3 triggers sandhi in Mandarin. All other tonal collocations remain stable, so it cannot be the case that the initial T3 in a foot becomes rising by need of headship. One is thus forced to look to other possibilities in the establishment of Mandarin prosody.

An alternative to Duanmu's claim is to assume that Mandarin prosody is right-headed.[15] This view of Mandarin prosody is more consistent with T3 sandhi facts since that would naturally explain why sandhi occurs only when two T3s are adjacent rather than anytime when T3 is the initial syllable—it is simply a matter of OCP against T3 adjacency such that the tone of the head syllable is kept stable while the initial tone alternates to satisfy OCP. There is a crucial difference between the iambic account and the trochaic account. The former explains tone sandhi as a result of OCP satisfaction whereas the latter derives tone sandhi by appealing to special characteristics of prosodic headship. It is this that gives the trochaic account the erroneous prediction that all T3s in initial positions undergo sandhi, contrary to fact.

An iambic prosodic structure of Mandarin is important to the ICT analysis of Mandarin T3 sandhi because it is for this reason that INTF-HD preserves the T3 from the right-side branch (cf. (10)-(12)).

Binarity in Mandarin prosody is quite unambiguous. The ensuing paragraphs present a few such pieces of evidence, beginning with the positions of expletive epenthesis in monomorphemic polysyllables as shown in (20).

(20) Expletive epenthesis (Fun 2005)



Examples:

a. luo.ma-EXPLETIVE-ni.ya 'Romania'

b. bao.jia-EXPLETIVE-li.ya 'Bulgaria'

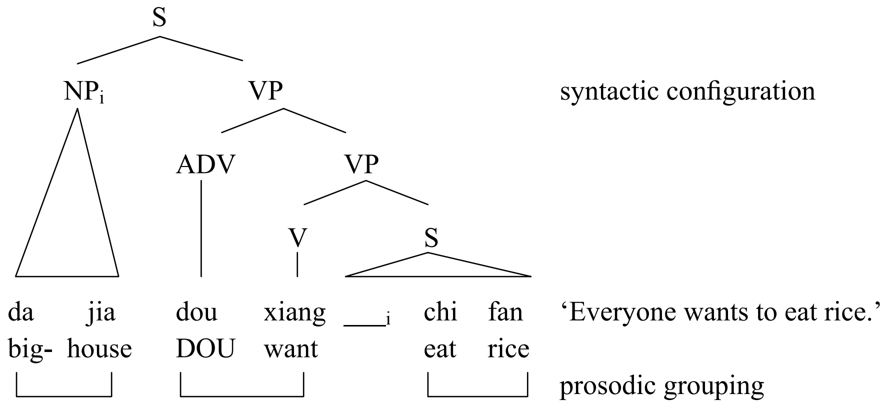
---

[15] Wee (2004) provides an argument for the iambic position by typological comparison with Tianjin, a close sister of Mandarin. In Tianjin, 3 out of 4 tones undergo tone sandhi when adjacent to an identical tone. Tone sandhi is also uniformly regressive. A trochaic account with Tianjin would be quite impossible.

As indicated by the schematic diagram, (20) shows that given a tetrasyllabic monomorphemic string, expletive epenthesis is allowed only between the second and third syllables, all other positions do not allow epenthesis (not very different from English; cf. Hammond 1999). This is an effect of grouping syllables into binary feet.

The requirement for feet to be binary extends beyond monomorphemic words even to sentences, where mismatches between prosody and syntax sometimes arise because of this need. Consider (21) where the syntactic configuration of a sentence is compared with its prosodic grouping.

(21) Mismatches



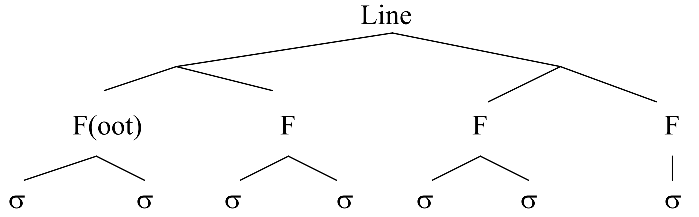
Noteworthy in (21) are the prosodic grouping of the two syllables *dou* and *xiang*. It is interesting that rather than having two monosyllabic feet, these two syllables straddle across syntactic constituencies to make a foot (cf. also (4) for a similar case).

