

THE AVOIDANCE OF THE THIRD TONE SANDHI
IN MANDARIN CHINESE*

An optimality-theoretic analysis of third tone sandhi (TS) domains of Mandarin is proposed in preference to other approaches. This constraint-based analysis provides a descriptively better solution to questions such as why it is possible for a preposition to resist tone sandhi in certain structures, a long-standing problem in tone sandhi studies. The paper shows that this resistance to tone sandhi is dependent on both syntactic structures and syntactic categories. In this study, Mandarin tone sandhi domains are related to constituent strength representations, which are direct mappings of syntactic structures. An unspecified order of strong/weak values of constituent strength for a prepositional phrase is proposed. To define a TS domain, several constraints related to metrical factors, constituent strength, the tone sandhi domain grouping direction, and output condition are shown to interact with each other. The optimal tone sandhi domain representation is always the one which violates the lowest-ranked constraints and violates any single constraint to the least degree possible, compared to other representations. The avoidance of tone sandhi by an element, whether it is a preposition or another category, is the result of interactions of the constraints. The variability of surface tone patterns comes from more than one optimal output, from speaking rate or style, and from two possible kinds of competition due to the unspecified constituent strength.

1. THE ISSUE

Mandarin Third Tone Sandhi (TS) changes a third tone into a second tone when this underlying third tone is immediately followed by another third tone.¹ The domain of TS has been discussed extensively in the literature (C. Cheng (1973), Shih (1986, 1989), L. Cheng (1987), Z. Zhang (1988), Hung (1989), Chen (1990), Jin (1992), Mok (1993), etc.), but there has been no convincing explanation for the contrast between forms such as (1a) and (1b). (UT means underlying tone pattern and ST means surface tone pattern.)

(1) a.	gou	[[bi	ma]	xiao]	
	dog	than	horse	small	‘A dog is smaller than a horse.’
	3	3	3	3	UT
	(2	3)	(2	3)	ST1 (unmarked, moderate)
	(3)	(2	2	3)	ST2 (unmarked, moderate)
	(2	2	2	3)	ST3 (presto)

b. ma	[[hen	shao]	hou]	
horse	very	seldom	roar	‘Horses seldom roar.’
3	3	3	3	UT
* (2	3)	(2	3)	ST1
(3)	(2	2	3)	ST2
(2	2	2	3)	ST3

The third syllable in both (1a) and (1b) has Tone 3 (T3) in the underlying form and should trigger TS on the second syllable, which also has T3 in the underlying form. Avoidance of TS is allowed on the second syllable in (1a) (ST1) but not in (1b) (ST1). In (1b), TS of the second syllable is obligatory (ST2, ST3).

General speaking, in a disyllabic constituent, be it a word or a phrase, where both syllables bear T3 in the underlying form, if the first syllable is not a preposition, it must undergo TS, regardless of the speed. Thus, in the adverbial phrase in (1b), *hen* of *henshao* is obligatorily affected by TS. (1a) differs from (1b) in that it contains a disyllabic prepositional phrase (PP). Disyllabic PPs in certain contexts behave differently: a preposition is allowed to keep T3 without the application of TS, as is illustrated in (1a).

The avoidance of TS with PPs seen in (1a) is not an isolated phenomenon. In general in the same structure, in contrast to other categories, prepositions which are not followed by a pronoun exhibit avoidance of TS, as shown by comparing the acceptability of ST1 in the examples in (2) and (3).

(2) Disyllabic prepositional phrases

a. ma	[[wang	bei]	zou]	
horse	to	north	walk	‘The horse walked to the north.’
3	3	3	3	UT
2	3	2	3	ST1
3	2	2	3	ST2
2	2	2	3	ST3

b. ma	[[gei	gou]	yao]	
horse	by	dog	bite	‘The horse was bitten by the dog.’
3	3	3	3	UT
2	3	2	3	ST1
3	2	2	3	ST2
2	2	2	3	ST3

c.	[[bi	gou]	xiao]		
	than	dog	small		‘smaller than a dog.’
	3	3	3		UT
	2	2	3		ST1
	3	2	3		ST2

(3) Other disyllabic phrases

a.	kan	[[xiao	gou]	zou]	
	watch	small	dog	walk	‘to watch a small dog walking’
	4	3	3	3	UT
	*4	3	2	3	*ST1
	4	2	2	3	ST2
b.	you	[[liang	wan]	mi]	
	have	two	bowl	rice	‘There are two bowls of rice’
	3	3	3	3	UT
	*2/3	3	2	3	*ST1
	3	2	2	3	ST2
	2	2	2	3	ST3
c.	gou	[[da	san]	zou]	
	dog	take	umbrella	walk	‘The dog walked with an umbrella.’
	3	3	3	3	UT
	*2	3	2	3	*ST1
	3	2	2	3	ST2
	2	2	2	3	ST3
d.	[[xiao	gou]	pao]		
	small	dog	run		‘The small dog run.’
	3	3	3		UT
	2	2	3		ST1
	*3	2	3		*ST2

All of the data in (2) and (3) contain the structure of $[[_{XP}\sigma^a\sigma^b]\sigma^c]$. The σ^a of $[[_{XP}\sigma^a\sigma^b]\sigma^c]$ is a preposition in (2), an adjective in (3a) and (3d), a numeral in (3b), and a verb in (3c). In (1b) above, σ^a is an adverb. Thus in the structure $[[_{XP}\sigma^a\sigma^b]\sigma]$, σ^a exhibits avoidance of TS only when it is a preposition but not another category. I term this phenomenon “category dependency in avoidance of TS”.

There is also structure dependency in avoidance of TS. A preposition in a different structure does not contrast in its patterning with other categories. On the one hand, both a preposition and an element of other

category can escape TS in certain structures. On the other, both a preposition and an element of other categories must undergo TS in some structures. These two cases are shown in (4) and (5), respectively. The structure of (4) is $[[\sigma^d[_{XP}\sigma^a\sigma^b]]\sigma^c]$. The first syllable in this structure, σ^d can avoid TS, regardless of its category. In (4a) the first syllable *mai* ‘buy’ is a verb, while in (4b) the first syllable *bi* ‘than’ is a preposition.

(4)	a.	[mai	[xiao	ma]]	hao	
		buy	small	horse	good	‘It is good to buy small horses.’
		3	3	3	3	UT
		3	2	2	3	ST1
		2	2	2	3	ST2
	b.	[bi	[xiao	gou]]	lan	
		than	small	dog	lazy	‘to be lazier than the small dog.’
		3	3	3	3	UT
		3	2	2	3	ST1
		2	2	2	3	ST2

The structure of (5) is $[\sigma^d[[_{XP}\sigma^a\sigma^b] [\sigma^c\sigma^e]]]$. The second syllable σ^a must undergo TS, again regardless of its category. In (5a), the second syllable *da* ‘take’ is a verb, while in (5b), the second syllable *gei* ‘for’ is a preposition.²

(5)	a.	gui	[[da	san]	[mai	jiu]]	
		ghost	take	umbrella	buy	wine	‘The ghost bought wine with an umbrella.’
		3	3	3	3	3	UT
		3	2	3	2	3	ST1
		*2	3	2	2	3	ST2
	b.	ma	[[gei	gou]	[xi	zao]]	
		horse	for	dog	wash	bath	‘The horse bathed the dog.’
		3	3	3	3	3	UT
		3	2	3	2	3	ST1
		*2	3	2	2	3	ST2

Furthermore, in the structure $[[_{XP}\sigma^a\sigma^b]\sigma^c]$, if σ^a is a preposition and σ^b is a pronoun, σ^a does not show TS avoidance. The following example contrasts to (1a) and (2):

(6)	gou	[[bi	wo]	xiao]	
	dog	than	me	small	‘The dog is younger than me.’
	3	3	3	3	UT
	*2	3	2	3	ST1
	3	2	2	3	ST2
	2	2	2	3	ST3

TS can be applied nearly everywhere in Mandarin, especially when speaking fast or casually (Shih (1989) and Jin (1992)).³ But avoidance of TS does not occur everywhere. The above data show that avoidance of TS is both category dependent and structure dependent.

In this paper, I will argue, within the framework of Optimality Theory, that avoidance of TS is the result of interactions of different violable constraints. I also argue that the variability of surface tone patterns is accounted for by ranked constraints such that more than one optimal output is allowed. By allowing forms with prepositions to enter into two possible kinds of competition due to the nonspecified constituent strength of elements in a prepositional phrase, I further shed new light on the understanding of the relationship between tone sandhi domains and constituent strength representations linked to syntactic structures. I finally argue that violable and ranked constraints provide an account of the data that is empirically superior to a rule reordering account.

