

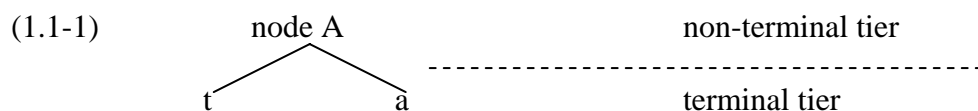
Chapter One

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,



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.

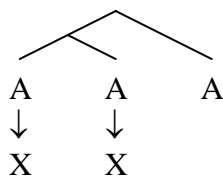
Thus, when confronted with opacity effects, standard accounts, be they derivational models or parallel ones, respond in the following way: Apply rules or constraints to linear strings. Structural information, if relevant, indicates the domain for application and order of application. For expository convenience, 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.

$$(1.1-2) \quad A \rightarrow X / _ A \quad = \quad \begin{array}{c} \diagup \quad \diagdown \\ A \quad A \\ \downarrow \\ X \end{array}$$

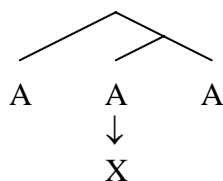
For clarity in presentation, I shall use the tree diagram in (1.1-2) as a notational equivalent¹ of the more traditional SPE type rule: $A \rightarrow X / _ A$. Now, suppose the application of (1.1-2) in language **L** is as given in (1.1-3).

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)

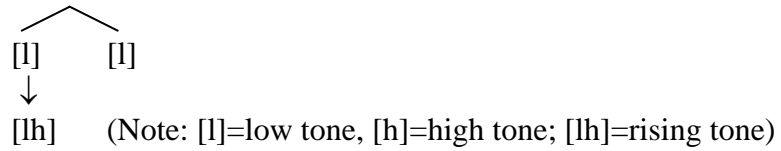
	/AA/ + /A/	/A/ + /AA/
	↓	↓
apply rule to lowest constituent	X	XA
	↓	
apply rule to next constituent	X	n.a.
	[XXA]	[AXA]

Languages like **L** do exist, for example, Standard Mandarin (henceforth Mandarin²).

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.

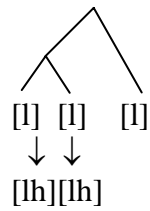
(1.1-5) Mandarin tone sandhi

a. ditonal sandhi



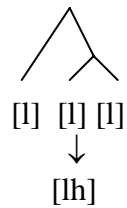
e.g. lao.gou 'old dog'

b. tritonal, left-branching sandhi



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

c. tritonal, right-branching sandhi



e.g. hao [lao.gou] 'good old dogs'

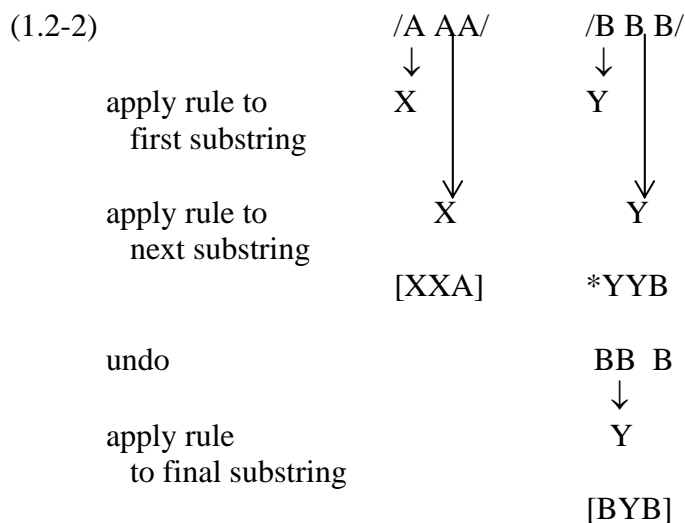
The account outlined above crucially refers to constituents, though prima facie, rules are applying to terminal strings, (hence, terminal-based).

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.