At first blush, binarity in feet appears not to extend to higher prosodic constituencies like P-phrases. This façade is easily removed when one considers number sequences as in (22), where it is clear that binarity is applicable at all levels of the hierarchy.

(22) yi.er – san.si –##– wu.liu – qi '1, 2, 3, 4, 5, 6, 7'

When a string of 7 numbers are recited, the natural rhythm is to have the main pause between the fourth and fifth syllable, as indicated with ## in (22). In addition, syllables group themselves into binary units (separated by '–'), leaving only the final syllable without a partner. This final syllable, however, is phonetically longer, arguably taking up the whole time for a foot. Chen (1984) provides a long list of examples taken from folk poetry where similar effects are observed. Upon these bases, the default prosodic configuration of heptasyllabic sequences must be (23).

(23) Prosodic configuration of a heptasyllabic sequence

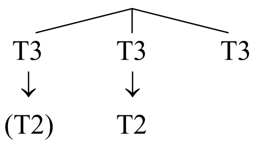


From (23), it is clear that binary feet are in turn grouped into larger binary constituents. Since numerical sequences do not have any morphosyntactic structure, it follows that this effect must come from a constraint such as (24).

(24) **BIN**ARY Nonterminal nodes are binary branching.

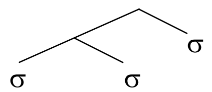
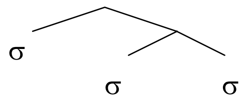
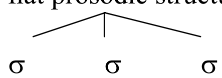
With (24), a trisyllabic sequence is prosodically grouped either as left-branching or right-branching, but not flat. If it were left-branching, ICT predicts counterbleeding opacity. Otherwise, if it were right-branching, then ICT predicts bleeding rule application effects. BIN predicts the possibility of two kinds of prosodic groupings for syntactically flat trisyllabic strings, (25).

(25) Mandarin T3 sandhi with morphosyntactically flat structure



e.g. *wu2jiu2 wu3* ‘5-9-5’ (cf. (2c))

(26) Reactions of BIN to various prosodic candidates given a flat structure like (25)

Input: Morphosyntactically flat structures like (25)	BIN
a. left branching prosodic structure 	
b. right-branching prosodic structure 	
c. flat prosodic structure 	*

(26) shows how BIN disprefers candidate (26c) since the structure is ternary branching. However, BIN is neutral towards the other two candidates, so both are possible prosodic structures upon which tone sandhi applies.[16] Under ICT, candidate (26a) would yield a situation where both the initial and the medial tone alternate while candidate (26b) would give result in the alternation of only the medial tone. For (26a), the situation would be as presented in (27). Here we consider relevant left-branching candidates with their varied inter-tier correspondences and violations.

(27) 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	

16 Constraints such as ALIGN-XP, R and ALIGN-XP, L do not figure into this because there is no XP in (25). In fact, the violation profile of these two candidates is identical with respect to all the constraints considered in this paper.

As may be seen in (27), 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. (28) provides an OT tableau to illustrate how the attested candidate is predicted to be optimal.

(28) Left-branching, tritonal T3 (counterbleeding effect)

	INTF-HD	OCP [T3]	INTF
Candiate (i)		*!**	
☞Candidate (ii)			**
Candidate (iii)	*!		*
Candidate (iv)			***!

It should be easy to work out the right-branching case, which would produce a bleeding effect. One therefore sees how, when the interface constraints between morpho-syntax and prosody have determined the tone sandhi structures, ICT constraints set in to produce the right results.[17]

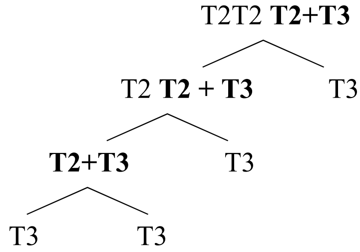
3.4 Interim summary

Using Mandarin T3 sandhi as an example of opacity effects commonly described as ‘cyclicity’, this paper has thus far presented how ICT effectively accounts for such phenomena when set within an Optimality Theoretic framework. ICT captures what appear to be derivation histories by virtue of correspondence in information across tiers, as is shown in (13) and (14), repeated below as (29a, b).