In section 2, a number of previous approaches to the TS avoidance of a preposition are argued to be inadequate. Section 3 is concerned with constituent strength representations, and section 4 deals with ranked constraints for defining TS domains. In section 5 I will discuss how the constraints interact with each other in various constructions, why TS avoidance is allowed in certain structures, and how alternative surface tone patterns are derived. Section 6 compares the choices between a rule ordering approach and a constraint-based approach with respect to TS domains. The last section, section 7, is a summary and conclusions.

2. PREVIOUS TREATMENTS

The different tone sandhi behavior between PPs and other XPs in certain contexts has been noticed by many Chinese linguists. In this section I will review six approaches to this issue since Shih (1986) and show that none of these proposals is adequate.

2.1. *Direct DM Approach*

Shih's (1986) research is an important work on Mandarin tone sandhi. However, she leaves TS in a prepositional phrase as an unsolved problem (p. 151). Based on Chen (1983), Shih puts forward the following Foot Formation Rule.

- (7) Foot Formation Rule (FFR) (Shih (1986, p. 110)):
- I. Foot (f) Construction
 - a. IC (Immediate Constituency): Link immediate constituents into disyllabic feet.
 - b. DM (Duple Meter): Scanning from left to right, string together unpaired syllables into binary feet, unless they branch to the opposite direction.
 - II. Super-foot (f') Construction

Join any leftover monosyllable to a neighboring binary foot according to the direction of syntactic branching.

It is important that FFR-DM follow FFR-IC. As the theory claims (p. 111): "If the neighboring constituent is already disyllabic, the attachment of an additional syllable creates a trisyllabic or quadrisyllabic super-foot, so called because it still has the status of a prosodic foot, only larger in size." Example (8) illustrates with the structure $[\sigma^d[[_{XP}\sigma^a\sigma^b]\sigma^c]]$ (Shih (1986), p. 114, her example (38)).⁴

(8)		
	(deng (jiu- dian)_f zheng)_r wait nine o'clock sharp	‘wait until 9 o’clock sharp’
	3 3 3 3	UT
	2 3	IC
	3 2 2 3	f' (any tempo)
	*3 2 3 3	
	*2 3 2 3	

Example (8) shows that σ^a and σ^b in $[\sigma^d[[_{XP}\sigma^a\sigma^b]\sigma^c]]$ are in one foot and σ^b must trigger the tone sandhi of σ^a . Thus, it is unexpected that σ^a can escape TS in $[\sigma^d[[_{XP}\sigma^a\sigma^b]\sigma^c]]$ if it is a preposition and σ^b is a noun. The category dependency of the avoidance of TS thus remains unaccounted for. Shih suggests that one way of dealing with this problem is not to apply FFR-IC to a prepositional phrase with a full NP so that the quadrisyllabic string is separated into two prosodic feet by FFR-DM (Shih (1986,

p. 152)). For example, *mao bi gou xiao* ‘cat is smaller than dog’ is directly analyzed by DM into two DMs ((*mao bi*) (*gou xiao*)). This procedure of skipping over FFR-IC is descriptively problematic. In section 6, I will show in addition that a rule reordering approach sometimes predicts wrong representations.

2.2. *Special Circumstance Approach*

Z.-S. Zhang (1988, pp. 116–120) takes $[\sigma^d[[_{pp}\sigma^a\sigma^b]\sigma^c]]$ to be a special circumstance where IC is overridden by DM. He claims that in the face of such examples, it is necessary to concede that prosodic structures are not constructed with one mechanism alone but by two separate ones. The two mechanisms are:

- 1) initial prosodic structure construction like FFR (see (7)), used in normal conditions;
- 2) restructuring under special circumstances.

He argues that in special circumstances reanalysis alters prosodic structures in favor of the underlying rhythmic patterns of the language. One such context is poetry, which places a high premium on strict rhythmic patterns. Here, the IC part of the FFR might no longer take precedence over DM.

It is true that the DM part of the FFR plays a more important role than the IC part of the FFR in poetry. This is shown in the work of Chen (1979). But we cannot find any explanation for separating $[\sigma^d[[_{pp}\sigma^a\sigma^b]\sigma^c]]$ from other $[\sigma^d[[_{xp}\sigma^a\sigma^b]\sigma^c]]$ phrases, and grouping $[\sigma^d[[_{pp}\sigma^a\sigma^b]\sigma^c]]$ cases with poetry cases. No more poetic flavor in $[\sigma^d[[_{pp}\sigma^a\sigma^b]\sigma^c]]$ is found than in other $[\sigma^d[[_{xp}\sigma^a\sigma^b]\sigma^c]]$ phrases. Thus this special circumstance theory does not explain anything.

2.3. *Sense Unit Approach*

Hung (1989) and Chen (1990, p. 34) claim that the first two syllables of the $[\sigma^d[[_{pp}\sigma^a\sigma^b]\sigma^c]]$ structure, i.e., σ^d and σ^a , can form a disyllabic sense unit. Thus the reorganization of this structure into $((\sigma^d\sigma^a)(\sigma^b\sigma^c))$ in tone sandhi has some motivation. The argument behind this approach is that Chinese prepositions can also be taken as verbs, and the $(\sigma^d\sigma^a)$ in the $((\sigma^d\sigma^a)(\sigma^b\sigma^c))$ could be an argument-verb constituent.

It is true that some Chinese prepositions and verbs share the same form and are related historically. However, prepositions in examples such as *ma wang bei zou* ‘the horse walked to the north’ (2a), *ma gei gou yao* ‘the horse was bitten by the dog’ (2b), and *gou bi ma xiao* ‘a dog is smaller

than a horse' (1a) differ from verbs. First, they cannot occur with any aspect markers, while a verb usually can. For instance, *bi* in (9a) is a verb and occurs with the aspect marker *guo*, while *bi* in (9b–c) is a preposition and cannot occur with *guo*. Thus, the fact that *bi* is verb in (9a) does not imply that *bi* in other sentences is also a verb. A similar situation can be found with *ti*, which is a verb in (10a) but a preposition in (10b–c).

- (9) a. xiaqi women bi-guo liang ci.
 chess we compare-ASP two times
 'We have competed with each other at chess twice.'
- b. gou bi ma xiao.
 dog than horse small
 'A dog is smaller than a horse.'
- c.*gou bi-guo ma xiao
- (10) a. ta ti-guo wo.
 he replace-ASP I
 'He once took my place (in working).'
- b. dajia dou ti ni gaoxing.
 everyone all for you glad
 'Everyone felt glad for you.'
- c.*dajia dou ti-guo ni gaoxing.

Second, when σ^d of [σ^d [[pp $\sigma^a\sigma^b$] σ^c]] is the subject and σ^b is the complement of a preposition σ^a , then the constituent represented by the last syllable σ^c is obligatorily present since it is the head of the whole phrase (verb or adjective predicate). This can be explained only by saying that σ^a here is not a verb position because a verb does not always require a post-complement element to co-occur. This too supports the claim that not all prepositions can be analyzed as verbs.

Third, if σ^a were a verb, its complement σ^b would be able to be fronted to undergo a topicalization or focus movement found in Mandarin.

- (11) a. gou yao-zhe neigen gutou.
 dog bite-ASP that bone
 'The dog is biting that bone.'
- b. neigen gutou gou yao-zhe.
 'That bone, the dog is biting.'

- c. gou neigen gutou yao-zhe.
 ‘The dog is biting THAT BONE.’

However, the complement of a preposition cannot be fronted, as Chinese does not allow preposition stranding. In $[\sigma^d[[_{PP}\sigma^a\sigma^b]\sigma^c]]$, σ^b cannot be fronted.⁵

- (12) a. gou wang bei zou.
 dog to north walk
 ‘The dog walked to the north.’
 b.*bei gou wang zou.
 c.*gou bei wang zou.

In (12b) and (12c), when the complement of a preposition is fronted, the sentence is unacceptable, whereas in (11b) and (11c), when the complement of a verb is fronted, the sentence is acceptable.

From the above discussion we see that σ^a in $[\sigma^d[[_{PP}\sigma^a\sigma^b]\sigma^c]]$ cannot be a verb, and σ^a should not form an argument-verb constituent with its preceding syllable σ^d . That no clear semantic relations could be established here is also pointed out by Shih (1989). Thus the Sense Unit approach fails to explain why σ^a in $[\sigma^d[[_{PP}\sigma^a\sigma^b]\sigma^c]]$ can be grouped with its preceding syllable and escapes TS. A sense unit cannot be a combination of an external argument and a following preposition, which is neither a predicate of the argument nor a head selecting the argument. In addition, this approach cannot explain the structure dependency of TS avoidance.