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,

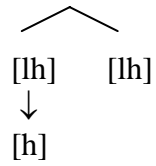
possibly contrary to well-established notions of strict cyclicity or bracket erasure (see Cole 1995, Mohanan 1995 for discussions on these notions). Neither does (1.2-2) explain why there should be a strange rule that undoes two prior steps in the derivation, nor does it explain what stops the *[YYB] 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/ → [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).

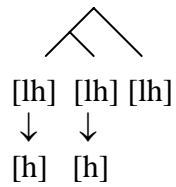
(1.2-3) Tianjin tone sandhi with rising tones

a. Tianjin ditonal sandhi with rising tones



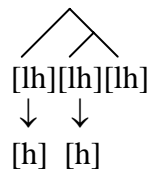
e.g. li.fa 'cut one's hair'

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



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

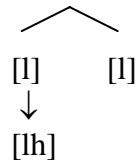
c. Tianjin tritonal sandhi with rising tones (right-branching structure)



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

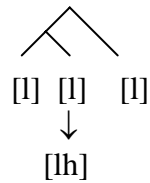
(1.2-4) Tianjin tone sandhi with low tones

a. Tianjin ditonal sandhi with low tones



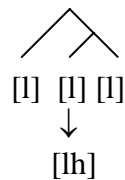
e.g. fei.ji ‘air plane (fly machine)’

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



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

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

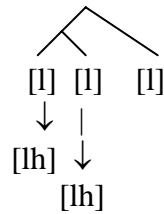


e.g. kai [fei.ji] ‘pilot a plane’

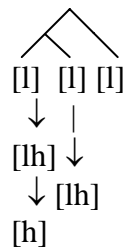
Notice that in (1.2-3), regardless of morphosyntactic constituency the rules are applying in counterbleeding order. In (1.2-4), regardless of morphosyntactic constituency, the rules are applying in bleeding order. Crucially, with (1.2-4), there is no feeding/counterfeeding application such as that in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

(1.2-5) Unattested Tianjin derivation

a.*



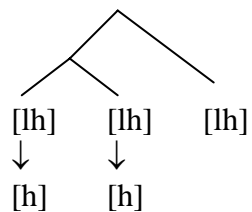
b.*



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

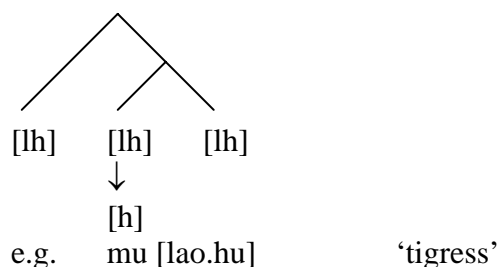
a.



e.g. [li.fa] suo

'barber shop'

b.



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.

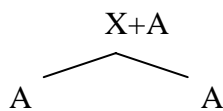
To summarize, by allowing rules to apply only to terminal nodes, terminal-based accounts are awkward with structure-sensitive recursive rule application (cf. Mandarin) and in the reversal of marked recursive rule application (cf. Tianjin). In the first case, it misses the point that the domain of application 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.

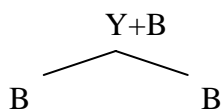
1.3. Inter-tier Correspondence Theory

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 (Jespersen 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.

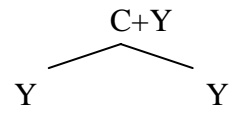
(1.3-1) a.



b.

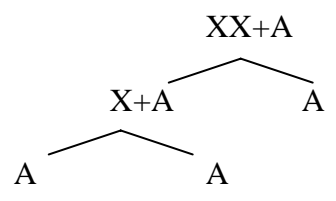


c.

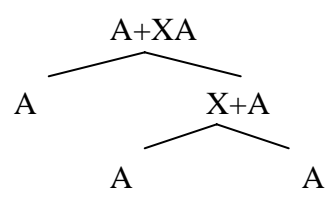


(1.3-1) corresponds to SPE rules like $A \rightarrow X/ _A$. There is a conceptual difference in that the representations in (1.3-1) are by far richer because they contain the “derivational histories” (to use convenient derivational terminology). In a sense, both underlying and surface information are 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 percolated 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).