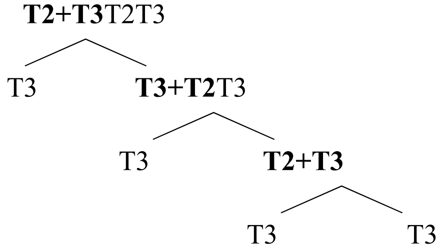
---

[17] A reviewer queried about the applicability of ICT to predict the selection of T2 from the underlying T3. If one assumes that T3 is a low tone /L/, then the OC-violating /L+L/ can be easily resolved by the insertion of H between them. In the ICT account here, the right /L/ is head, so the H must be attached to the initial /L/ to prevent violation of positional faithfulness to the head syllable. So, ICT is compatible with accounting for choice of tone in the alternation. For details, see Wee (2004).

(29) a. ICT and counterbleeding



b. ICT and bleeding



ICT does not apply to a vacuum, but rather relies on a set of structure identification constraints. In the case of Mandarin T3 sandhi, it is the prosodic structure that must be established through interface constraints with morphosyntax as well as prosodic constraints such as BIN. Though simple in conception, ICT rises to the challenges of opacity rather gracefully. The next section explores some theoretical consequences of ICT.

4. Theoretical consequences

ICT brings about a number of theoretical consequences. For one, it requires that output candidates be hierarchical structures rather than linear strings, and in so doing, ICT claims that phonological operations apply as a result of constituency rather than mere adjacency. Further, the requirement for inter-tier correspondence of information entails that phonological structures are percolative (akin to syntax), although, percolation in phonology has rarely been discussed. Finally, terminal nodes correspond to input strings in ICT, which calls forth the ‘containment’ condition from Prince & Smolensky (1993[2004]) formulation of Optimality Theory. These issues will be discussed in this section.

4.1 Adjacency and constituency

One of the most obvious theoretical consequences for ICT is that it stands the regular view of candidate structure on its head. In most conceptions, the surface form is the linear string of phonetic representation. With ICT, it is quite the reverse. This property of ICT was discussed earlier in §3.1, where terminal nodes correspond to the underlying string. Thus, it is the constituency of these nodes that triggers alternation rather than mere adjacency. This is precisely why Mandarin T3 sandhi exhibit cyclic rule application effects—T3 sandhi applies not because of their adjacency but because of their constituency. However, one should bear in mind that within ICT, derivational procedures are not necessary since each candidate structure is evaluated as a whole for constraint violations at every tier of the structural representation.

There are empirical differences between the ICT representation and the oft-held view of surface strings. ICT predicts that adjacency does not necessarily trigger alternation and provides a natural explanation to why membership to different domains condone otherwise undesirable collocations. As it turns out, ICT's prediction is borne out in sentences such as (30) where Mandarin T3 sandhi is blocked.

(30) a. [$_{\textbf{topic}}$ zhe4 zhong2 **jiu3**] [$_{\text{IP}}$ **wo3** ai4 he1].
this CL wine I love drink
'This kind of wine, I like to drink.'

b. [$_{\textbf{topic}}$ xin1-wen2 **gao3**] [$_{\text{IP}}$ **zong3** bian1 jie1shou4 le].
new-hear script chief edit accept ASPECT
'The news script, the chief editor has accepted it.'

In (30a), *jiu3* 'wine' does not sandhi even though it is left adjacent to another T3 syllable *wo3* 'I', as is also the case with (30b). As may be clearly seen in (30), this is because these two syllables belong to very different domains. Recall in §3.1 and §3.2 that P-phrases are the domains within which OCP[T3] apply. P-phrases are in turn derivable by the projection of boundaries of syntactic XPs into the prosodic structure. This situation is in fact predicted given the account in §3.2. This is because NONRECURSIVITY ensures that P-phrases do not recur excessively to include the entire CP (which contains the topic NP). After all, WRAP XP does not include functional projections (CP is a functional projection) and WRAP-IP does not apply to the CP level.