2.4. *Functor Approach*

Hsiao (1991, p. 39) distinguishes functor beats from lexical beats (‘beat’ is used in the sense of Selkirk (1984)). Both pronouns and prepositions, as well as aspect markers, are taken as functor beats. This approach utilizes a procedure similar to Shih’s (1986) IC and DM (see (7)) but differs from Shih’s in that Functor Beat Assignment takes place after lexical syllables have been made into Immediate Constituent Feet or Adjacent Beat Feet. Thus in $[\sigma^d[[_{XP}\sigma^a\sigma^b]\sigma^c]]$, the prosodic structures are different depending on whether σ^a is a preposition (13a) or a verb (13b) (Hsiao (1991, p. 75)):

In both (14) and (15), objective pronouns *ni* ‘you’ and *wo* ‘me’ must be in the same domain with the preceding verb or preposition and trigger tone sandhi on the verb or preposition (the pronouns themselves also undergo TS triggered by the following T3). Thus, the difference between prepositions and pronouns should be accounted for in tone sandhi domain analysis. In other words, functor beats, which cover both prepositions and pronouns, are too coarse-grained.

2.5. *Semantic-Pragmatic Effect Approach*

Jin (1993, p. 10) claims that in $[\sigma^d[[_{PP}\sigma^a\sigma^b]\sigma^c]]$, σ^b receives contrastive stress. Because it is contrastively stressed, it cannot be strung together with the preceding preposition σ^a . However, according to my and my informants’ intuitions, the reorganization of $((\sigma^d\sigma^a)(\sigma^b\sigma^c))$ from $[\sigma^d[[_{PP}\sigma^a\sigma^b]\sigma^c]]$ can be achieved without any contrastive stress on σ^b . This occurs with all prepositions in such a construction. For example, the ST1 of (1a), repeated here as (16), can be a response to either the question “What is a dog smaller than?” (σ^b has contrastive stress) or to the question “What is smaller than a horse?” (the first syllable σ^d of $[\sigma^d[[_{PP}\sigma^a\sigma^b]\sigma^c]]$ has contrastive stress).

(16) a.	gou	[[bi	ma]	xiao]	
	dog	than	horse	small	A dog is smaller than a horse.
	3	3	3	3	UT
	(2	3)	(2	3)	ST1

Thus, this theory cannot explain why σ^a in $[\sigma^d[[_{XP}\sigma^a\sigma^b]\sigma^c]]$ can resist the tone sandhi if σ^a is a preposition, regardless of the position of a contrastive stress. In addition, this theory also fails to account for the structure dependency of avoidance of TS of a preposition, as shown in section 1.

2.6. *Clitic Approach*

Like Hsiao (1991), Shih (1989) groups prepositions with clitics such as pronouns. This approach requires that prepositions in Chinese are clitics. They are prosodically weak and cliticize to a host to their left, forming a prosodic domain with the preceding syllable. Thus the grouping of $[\sigma^d[[_{PP}\sigma^a\sigma^b]\sigma^c]]$ into $((\sigma^d\sigma^a)(\sigma^b\sigma^c))$ seems to be explained. However, there are differences between a T3 preposition and a usual T3 clitic: the latter always belongs to the same TS domain with the preceding T3 syllable if there is one (see (25) below), but the grouping of a preposition varies with context. For example, the preposition in (5b) above does not belong to

the same TS domain as the preceding syllable. Thus TS avoidance is both category dependent and structure dependent.

2.7. *Summary*

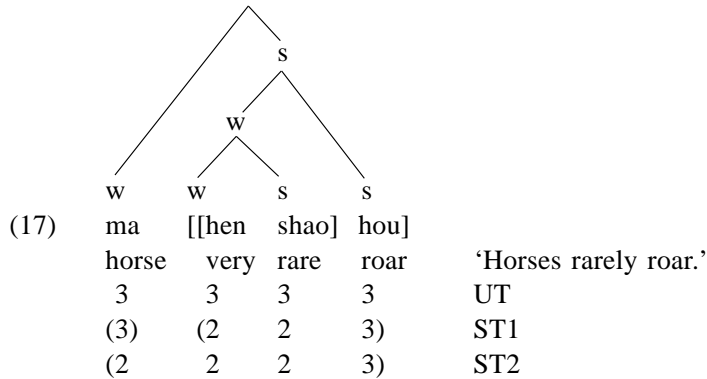
In this section we have seen the inadequacy of previous explanations for the TS avoidance of prepositions in some contexts. In the remainder of this paper I will try to explain TS avoidance from a new perspective: constituent strength of a phrase structure and interactions of various constraints. I will propose that the strength of a preposition is unspecified and that the various surface tone patterns arise either from more than one optimal output or from two possible kinds of competition due to the unspecified constituent strength.

3. CONSTITUENT STRENGTH REPRESENTATIONS

To account for the category and structure dependent TS avoidance shown in section 1, I will examine the relationship between constituent strength and tone sandhi on the one hand, and the interactions of various constraints on the other (section 4).

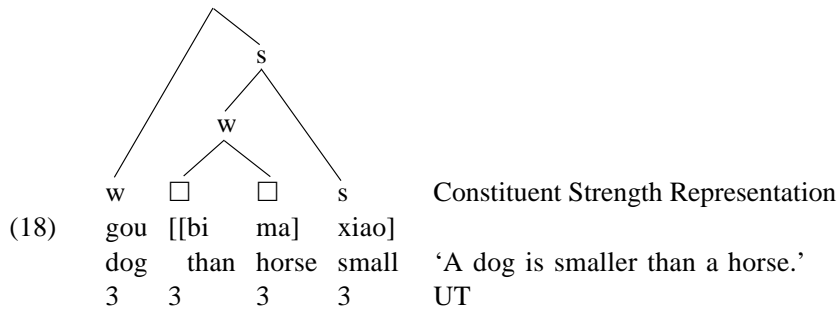
My constituent strength hypothesis is based on the Null Theory of Phrase Stress proposed by Cinque (1993). According to this theory, when a complement of a phrase is present, the complement, rather than the head and the specifier, is the phrase stress bearer; when no complement is present, the head of the phrase qualifies as the phrase stress bearer. Specifiers and pre-head modifiers are always weak. In default cases, the Null Theory of Phrase Stress posits a phrase-final stress. Although the phrase-final stress hypothesis has recently received some support in Mandarin in a perception study by Jin (1995), the issue of Mandarin phrasal stress is complicated due to the rich tone representations and to the lack of detailed experimental and perception studies.

In this paper, I take a more conservative position: I will regard Cinque's contrast of s/w stress as contrast of s/w constituent strength rather than as a reflection of stress directly. In other words, constituent strength is represented by s(trong) and w(eak) values which are mapped from syntactic modifier/spec-head-complement relations. Every monosyllabic morpheme has a strength value assigned according to its structural function.⁷ For example, (1b) has the following constituent strength representation:



The innermost constituent receives constituent strength; this forms a constituent with the final word; and finally this entire constituent enters into a strength unit with the initial word. I will assume that constituent strength representation given by the Null Theory plays a role in the derivation of TS domains.

In section 2, I argued that the basic empirical failing of a number of theories proposed to account for TS in Mandarin comes in their treatment of prepositions. I too will assume that prepositions are special, but I differ in how I represent this. I assume that prepositions require a different constituent strength representation than that of other constituents: constituent strength representations of all other categorical phrases are defined by the Null Theory, and the head and non-head nodes are specified with either w or s; however, the head and non-head of a prepositional phrase are unspecified with a s or w value. The symbol □ denotes the unspecified s/w value. The constituent strength representation of (1a) is assumed to be as follows:



This representation can be compared with that of (17) above, where all categories are labeled s or w.

In the following sections, I will illustrate how the TS domains in (1) are defined by the interactions of various constraints.