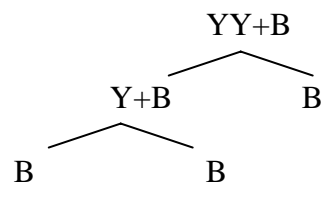
(1.3-2) a.

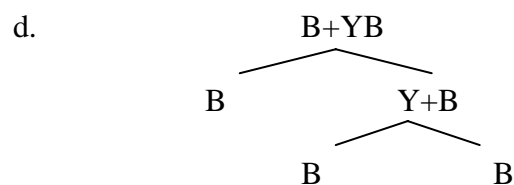


b.



c.





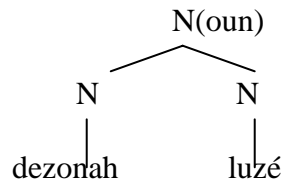
An account for language **L** or **L'** would simply be the mapping of the underlying sequences and their structures to one of the forms in (1.3-2). This can be done with (i) a set of faithfulness requirements on the second element in a di-elemental string; (ii) a set of markedness constraints such as 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:

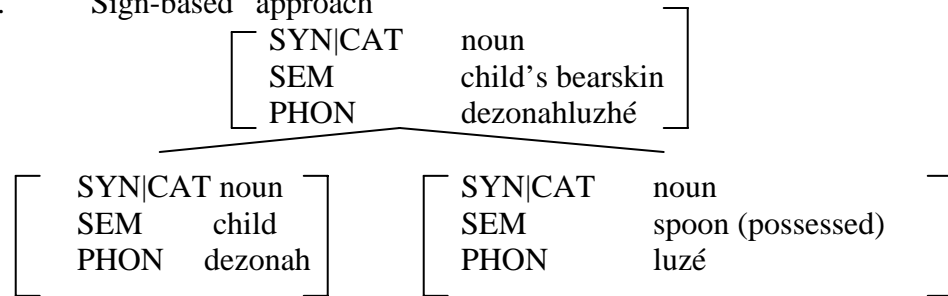
a Saussurean pairing between some phonological shape and some semantic information. In sign-based theories, a constituent structure is a statement of how the grammar justifies (licenses) the sign represented at the top node.

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



b. “Sign-based” approach



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 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

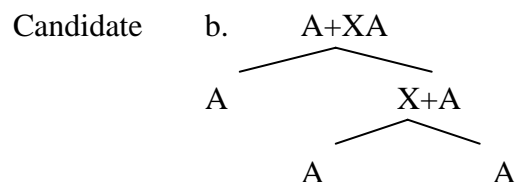
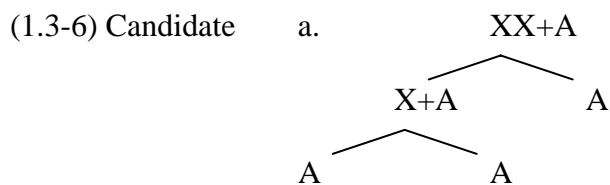
Align (prosodic) constituencies right.

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.



Comparative tableau

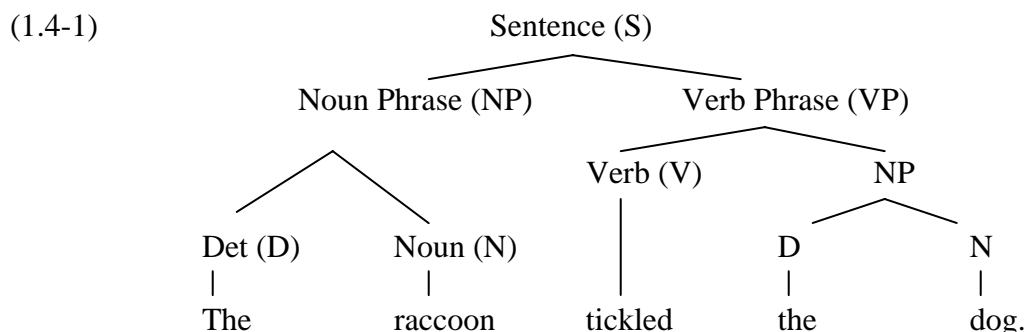
	OCP	INTF	ALIGN LT	ALIGN RT
candidate a ~ candidate b	Cand. b	Cand. b	Cand. a.	Cand. b.