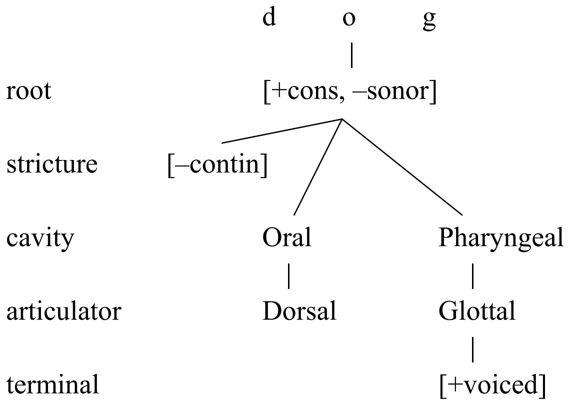
This is perhaps the most fundamental theoretical significance of the ICT. It claims that constituency is what triggers phonological alternations (not just adjacency) and in so doing, it stands conventional ideas of surface representations as a linear string of terminal nodes on its head. The output is, in ICT view, a structural representation where nodes across tiers carry information percolated from the terminals to the root. This is why and how constituency triggers phonological processes so that one gets the effect of derivation (through upward percolation) when in fact, correspondence is what goes on.

This correspondence is resonant of percolation so common in theories of syntax. The next section explains that in this respect, phonology may not be very different.

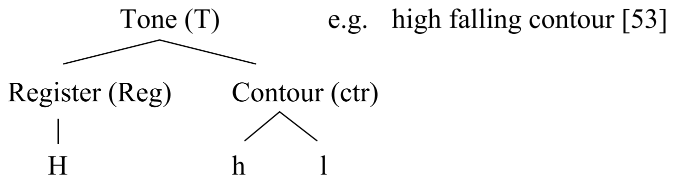
4.2 Percolation in phonology

The idea of inter-tier correspondence is not new to linguistics, especially in syntax where percolation is common and widely accepted. However, percolation is rarely explicitly maintained in phonology as may be seen from the following examples of phonological representation.

(31) Feature Tree (adapted from Kenstowicz 1994:151)



(32) Representation of Tone (Bao 1990)



Notice that both structures (31) and (32) are exocentric—the dominating nodes are not projections of the subordinate nodes.[18] Nonetheless, in prosodic phonology and tonology, one might see traces where percolation is implicit. For example, stress is phonetically manifested on vowels (or rather on the nuclei of syllables), rather than on

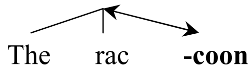
[18] This does not mean that it is impossible for us to have an endocentric interpretation of (31), say for example the existence of a Place node that is dependent on the existent of features such as Dorsal or Coronal. However, it is clear that taken in the way as represented in (31), the idea of projection is obscure.

the consonants. However, prosodic analyses make reference to stressed syllables or 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.

(33) 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.)

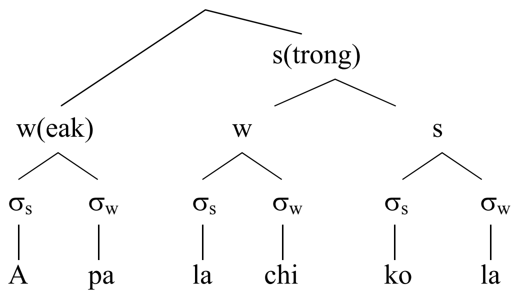
In (33), underlined items receive focus; boldface syllables are accented. Notice that accents (=stress) are manifested on the vowels of the stressed syllable, yet, it indicates that the entire constituent is under focus.

(34) Focused constituent



Whether one construes of focus as having percolated downwards or accents as having percolated upwards, indicated by double-headed arrow in (34), it is quite clear that phonological features do percolate. Percolation is actually common in metrical matters. Consider, for example, a metrical tree such as the one below (taken from Kager 1999).

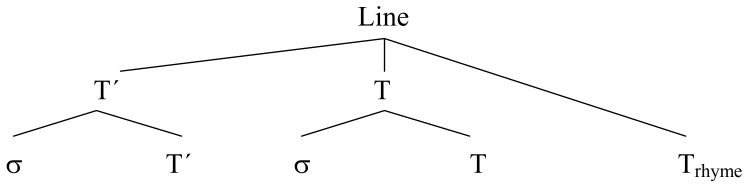
(35)



In the case of (35), 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.

Tonal features percolate too, as is evidenced by the requirement for categorical opposition of tones in Chinese Tang poetry. Each line of a Tang poem has either 5 or 7 syllables. An even-numbered syllable must contrast in tone category, where tone contour is categorized as either even (E) or oblique (O), the last syllable is reserved for rhyming, though not all lines rhyme. Under a metrical analysis along the lines of Chen (1979, 1984), a pentasyllabic line resembles the following diagram.