4. RANKED CONSTRAINTS ON TS DOMAINS

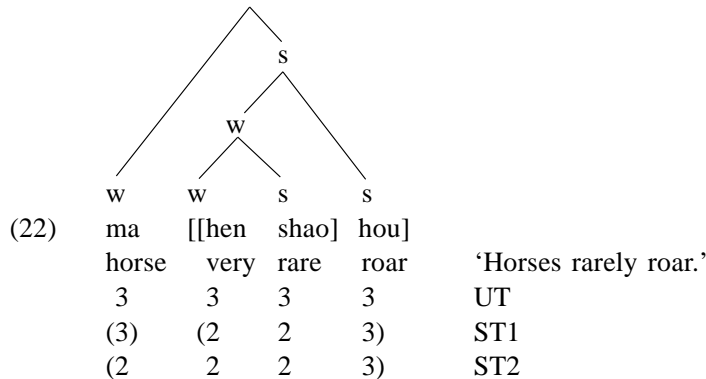
In this section, I will propose an Optimality Theory analysis of Mandarin TS domains. In this theory, constraints are violated and ranked. The optimal representation is always the one which violates the lowest-ranked constraints and violates any single constraint to the least degree possible, compared to other representations. See Prince and Smolensky (1993) and McCarthy and Prince (1993) for details.

A third tone sandhi domain in Mandarin is a span which contains a T3 as a TS trigger, where the T3 of all other elements preceding the trigger T3 surfaces as T2. The selection of optimal TS domains involves a competition between several potential output candidates. The outcome of the competition is determined by constituent strength related constraints, constraints on the third tone sandhi output and its grouping direction, and prosodic constraints. I will first introduce each of these constraints and then discuss their ranking.

The first two constraints that I propose are Parse Underlying Tone (UT) of an Absolutely Strong Node and Parse UT of a Relatively Strong Node:

- (19) *Parse UT of an Absolutely Strong Node (PTAS)*
The underlying tone of a strong constituent which is not dominated by any w node must be parsed.
- (20) *Parse UT of a Relatively Strong Node (PTRS)*
The underlying tone of a strong constituent which is dominated by at least one w node must be parsed.

These two constraints require the underlying tone of a strong element to surface.



In the tree above, for example, *hou* 'roar' is an absolute strong element since it is dominated by s nodes only. Its underlying tone, i.e., T3, surfaces in

both ST1 and ST2. Thus PTAS is obeyed in these two outputs. *Shao* 'rare' in the tree above is a relatively strong element since it is strong but has one *w* node in the chain of nodes that dominate it. Its underlying tone, i.e., T3, does not surface in either ST1 or ST2. Thus PTRS is violated in both outputs. PTAS and PTRS are faithfulness conditions that guarantee that the underlying tones of strong elements are maintained on the surface. Later we will see that the violation of PTRS is the result of interactions of various constraints.

The third constraint is an OCP-type constraint that disallows sequences of third tones.⁸

- (22) *No sequential third tones* (*33):
No adjacent third tones are allowed.

The fourth constraint concerns the inseparability of clitics from their preceding verbs or prepositions in TS domains.

- (23) *Clitic Dependency* (CI):
A clitic cannot be separated from the TS domain of the preceding verb or preposition head.

Mandarin clitics include pronouns which function as direct object of verbs or prepositions, as in (6) above, repeated here as (24), and bare classifiers which are not preceded by numerals, such as *ba* and *dian* in (25):

- (24) *gou* *bi* **wo** *xiao*
 dog than me small 'The dog is younger than me.'
 3 3 3 3 UT
 *(2 3) (2 3) ST1
 (3) (2 2 3) ST2
 (2 2 2 3) ST3
- (25) a. *xiang* *mai* **ba** *san*
 want buy CL umbrella '(I) want to buy an umbrella'
 3 3 3 3 UT
 *(2 3) (2 3) ST1
 (3) (2 2 3) ST2
 (2 2 2 3) ST3
- b. *mai* **dian** *hao* *jiu*
 buy CL good wine 'Buy a little good wine'
 3 3 3 3 UT
 (2 3) (2 3) ST1
 (2 2 2 3) ST2
 *(3) (2 2 3) ST3

Clitic Dependency prevents a verb or a preposition from ending a domain when the verb or preposition is followed by a clitic.

The fifth constraint is a binarity-type constraint that prefers two elements in a prosodic domain.

- (26) *Maximal Domain (Max):*
The maximal TS domain is two syllables in normal speaking rate but larger in more casual or faster style.

For example, in ST1 of (27), a numeral word is divided into two TS domains.

- | | | |
|------|---------------------|--------|
| (27) | wu- wu- jiu- wu | |
| | five-five-nine-five | ‘5595’ |
| | 3 3 3 3 | UT |
| | (2 3) (2 3) | ST1 |
| | (2 2 2 3) | ST2 |

(27) shows that, at normal speaking rate, a complex numeral word is divided into two TS domains based on disyllabic feet, so a Mandarin TS domain is related to metrical factors. Every two syllables form a foot, and a TS domain should ideally be mapped to the length of a foot. Since this constraint was argued for long ago (Shih’s (1986) DM, see (7)) and has been assumed by all TS researchers, I will not provide any additional arguments for it.

In a more casual or faster style of speaking, a TS domain can be larger than two syllables. It can be as large as an intonational phrase, which roughly corresponds to a syntactic clause (Shih (1989), Jin (1992)). I will assume that if two outputs A and B tie each other with respect to all constraints except Max, A and B have the same acceptability. They differ only in style of speaking.

The last constraint deals with the alignment of a disyllabic constituent.

- (28) *Disyllabic Constituent Alignment (Align-Di-L):*
Align the left side of a TS domain with the left side of a disyllabic constituent when two or more TS domains occur.

This constraint first ensures that the two syllables of a disyllabic constituent are within the same TS domain. This is a revision of the traditional Lexical Integrity, assumed in treatments of TS domains. Lexical Integrity claims that a lexical item such as a compound word cannot be broken up to group with other words. Note that this Lexical Integrity constraint allows word-internal grouping, as pointed out by Shih (1986), shown in the above (27). However, Lexical Integrity is not strong enough to explain obligatory TS

within a disyllabic phrase which is not a lexical item, as *dian huo* ‘light a fire’ in (29a) and *hao jiu* ‘good wine’ in (29b):

- (29) a. xi [dian huo] zhu
 wash light fire cook ‘wash (it), light a fire, and cook (it).’
 3 3 3 3 UT
 *(2 3) (2 3) ST1
 (3) (2 2 3) ST2
- b. bi [hao jiu] zhi
 pen good wine paper ‘pen, good wine, and paper’
 3 3 3 3
 *(2 3) (2 3) ST1
 (3) (2 2 3) ST2

Lexical Integrity only protects compounds from being broken up to group with other words. It does not protect a disyllabic phrase from being broken up. The Align-Di-L constraint proposed here overcomes this shortcoming. For TS domains, a syntactic-semantic disyllabic unit is an unanalyzable unit, regardless of whether it projects to a phrase or is a terminal lexical item.

The Align-Di-L constraint also restricts the grouping direction with respect to a disyllabic constituent: there is a TS boundary to the left of a disyllabic constituent. This constraint implies that if a monosyllabic constituent occurs to the left of a disyllabic constituent, they do not group together.

In order to show that the grouping direction claimed by this constraint is only relevant to the context where a disyllabic constituent occurs, I introduce other contexts to make a comparison. We first examine how odd numbered syllables in a flat structure are grouped with respect to TS domains. All elements in (30) have underlying T3. Their surface tone patterns are either (23)(223) or (223)(23).

- (30) a. wu wu jiu wu wu
 five five nine five five ‘55955’
 3 3 3 3 3 UT
 (2 3) (2 2 3) ST1
 (2 2 3) (2 3) ST2
- b. mei lü jia meng tie
 magnesium aluminum potassium manganese iron
 ‘Mg, Al, K, Mn, and Fe’
 3 3 3 3 3 UT
 (2 3) (2 2 3) ST1
 (2 2 3) (2 3) ST2

c.	Ma	Jiang	Hao	Li	Xu		‘Ma, Jiang, Hao, Li, and Xu’ (family names)
	3	3	3	3	3		UT
	(2	3)	(2	2	3)		ST1
	(2	2	3)	(2	3)		ST2
d.	ma	gou	hu	shu	niao		‘horse, dog, tiger, mouse, and bird’
	horse	dog	tiger	mouse	bird		
	3	3	3	3	3		UT
	(2	3)	(2	2	3)		ST1
	(2	2	3)	(2	3)		ST2

The availability of two surface tone patterns for each of the flat structures of (30a–d) implies that the grouping of every two syllables into a TS domain can be either leftward or rightward, and the leftover one is grouped with the adjacent disyllabic domain.

The following data show that if a disyllabic constituent occurs to the left (31a, b) or the right (31c, d) of three sequential monosyllabic words, it forms an independent TS domain, and the three monosyllabic words form another TS domain.