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

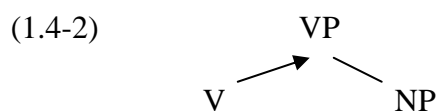
While the notion of percolation has found widespread acceptance in syntax, it has received relatively little attention in phonology. To illustrate the notion of percolation in syntax, consider the following sentence and its syntactic constituency.



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.



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.

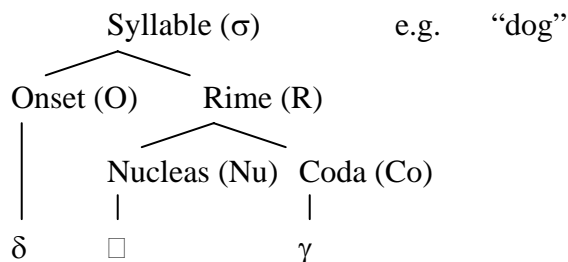
(1.4-3) Phrase Structure Rules (Standard Syntactic Theory)

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

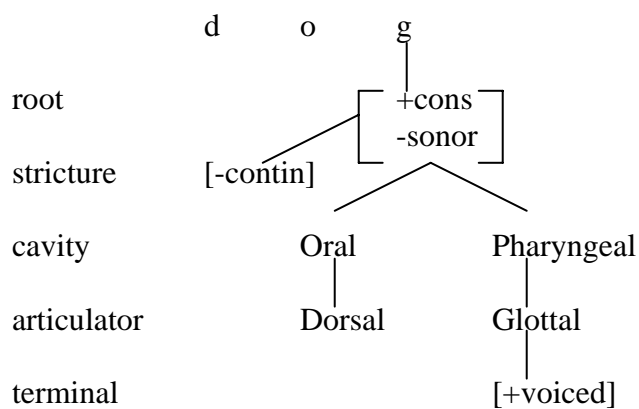
A uniformly endocentric model of syntactic constituency appeared only with the advent of X-bar theory (Jespersen 1924:96, Jackendoff 1977) and the introduction of Infl to include tense, modals and other auxiliaries and the IP (Infl Phrase) in place of S.

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).

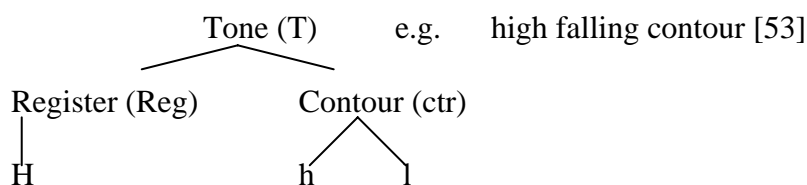
(1.4-4) Representation of a syllable⁴



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



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



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.

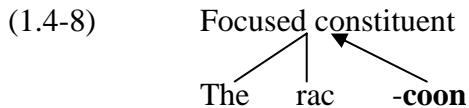
(1.4-7) a. The raccoon tickled the dog.

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

b. The raccoon tickled the dog.

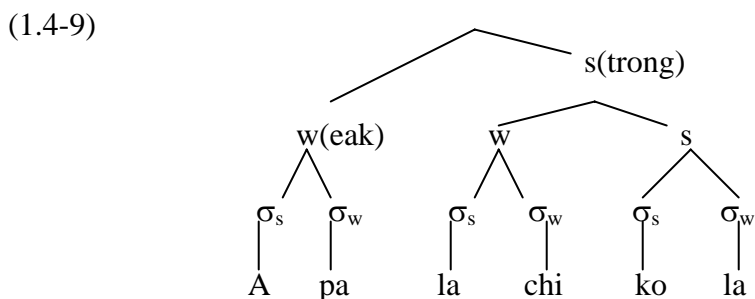
(Roughly means: It was the dog that the raccoon tickled.)