(36)



σ	T´	σ	T	T_{rhyme}
guo-O	po-O	shan-E	he-E	zai-O
cheng-E	chun-E	cao-O	mu-O	shen-E
gan-O	shi-E	hua-E	jian-O	lei-O
hen-O	bie-O	niao-O	jing-E	xin-E

As ever are hills and rills while my country crumbles;
When springtime comes over the Capital the grass scrambles;
Blossoms invite my tears as in wild times they bloom;
The flitting birds stir my heart as I'm parted from home.

A stanza from Du Fu (712-770AD) *Chun Wang* 'A Spring View',
translation from Xu et al. (1987:151)

In (36),[19] 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 is any position where tones may belong to either category E or O. 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. Herein lies the percolation of tonal categorical features from the head syllable to the foot.

Clearly then, percolation is not unique to syntax, but is also found in phonology. What ICT has done is to spell this percolation out explicitly, thus making clear why metrical patterns happen the way they do—there is correspondence in information across structural tiers.

[19] Tonal categories given here are as documented in medieval rhyming dictionaries such as the *Guangyun*. The segmental transcription here is Modern Mandarin in Hànyǔ Pīnyīn.

4.3 Containment and Correspondence Theories of OT

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 & Smolensky 1993[2004]). This section serves to clarify how the ICT relates to these issues.

Essentially, the containment condition is a constraint on GEN (Prince & Smolensky 1993[2004], but see also McCarthy & Prince 1993:20, Kager 1999:98ff, and LaCharité & Paradis 2000:228f). It disallows GEN from removing any element from the input form. Thus GEN may never actually delete anything from the input. Effects of deletion are obtained by not parsing certain elements. Unparsed elements do not get articulated (cf. 'stray-erasure' in McCarthy 1979, Steriade 1982, and Itô 1986, 1989).

(37) **Containment** (from McCarthy & 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 brackets indicating that the final V is not parsed into the syllable. While this is fine for accounts on syllabification, it is less straightforward with alternation. Imagine a situation where C → 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 the Containment Approach, one adopts the Correspondence Approach (McCarthy & Prince 1995). With alternation, the Correspondence Approach works more naturally than the Containment Approach. This is so since C and D now correspond, albeit violating some faithfulness constraints. The Correspondence Approach 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 the Correspondence Approach can do everything the Containment Approach can do and more. These two theories have different empirical predictions as may be illustrated by the hypothetical rules in (38).

(38) Language H exhibits the following pattern
A alternation rule: A → B / __ A
C alternation rule: C → D / __ B

With (38), the Containment Approach predicts that given /AAA/ counterbleeding effects will result, while given /CAA/ counterfeeding effects will result. This is shown below.

(39) Empirical possibilities of the **Containment Approach**
No element may be literally removed from the input form. The input is thus contained in every candidate form.

a. Counterbleeding

/AAA/	A → B / __ A[20]	Faith
i. A[B/A]A	*!	*
ii. ☞[B/A][B/A]A		**
iii. AAA	*!*	

b. 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 counterbleeding or counterfeeding. With the case of counterfeeding, complications result from how markedness constraints work. Unless markedness constraints are insensitive to surface strings, candidate (39bi) does incur a violation in the cell marked by a question mark '?'. Nonetheless, the Containment Approach provides a grasp on the opacity effects, but at the cost of transparent effects. The same assumption never yields 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 the Correspondence Approach.

(40) Empirical possibilities of the **Correspondence Approach**
Elements in the input correspond to elements in the output. The input is not contained in any candidate form.

[20] Technically such constraints do not exist in OT and should be written as markedness constraints, for example, *AA. However, to simplify things I have written this as a rule here so that we are confined to cases where *AA is satisfied by alternating the initial A with B.

a. Bleeding

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

b. 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 the Correspondence Approach 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 (Odden 2000) provides much useful machinery).