(31) a.	[ye	gou]	ma	hu	shu		
	wild	dog	horse	tiger	mouse		‘wild dogs, horses, tigers and mice’
	3	3	3	3	3		UT
	(2	3)	(2	2	3)		ST1
	* (2	2	3)	(2	3)		*ST2
b.	[ma	nai]	mi	shui	jiu		
	horse	milk	rice	water	wine		‘horse milk, rice, water and wine’
	3	3	3	3	3		UT
	(2	3)	(2	2	3)		ST1
	* (2	2	3)	(2	3)		*ST2
c.	shui	xue	mi	[hao	jiu]		
	water	snow	rice	good	wine		‘water, snow, rice and good wine’
	3	3	3	3	3		UT
	* (2	3)	(2	2	3)		*ST1
	(2	2	3)	(2	3)		ST2

d.	jiu	shui	mi	[ma	nai]	
	wine	water	rice	horse	milk	‘wine, water, rice and horse milk’
	3	3	3	3	3	UT
	* (2	3)	(2	2	3)	*ST1
	(2	2	3)	(2	3)	ST2

However, if a monosyllabic word occurs between two disyllabic constituents, it always groups with the preceding one rather than the following one.

(32) a.	[xiao	niao]	ma	[ye	gou]	
	small	bird	horse	wild	dog	‘small bird, horse, and wild dog’
	3	3	3	3	3	UT
	* (2	3)	(2	2	3)	*ST1
	(2	2	3)	(2	3)	ST2
b.	[shui-	shou]	hai	[xiao	dao]	
	water-hand	sea	small	island		‘sailor, sea, and small island’
	3	3	3	3	3	UT
	* (2	3)	(2	2	3)	*ST1
	(2	2	3)	(2	3)	ST2

The constraint Align-Di-L, which claims that there is a TS domain boundary to the left of a disyllabic constituent, reflects this fact.

Both of the unacceptable cases discussed above, that there is a TS domain boundary within a disyllabic constituent (29) and that there is no TS domain boundary to the left of a disyllabic constituent (32), are ruled out by the Align-Di-L constraint. If a disyllabic constituent has one of these properties, it violates Align-Di-L once. For example, the form $(\sigma\sigma\sigma)$ violates Align-Di-L once because there is a TS boundary within the first two syllables, which forms a grammatical constituent (TS domain boundaries are marked by (), while grammatical constituents are marked by []). The form $(\sigma\sigma\sigma)$ also violates Align-Di-L once because the only disyllabic constituent here, which is composed of the second and the third syllables, lacks a TS boundary to its left and contains a TS boundary within it. The form $(\sigma[\sigma\sigma])$, on the other hand, violates Align-Di-L twice, because the first disyllabic constituent contains a TS boundary within it, and the second disyllabic constituent does not have a TS boundary to its left.

The motivation behind this constraint is to decide the boundary position between two TS domains. If there is only one TS domain and all syllable-

bles are grouped together, this alignment constraint plays no role. In the following analysis, ST patterns which contain only one TS domain do not violate this alignment constraint.

Summarizing, I have introduced six constraints. PTAS, PTRS, and Clitic Dependency are directly or indirectly related to syntactic structures or categories. Maximal Domain is related to metrical information. The constraints *33 and Align-Di-L are related to the third TS output and grouping direction. Thus various factors are involved in Mandarin third tone sandhi domain representations.

The basic ideas underlying some of these constraints (e.g., Cl and Max) have been proposed in the Mandarin literature. However the relationship of these constraints to each other has not been studied. We have seen in (21) above that PTRS is violated in both ST1 and ST2. If this constraint were not violated, we would get a 3233 or 2233 tone pattern, where *33 is violated. Both of these are unacceptable. The unacceptability of these forms shows that violability of different constraints varies. This is exactly what Optimality Theory claims: constraints are violable, and the optimal output is determined by their language-particular ranking. To achieve an optimal output, violating a low ranked constraint might be necessary in order to obey a high ranked constraint.

I propose the following ranking of the six constraints. This ranking will be shown to be adequate to account for TS domains and TS avoidance of various syntactic and phonological structures.

PTAS, *33, Cl;
 PTRS, Align-Di-L;
 Max.

Constraints on the same line are equally ranked with respect to each other while those on a higher line are ranked above those on a lower line.

To save space, if there is no clitic in a phrase, I will not list the constraint Cl.

Following the conventions of the Optimality Theory, constraints and output candidates are listed in a tableau like (33). Constraints in columns separated by a solid line are ranked: those on the left are more important than those on the right. A representation which does not violate any constraint or violates a lower ranked constraint is preferred over one which violates a higher-ranked constraint. Thus a representation violating a constraint in the left column is less optimal than a representation violating a constraint in the right column. Constraints in columns separated by a dotted line are at the same level and tie each other. The symbol * means that a constraint is violated. The number of * indicates the number of

violations in the representation. Among several candidates which violate the same constraint, the one which violates the constraint to the least degree wins. The symbol \Rightarrow marks the optimal representation. The sign ! after a * draws attention to a fatal violation, the one that is responsible for a candidate's nonoptimality. It highlights the point at which the candidate in question loses to other more successful candidates. Shading emphasizes the irrelevance of the constraint to the fate of the candidate. A loser's cells are shaded after the fatal confrontation; the winner's cells are shaded when there are no more competitors.

(33)

	PTAS	*33	PTRS	Align-Di-L	Max
representation-1	*!				
\Rightarrow representation-2			*		*
representation-3			*	*!	

5. A CONSTRAINT-BASED ANALYSIS OF TS AVOIDANCE

In this section I examine how the ranked constraints introduced in section 4 interact with each other to give rise to the optimal TS domains and TS avoidance. Depending on the syntactic structures and the number of syllables, different constraint violations arise. Thus one can examine various interactions between syntactic and metrical constraints.

I will begin by discussing structure of the form [^d σ [[_{XP} σ^a σ^b] σ^c]], where σ^a is not a preposition. Brackets indicate the TS domains. In tableaux, underlined elements represent disyllabic words or phrases, S is an absolutely strong node and s is a relatively strong node.

(34)

a.	gou	da	san	zou	
	dog	take	umbrella	walk	‘The dog walked with an umbrella.’
	3	3	3	3	UT
	(3)	(2 2)	(3)	(3)	ST1
	(2	2 2	(3)	(3)	ST2
	*(2	3) (2	(3)	(3)	ST3

b.	ma	hen	shao	hou	
	horse	very	rare	roar.	‘Horses rarely roar.’
	3	3	3	3	UT
	(3)	(2	2	3)	ST1
	(2	2	2	3)	ST2
	*(2	3)	(2	3)	ST3

(35) Tone Sandhi Domains for (34):

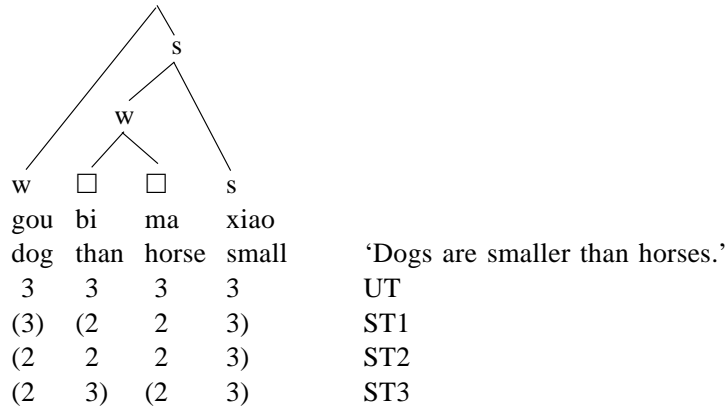
	w <u>ws</u> S	PTAS	*33	PTRS	Align-Di-L	Max
a.	(<u>223</u>)(3)		*!		*	*
b.	(2 <u>3</u>)(<u>22</u>)	*!		*	*	
☞ c.	(3)(<u>223</u>)			*		*
☞ d.	(<u>2223</u>)			*		*
e.	(2 <u>3</u>)(<u>23</u>)			*	*!	

Candidates (35a, b) each violate one of the highest ranked constraints. In the first candidate, two T3s are adjacent, violating the *33 constraint. In the second candidate, the last tone is T2, which is different from its underlying tone, T3. Since this last syllable represents the grammatical constituent which is dominated entirely by strong nodes all the way, failing to parse its underlying tone violates the PTAS constraint. Therefore, the first two candidates are defeated by the other three candidates.