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.



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).



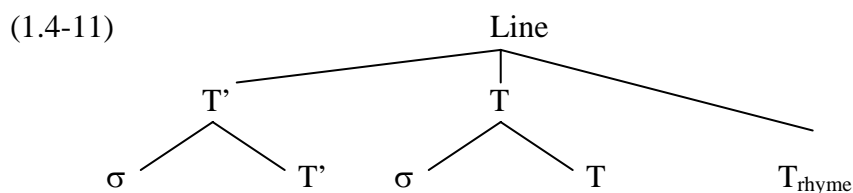
In the case of (1.4-9), one identifies the relative prominence of each syllable by looking from the top-down. The syllable that is most stressed is the one dominated by an unbroken string of S, while the weakest would be dominated by an unbroken thread of W. This can be conceived of as an example of 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. | EEOOE | (but *EEOEE) |
| b. | EEEE O | (but *EOEOE) |
| c. | OOEE O | (but *OOEEO) |
| d. | OOOE E | (but *OEOEE) |
| e. | EEEE O | (but *EOEEO) |
| f. | OEEEO | (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.



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.

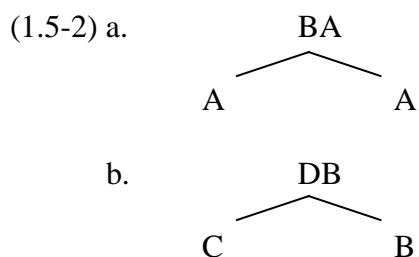
Correspondence of information

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

Violability of correspondence

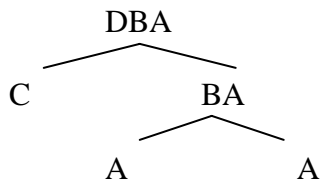
Correspondence of information between nodes is not necessarily perfect.

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.

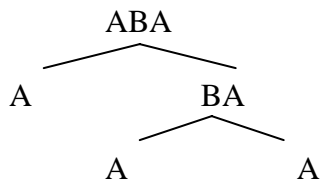


(1.5-2) corresponds to SPE rules like $A \rightarrow X / _A$. Such a notation is by far richer because it contains the “derivational history”. In (1.5-2), the terminal nodes correspond to the underlying string. To simplify matters, the rules shown here are those where percolation is not faithful with 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.

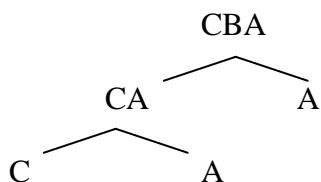
(1.5-3) a. Feeding



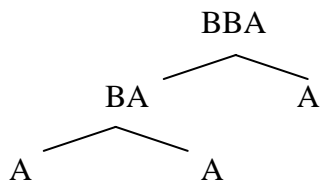
b. Bleeding



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.

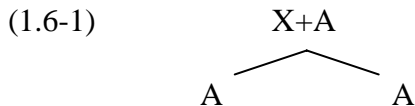
It is important to note that ROOT-EFFECTIVE constraints simply allow for certain collocations to be tolerated at intermediate nodes. It does not prevent GEN from producing candidates where intermediate nodes do not contain collocations otherwise deemed marked by ROOT-EFFECTIVE constraints. Having made 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.



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. φ [B/A][B/A]A		**
iii. AAA	*!*	

Counterfeeding

/CAA/	A → B / __ A	C → D / __ B	Faith
i. φ 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/	$A \rightarrow B / _ A$	Faith
i. $\not\Leftarrow$ ABA		*
ii. BBA		**
iii. AAA	*!*	

Feeding

/CAA/	$A \rightarrow B / _ A$	$C \rightarrow D / _ B$	Faith
i. CBA		*!	*
ii. $\not\Leftarrow$ 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 analysis⁵ 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 preserved⁶.

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 constraints 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.