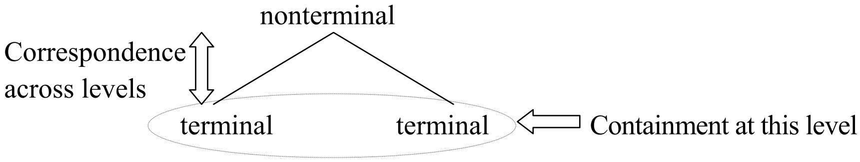
The implication of empirical possibilities outlined in (39) and (40) is that whichever one (if only one) of these theories is correct, then there can be no languages exhibiting rule ordering effects of the following combinations: (i) counterbleeding and bleeding; (ii) counterbleeding and feeding; (iii) 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 T3 sandhi, for example, exhibits both bleeding and counterbleeding.

Nonetheless, the wisdom behind both the Containment Approach and the Correspondence Approach must not be blighted in view of these limitations. While the Containment Approach is clumsy with alternation (recall the 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[21] property of GEN. ICT reconciles both Containment and Correspondence and reaps their benefits. Since the terminal nodes always correspond to the input string, the input must thus be contained in every output. Further, because nonterminal nodes are information-bearing and information between tiers is related by correspondence constraints (inter-tier faithfulness), the essential character of the Correspondence Approach is preserved.[22]

[21] Under the freedom of analysis, GEN is allowed to create (or destroy) any structure (Prince & Smolensky 1993[2004], and also McCarthy & Prince 1993:20).

[22] Although, there is disparity in the globality of traditional faithfulness constraints and the locality of inter-tier faithfulness.

(41) ICT as the product of Containment and Correspondence



5. Conclusion

Despite being well-understood and studied, current OT machinery (and to some extent traditional derivational machinery) does not actually rise up to the cyclic phenomenon of Mandarin T3 sandhi. Because Mandarin tone sandhi is cyclicity par excellence, by treating Mandarin T3 sandhi, this paper makes a stab at a general account of structural opacity within the Optimality Theoretic framework. As it turns out, cyclicity can best be explained by assuming inter-tier correspondence of information. Since faithful reconstruction of constituent information might result in marked collocations, alternation results. In this way, one can get the effect of derivation history without actually having to resort to procedural analyses. A number of interesting results are obtained from taking such a position. First, one now has an explanation for the blocking of phonological rules when offending units are adjacent but in different domains. Secondly, it provides a natural description of the percolative properties so necessary in metrical matters such as stress and focus. Thirdly, and perhaps more abstractly, the divergent assumptions of Containment and Correspondence approaches to Optimality Theory are unified under ICT.

References

Bao, Zhiming. 1990. *On the Nature of Tone*. Cambridge: MIT dissertation.

Bao, Zhiming. 1999. *The Structure of Tone*. New York: Oxford University Press.

Beckman, Jill N. 1997. *Positional Faithfulness*. Amherst: University of Massachusetts dissertation.

Beckman, Jill N., Laura Walsh Dickey, and Suzanne Urbanczyk. (eds.) 1995. *Papers in Optimality Theory*. University of Massachusetts Occasional Papers in Linguistics 18. Amherst: GLSA.

Benua, Laura. 1995. Identity effects in morphological truncation. *Papers in Optimality Theory*, ed. by Jill N. Beckman, Laura Walsh Dickey & Suzanne Urbanczyk, 77-136. University of Massachusetts Occasional Papers in Linguistics 18. Amherst: GLSA.

Benua, Laura. 1997. *Transderivational Identity: Phonological Relations between Words*. Amherst: University of Massachusetts dissertation.

Chen, Matthew Y. 1979. Metrical structure: evidence from Chinese poetry. *Linguistic Inquiry* 10.3:371-420.

Chen, Matthew Y. 1984. Unfolding latent principles of literary taste — poetry as a window onto language. *Tsing Hua Journal of Chinese Studies*, New Series 16.2: 203-240.

Chen, Matthew Y. 2000. *Tone Sandhi: Patterns across Chinese Dialects*. Cambridge & New York: Cambridge University Press.

Cheng, Chin-chuan. 1973. *A Synchronic Phonology of Mandarin Chinese*. The Hague: Mouton.

Cinque, Guglielmo. 1993. A null theory of phrase and compound stress. *Linguistic Inquiry* 24.2:239-297.

de Lacy, Paul. 1998. Sympathetic stress. Manuscript. Amherst: University of Massachusetts.

de Lacy, Paul. 2002. The interaction of tone and stress in Optimality Theory. *Phonology* 19.1:1-32.