According to Optimality Theory, if constraints A and B are unranked with respect to each other, and if candidate m violates both of them while candidate n violates only one of them, then n is more optimal than m. In (22), candidates (c) (3)(223) and (d) (2223) each violate only one of the constraints PTRS and Align-Di-L while candidate (e) (23)(23) violates both of these constraints. Since the two constraints tie each other, candidates (c) and (d), which violate fewer of these constraints, defeat candidate (e), which violates more of these constraints. Thus, both ST1, 3223, and ST2, 2223, are optimal and acceptable. In actual speech, ST1 occurs in unmarked moderate speed, while ST2 occurs in marked presto speed. This constraint-based approach explains the source of the ST variation.

I now turn to examples with the structure [^dσ[[_{xP}σ^aσ^b]σ^c]], where σ^a is a preposition. Recall that in this case, in addition to the patterns in (34), a third pattern (23)(23) is found. Further recall that I analyze prepositions as being unmarked for constituent strength, unlike the verb or the adverb in (34). Thus, when σ^a is a preposition, the structure in (36) occurs.

(36)



If the PP is ws, the constituent strength is wwsS. In such cases, the STs are as same as in (35), and both ST1 and ST2 are acceptable. If on the other hand, the PP is sw, we have the following analysis:

(37) Tone Sandhi Domains for (36):

	w _s wS	PTAS	*33	PTRS	Align-Di-L	Max
a.	(<u>223</u>)(3)		*!	*	*	*
b.	(3)(<u>223</u>)			*		*!
c.	(<u>2223</u>)			*		*!
☞ d.	(23)(<u>23</u>)				*	

We can see that ST3, (23)(23), is the best choice.

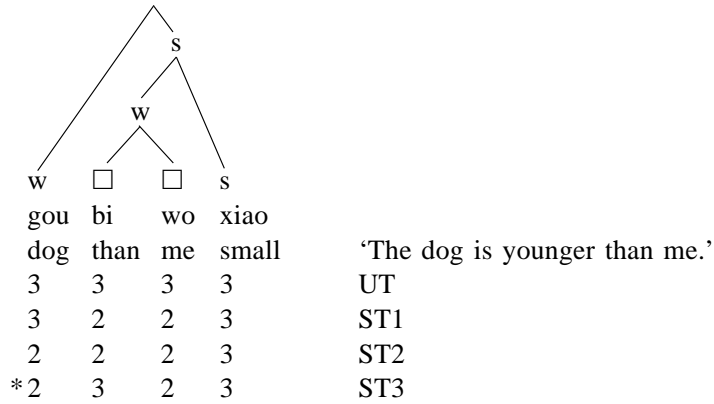
Notice that in tableau (37), (b), (c), and (d) each violate one of the constraints PTRS and Align-Di-L, which are equally ranked. (b) and (c) differ from (d) only in their violation of Max. The acceptable of patterns (b) and (c), i.e., ST1 and ST2 of (36), obtains either from the satisfaction of Max, which allows a larger domain in a more casual or faster style of speaking, or from a tableau like (35), where the PP is ws.

Comparing (37) with (35), we can see that the category-dependent property of TS avoidance comes from the fact that two different kinds of candidate competition are allowed, due to the unspecified constituent strength of a PP. Because the strength of other category types is fixed based on the syntactic structure they enter into, other categories do not show this variation. This analysis accounts for examples in (1), (2), etc.

Recall from (6) that when the preposition is followed by a clitic rather than a noun, the pattern (23)(23) is not found. The only difference between these cases is that instead of a referential noun serving as complement of

the preposition, a pronominal appears in this role. Tableaux (39a) and (39b) show us why only ST1 and ST2 are acceptable, regardless of ws or sw constituent strength representation of the PP.

(38)



(39) Tone Sandhi Domains for (38) (with a PP and a clitic):

a. PP is ws

w <u>ws</u> S	PTAS	*33	Cl	PTRS	Align-Di-L	Max
(<u>223</u>)(3)		*!			*	*
(2 <u>3</u>)(<u>23</u>)			*!	*	*	
☞ (3)(<u>223</u>)				*		*
☞ (<u>2223</u>)				*		*

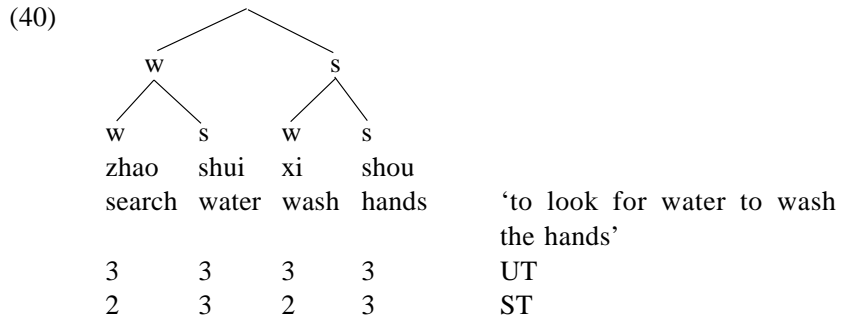
b. PP is sw

w <u>sw</u> S	PTAS	*33	Cl	PTRS	Align-Di-L	Max
(<u>223</u>)(3)		*!		*	*	*
(2 <u>3</u>)(<u>23</u>)			*!		*	
☞ (3)(<u>223</u>)				*		*
☞ (<u>2223</u>)				*		*

Comparing the form with a pronominal object (38) with one with a nominal object (36), we see that the nonspecified strength of a preposition is irrelevant with a pronominal object. This is because the high ranking of Cl rules out the (23)(23) form that was acceptable with a nominal complement. Recall that tone sandhi avoidance is both structure dependent and category dependent. Here not only the question whether a preposition

is involved but also whether a clitic follows a preposition is relevant to the issue. Our approach accounts for this by the interaction of constraint Cl with other constraints.

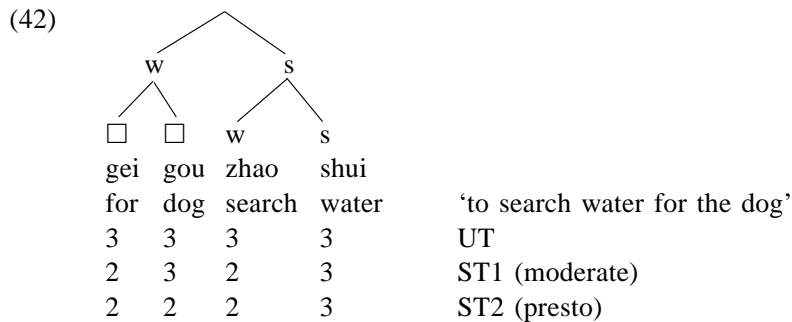
Forms in (40)–(50) also have four syllables and illustrate the structure dependency of TS domains. Their syntactic structures are different from those discussed so far. (40) and (42) are bi-directional branching forms. If UT pattern is 3333 and there is no clitic, ST of this form is always (23)(23), regardless of the categories.



(41) Tone Sandhi Domains for (40) (without a PP and clitic):

<u>ws wS</u>	PTAS	*33	PTRS	Align-Di-L	Max
a. (<u>22</u> 3)(3)		*!	*	*	*
b. (3)(<u>2 23</u>)			*!	**	*
c. (<u>22 23</u>)			*!		*
☞ d. (<u>23</u>)(<u>23</u>)					


When there is a PP, two underspecified s/w nodes occur in the constituent strength representation.



If the PP is ws, the constituent strength is wswS. In such cases, the ST is

as same as the above, i.e., 2323. If the PP is sw, we have the following analysis:

(43) Tone Sandhi Domains for (43) (with a PP but no clitic):

<u>sw</u> <u>wS</u>	PTAS	*33	PTRS	Align-Di-L	Max
a. (22 3)(3)		*!	*	*	*
b. (3)(2 23)				**!	*
c. (22 23)			*		*!
 d. (23)(23)			*		

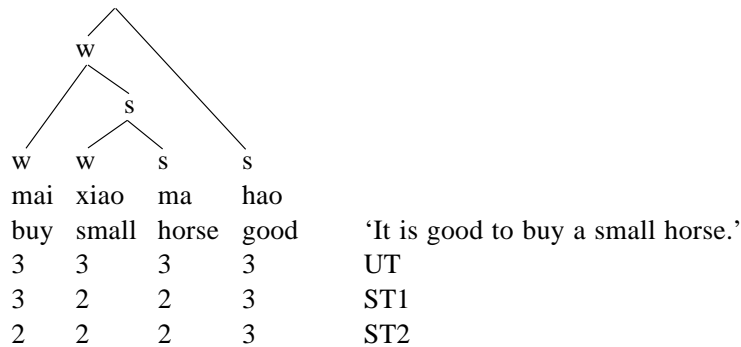
Both candidates (c) and (d) in (43) defeat candidate (b) because they violate PTRS once while (b) violates Align-Di-L twice.