Duanmu, San. 2000. *The Phonology of Standard Chinese*. Oxford & New York: Oxford University Press.

Fun, Howe Thern. 2005. Jiekou: xiandai Hanyu de liyan chuancha [Interface: expletive epenthesis in modern Chinese]. Manuscript. Singapore: National University of Singapore. (In Chinese)

Goldrick, Matthew. 2000. Turbid output representations and the unity of opacity. *Proceedings of NELS* 30:231-245. Amherst: GLSA.

Hammond, Michael. 1999. *The Phonology of English: A Prosodic Optimality Theoretic*

Approach. Oxford & New York: Oxford University Press.
Itô, Junko. 1986. *Syllable Theory in Prosody Phonology*. Amherst: University of Massachusetts dissertation.
Itô, Junko. 1989. A prosodic theory of epenthesis. *Natural Language and Linguistic Theory* 7.2:217-259.
Jackendoff, Ray. 1972. *Semantic Interpretation in Generative Grammar*. Cambridge: MIT Press.
Kager, René. 1999. *Optimality Theory*. Cambridge & New York: Cambridge University Press.
Kaisse, Ellen M. 1985. *Connected Speech: The Interaction of Syntax and Phonology*. Orlando: Academic Press.
Kenstowicz, Michael J. 1994. *Phonology in Generative Grammar*. Cambridge & Oxford: Blackwell.
Kiparsky, Paul. (to appear). *Opacity and Paradigm Effects*. Stanford: CSLI. Materials from Chapter One.
LaCharité, Darlene, and Carole Paradis. 2000. Derivational residue: hidden rules in Optimality Theory. *Optimality Theory: Phonology, Syntax, and Acquisition*, ed. by Joost Dekkers, Frank van der Leeuw & Jeroen van de Weijer, 211-233. Oxford & New York: Oxford University Press.
Liang, Yuan, and Lian-Hee Wee. 2004. Beijinghua de lianshang biandiao [Third tone sandhi in Beijing Mandarin]. *Zhongguo Yuwen* 2004.2:151-163. (In Chinese)
Liu, Feng-hsi. 1980. Mandarin tone sandhi: a case of interaction between syntax and phonology. Manuscript. Iowa City: University of Iowa.
McCarthy, John J. 1979. *Formal Problems in Semitic Phonology and Morphology*. Cambridge: MIT dissertation.
McCarthy, John J. 1998. Sympathy and phonological opacity. Manuscript. Amherst: University of Massachusetts.
McCarthy, John J. 2000a. Sympathy, cumulativity and the Duke-of-York gambit. *The Optimal Syllable*, ed. by Caroline Féry & Ruben van der Vijver, 23-76. Cambridge & New York: Cambridge University Press.
McCarthy, John J. 2000b. Harmonic serialism and parallelism. Manuscript. Amherst: University of Massachusetts.
McCarthy, John J., and Alan Prince. 1993. Generalized alignment. *Yearbook of Morphology 1993*, ed. by Geert Booij & Jaap van Marle, 79-153. Dordrecht: Kluwer.
McCarthy, John J., and Alan Prince. 1995. Faithfulness and reduplicative identity. *Papers in Optimality Theory*, ed. by Jill N. Beckman, Laura Walsh Dickey & Suzanne Urbanczyk, 249-384. University of Massachusetts Occasional Papers in

Linguistics 18. Amherst: GLSA.
Odden, David. 2000. Opacity and ordering: H-deletion in Kikerewe. *Linguistic Review* 17.2-4:323-335.
Orgun, Cemil Orhan. 1996a. Sign-based morphology: a theory of phonology-morphology interleaving. Manuscript. Berkeley: University of California.
Orgun, Cemil Orhan. 1996b. *Sign-based Morphology and Phonology with Special Attention to Optimality Theory*. Berkeley: University of California dissertation.
Pollard, Carl J., and Ivan A. Sag. 1994. *Head-driven Phrase Structure Grammar*. Stanford: CSLI; Chicago: University of Chicago Press.
Prince, Alan, and Paul Smolensky. 1993[2004]. *Optimality Theory: Constraint Interaction in Generative Grammar*. Malden: Blackwell.
Rooth, Mats. 1992. A theory of focus interpretation. *Natural Language Semantics* 1.1: 75-116.
Rooth, Mats. 1996. On the interface principles for intonational focus. *Proceedings of SALT* 6:202-226. Ithaca: Cornell University.
Selkirk, Elizabeth O. 1978[1981]. On prosodic structure and its relation to syntactic structure. *Nordic Prosody*, Vol. 2: *Papers from a Symposium*, ed. by Thorstein Fretheim, 111-140. Trondheim: Tapir.
Selkirk, Elizabeth O. 1995. The prosodic structure of function words. *Papers in Optimality Theory*, ed. by Jill N. Beckman, Laura Walsh Dickey & Suzanne Urbanczyk, 439-470. University of Massachusetts Occasional Papers in Linguistics 18. Amherst: GLSA.
Shen, Jiong. 1994. Beijinghua shangsheng liandu de diaoxing zuhe he jiezou xingshi [The tone and rhythmic configuration of sandhi in Beijing Mandarin]. *Zhongguo Yuwen* 1994.4:274-281. (In Chinese)
Shieber, Stuart M. 1986. *An Introduction to Unification-based Approaches to Grammar*. Stanford: CSLI.
Shih, Chi-lin. 1986. *The Prosodic Domain of Tone Sandhi in Chinese*. San Diego: University of California dissertation.
Shih, Chi-lin. 1988. Tone and intonation in Mandarin. *Working Papers of the Cornell Phonetics Laboratory* 3:83-109.
Shih, Chi-lin. 1997. Mandarin third tone sandhi and prosodic structure. *Studies in Chinese Phonology*, ed. by Jialing Wang and Norval Smith, 81-123. Berlin & New York: Mouton de Gruyter.
Steriade, Donca. 1982. *Greek Prosodies and the Nature of Syllabification*. Cambridge: MIT dissertation.
Truckenbrodt, Hubert. 1995. *Phonological Phrases: Their Relation to Syntax, Focus and Prominence*. Cambridge: MIT dissertation.

Truckenbrodt, Hubert. 1999. Syntactic phrases and phonological phrases. *Linguistic Inquiry* 30.2:219-255.

Wang, Hongjun. 2002. Putonghua zhong jielü bianjie yu jielü moshi, yufa, yuyong de guanlian [How the metrical boundary relates to metrical pattern, syntax, pragmatics in Chinese Mandarin]. *Yuyanxue Luncong* 26:279-300. Beijing: Commercial Press. (In Chinese)

Wee, Lian-Hee. 2001. Faithfulness as percolation — evidence from tone sandhi in Mandarin. *RuLing Papers 2: Working Papers from Rutgers University*, ed. by Graham Horwood & Se-kyung Kim, 163-196. New Brunswick: Rutgers University.

Wee, Lian-Hee. 2004. *Inter-tier Correspondence Theory*. New Brunswick: Rutgers University dissertation.

Xu, Yi. 1997. Contextual tonal variations in Mandarin. *Journal of Phonetics* 25.1:61-83.

Xu, Yuanchong, Peixian Lu, and Juntao Wu. (eds.) 1987. *300 Tang Poems: A New Translation*. Hong Kong: Commercial Press.

Zhang, Niina. 1997. The avoidance of the third tone sandhi in Mandarin Chinese. *Journal of East Asian Linguistics* 6.4:293-338.

[Received 29 January 2007; revised 17 December 2007; accepted 24 December 2007]

Department of English Language & Literature
Hong Kong Baptist University
Kowloon Tong, Kowloon
Hong Kong
lianhee@hkbu.edu.hk

源於組合的非透明現象

黃良喜
香港浸會大學

早在 1980 年代的 Lexical Phonology，推演的非透明度與結構的複雜度是對應的。可是 1990 年代後的優選論不再承認推演的過程，所以結構與非透明度的關係模糊了。本文以普通話連上變調爲例，在優選論框架內，提出層級對應論 (ICT)，假設結點之間須信息對應，重新將結構納入理論範圍。底層結點信息來自輸入項，其他結點由按結構逐層與底層結點相應。這麼一來標記性制約條件的適用範疇就轉到了結點上，得出標記性乃因同屬一個音系單位而起，非相鄰之罪的結果。

關鍵詞：非透明性，單位性，對應，連讀變調，普通話