Notice that in tableau (43), (c) and (d) each violate PTRS once. (c) differs from (d) only in its violation of Max. The acceptance of pattern (c), i.e., ST2 of (42), obtains from its satisfaction of Max, which allows a larger domain in a more casual or faster style of speaking.

Ignoring the role of Max, we do not see in examples (40) and (42) a contrast between a preposition and other categories as we saw in (34) and (36). In (40) the first syllable is a verb while in (42) it is a preposition. Candidate (b), in which the first syllable does not undergo TS, loses in both tableaux (41) and (43). This is the case because their structure is $[[\sigma^a\sigma][\sigma\sigma]]$, not $[\sigma^d[[_{XP}\sigma^a\sigma^b]\sigma^c]]$. Thus, category dependency of prepositions in TS avoidance is a relative rather than an absolute property depending upon the structure that the prepositional phrase occurs in. The structure and category dependent properties of tone sandhi avoidance are accounted for by the interactions of the constraints.

(44), (46), and (48) are left-branching forms with an embedded right branching constituent, i.e., $[[\sigma^d[_{PP}\sigma^a\sigma^b]\sigma^c]$. Here too, prepositions pattern together with other categories with respect to TS.

(44)



(45) Tone Sandhi Domains for (44) (without a PP and clitic):

w <u>ws</u> S	PTAS	*33	PTRS	Align-Di-L	Max
(2 <u>2</u> <u>3</u>)(3)		*!		*	*
☞ (3)(<u>2</u> <u>2</u> 3)			*		*
☞ (2 <u>2</u> <u>2</u> 3)			*		*
(2 <u>3</u>)(<u>2</u> 3)			*	*!	

The tableaux shows that both ST1 and ST2 are optimal.

If the object noun is replaced by a clitic, the CI constraint plays a role. Recall that this constraint is ranked above PTRS. The form (23)(23) will be ruled out because the clitic is separated from its host.

- (46) gou yao ni hao
 dog bite you good ‘It is good to let a dog bite you.’
 3 3 3 3 UT
 3 2 2 3 ST1
 2 2 2 3 ST2

(47) Tone Sandhi Domains for (46) (with a clitic):

wwsS	PTAS	*33	CI	PTRS	Align-Di-L	Max
(<u>223</u>)(3)		*!			*	*
☞ (3)(<u>223</u>)				*		*
☞ (<u>2223</u>)				*		*
(2 <u>3</u>)(<u>2</u> 3)			*!	*	*	

When a PP is involved in the structure $[[\sigma^d[_{PP}\sigma^a\sigma^b]]\sigma^c]$, there are two unspecified s/w nodes in the constituent strength representation.

- (48)
- bi xiao gou lan
 than small dog lazy ‘to be lazier than a small dog’
 3 3 3 3 UT
 3 2 2 3 ST1
 2 2 2 3 ST2

If the PP is *ws*, the constituent strength is *wwS*. In such cases, the STs are as same as in (43). Thus the two STs are derived. But if the PP is *sw*, the constituent strength is *swsS*. The following analysis shows that we derive ST1.

(49) Tone Sandhi Domains for (48) (with a PP but no clitic):

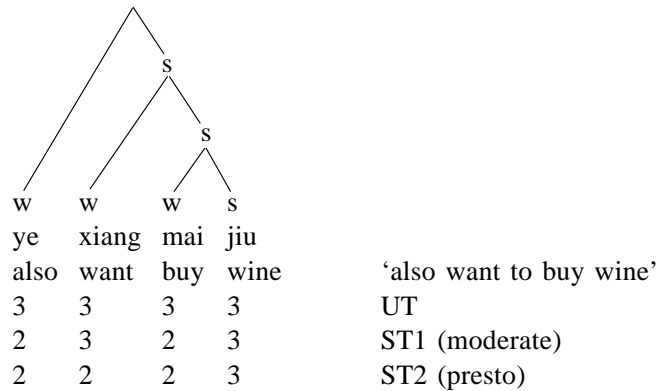
s <u>ws</u> S	PTAS	*33	PTRS	Align-Di-L	Max
(2 <u>2</u> <u>3</u>)(3)		*!	*	*	*
☞ (3)(<u>2</u> <u>2</u> 3)			*		*
(2 <u>2</u> <u>2</u> 3)			**!		*
(2 <u>3</u>)(<u>2</u> 3)			**!	*	

Notice that in tableau (49) pattern 2223 is ruled out. The acceptance of this pattern, which is ST2 of (48), obtains not from (49) but from a tableau like (45) when the PP is *ws*.

Here again, the contrast between a preposition and other categories is neutralized. Both a preposition and an element of another category avoid TS in this structure. Our constraint-based approach shows that the TS avoidance is the result of interactions of the constraints.

Varying the constituency but keeping constant the number of syllables, I now consider four-syllable right-branching forms.

(50)



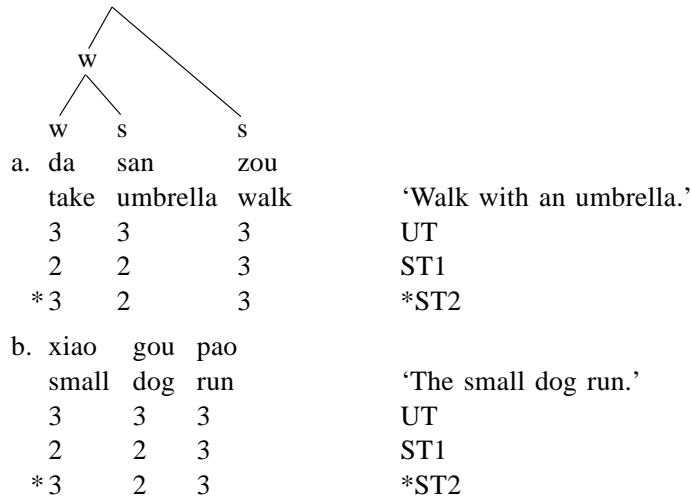
(51) Tone Sandhi Domains for (50) (without PP and clitic):

ww <u>wS</u>	PTAS	*33	PTRS	Align-Di-L	Max
(2 2 <u>3</u>)(<u>3</u>)		*!		*	*
(3)(2 <u>2</u> <u>3</u>)				*!	*
(2 2 <u>2</u> <u>3</u>)					*!
☞ (2 3)(<u>2</u> <u>3</u>)					

Tableau (51) shows that the optimal ST pattern is (23)(23) in normal speaking rate. The third candidate (2223) violates Max only. In the context of a casual or fast speaking rate, Max allows a larger TS domain, so this form is in fact acceptable in a casual or fast speaking rate.

I now turn to three-syllable forms, beginning with left-branching forms. (52) involves a case where σ^a in $[[\sigma^a\sigma^b]\sigma^c]$ is not a preposition.

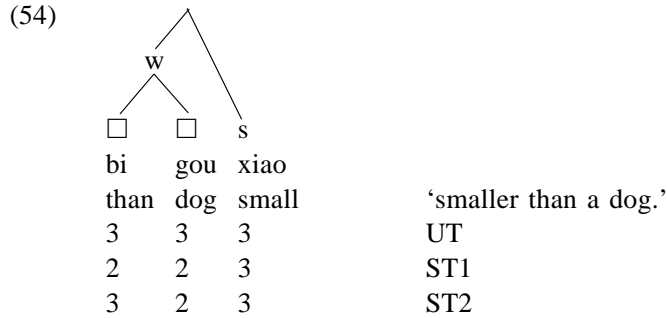
(52)



(53) TS domains for (52) (without any PP and clitic):

<u>wsS</u>	PTAS	*33	PTRS	Align-Di-L	Max
☞ (22 <u>3</u>)		*!		*	*
(3)(<u>2</u> <u>3</u>)				*!	

When σ^a in $[[\sigma^a\sigma^b]\sigma^c]$ is a preposition, there are two unspecified s/w nodes in the constituent strength representation.



If the PP is *ws*, the constituent strength representation of (54) is *wsS*, and (54) and (52) have the same TS domains, and ST1 (223) is the best output. If the PP is *sw*, we have the following analysis, and ST2 (3)(23) is the best output.

(55) TS domains for the form (54) (with a PP but without a clitic):

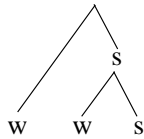
	<u>swS</u>	<u>PTAS</u>	<u>*33</u>	<u>PTRS</u>	<u>Align-Di-L</u>	<u>Max</u>
☞ a.	(<u>22</u> 3)			*		*!
☞ b.	(<u>3</u>)(<u>2</u> 3)				*	

Notice that in tableau (55), form (a) violates PTRS once, and form (b) violates Align-Di-L once. These two constraints are equally ranked. (a) differs from (b) only in its violation of Max. The acceptance of pattern (a), i.e., ST1 of (54), obtains either from (53) or from its satisfaction of Max, which allows a larger domain in a more casual or faster style of speaking.

(52) and (54) show a contrast between a preposition and other categories. The constraint-based approach shows that the category-dependent property of TS avoidance comes from two different kinds of candidate competition, due to the unspecified constituent strength of a PP.

As for right-branching three-syllable configuration, I cannot find any example which is a free form and contains a preposition. Data in (56) do not have a preposition.

(56)



- a.

gou	yao	gou
dog	bite	dog
3	3	3
3	2	3
2	2	3

‘Dogs bite dogs.’

UT

ST1 (moderate)

ST2 (presto)

- b.

mai	hao	jiu
buy	good	wine
3	3	3
3	2	3
2	2	3

‘To buy good wine.’

UT

ST1 (moderate)

ST2 (presto)

- c.

dang	xiao	zu
party	small	group
3	3	3
3	2	3
2	2	3

‘small groups of the party’

UT

ST1 (moderate)

ST2 (presto)

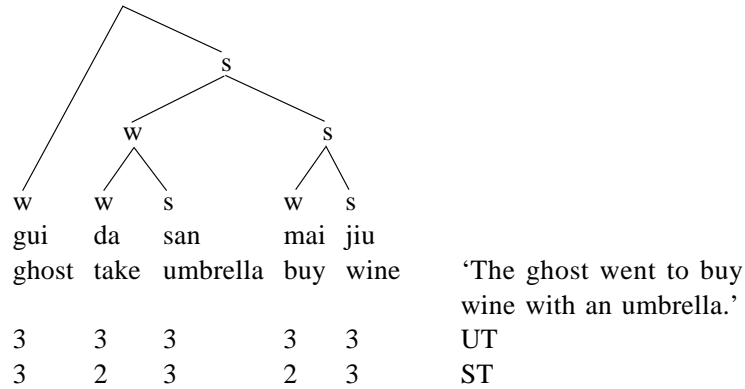
(57) Tone Sandhi Domains for (56) (without a PP and clitic):

wwS	PTAS	*33	PTRS	Align-Di-L	Max
(2 <u>2</u> 3)					*!
(2 <u>3</u>)(3)		*!		*	
☞ (3)(2 3)					

Tableau (57) shows that the optimal ST pattern is (3)(23) in normal speaking rate. The first candidate (223) violates Max only. But in the context of a casual or fast speaking rate, Max allows a larger TS domain. Thus this form is in fact acceptable in a casual or fast speaking rate.

So far I have considered only three- and four-syllable forms. I now turn to longer forms, beginning with the structure $[\sigma^d[[\sigma^a\sigma^b]\sigma^c\sigma^e]]$.

(58)



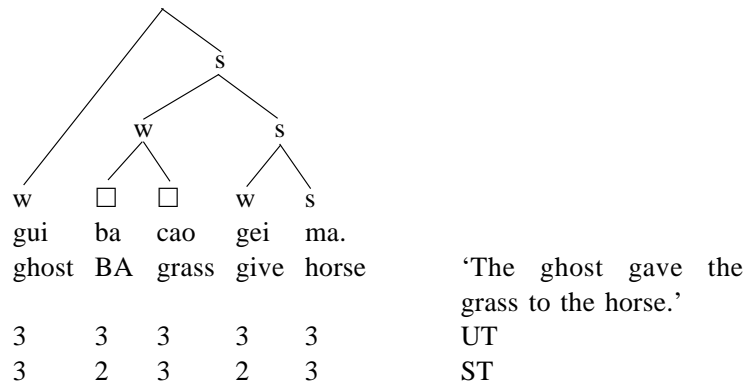
(59) Tone Sandhi Domains for (58) (without any PP and clitic):

w <u>ws</u> <u>wS</u>	PTAS	*33	PTRS	Align-Di-L	Max
(2 <u>23</u>)(<u>23</u>)				*!	*
(3)(<u>22</u> <u>23</u>)			*!	*	*
(2 <u>3</u>)(<u>2</u> <u>23</u>)			*!	**	*
☞ (3)(<u>23</u>)(<u>23</u>)					

We can see that (3)(23)(23) is the optimal output.

(60) contains an object preposing marker *ba*, which is generally assumed to be a preposition (Lü et al. (1980)). When a PP is involved, there are two unspecified s/w nodes in the constituent strength representation.

(60)



If the PP is *ws*, the constituent strength is *w ws wS*. In such cases, the ST is as same as in (59) above, i.e., 32323. If the PP is *sw*, we have the following analysis. In fact, the result is the same.

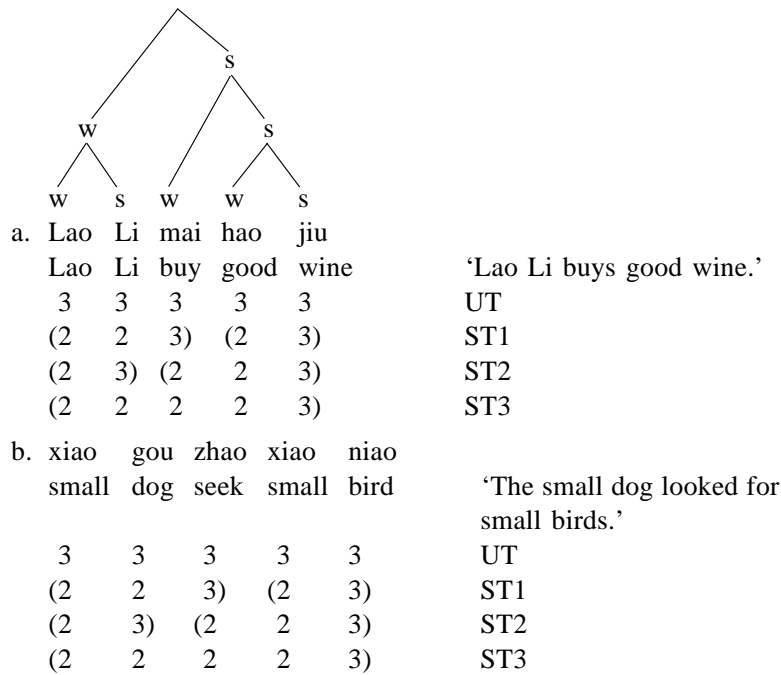
(61) Tone Sandhi Domains for (60) (with a PP but without a clitic):

w <u>sw</u> <u>wS</u>	PTAS	*33	PTRS	Align-Di-L	Max
(2 <u>23</u>)(<u>23</u>)			*	*!	*
(3)(<u>22</u> <u>23</u>)			*	*!	*
(2 <u>3</u>)(<u>2</u> <u>23</u>)				**!	*
☞ (3)(<u>23</u>)(<u>23</u>)			*		

As in the case of (40) and (42), we find that the contrast between a preposition and other categories is neutralized in this five-syllable structure. The constraint-based approach accounts for this structure-dependent property of TS avoidance.

(62) and (64) both have the structure [[σσ][σ[σσ]]]. These data have been widely discussed since Cheng (1973). It has been argued that a phonological cycle is needed to account for them (Shih (1986, 1989), among others). In the present approach, the interactions of *33, PTRS, and Align-Di-L allow for a non-cyclic analysis.

(62)



(63) Tone Sandhi Domains for (63):

$\underline{wS} \ w \ \underline{wS}$	PTAS	*33	PTRS	Align-Di-L	Max
$\leftarrow (2 \ 2 \ 3)(23)$			*		*
$(3)(2 \ 2 \ 23)$			*	*!*	*
$\leftarrow (2 \ 3)(2 \ 2 \ 3)$				*	*
$\leftarrow (22 \ 2 \ 23)$			*		*
$(3)(2 \ 3)(23)$			*	*!	

In (64) the underlying tone of the last syllable in the structure of $[[[\sigma][\sigma][\sigma]]]$ is not T3. Although (64) and (62) have the same constituent strength representation, they have different TS domains.

(64)

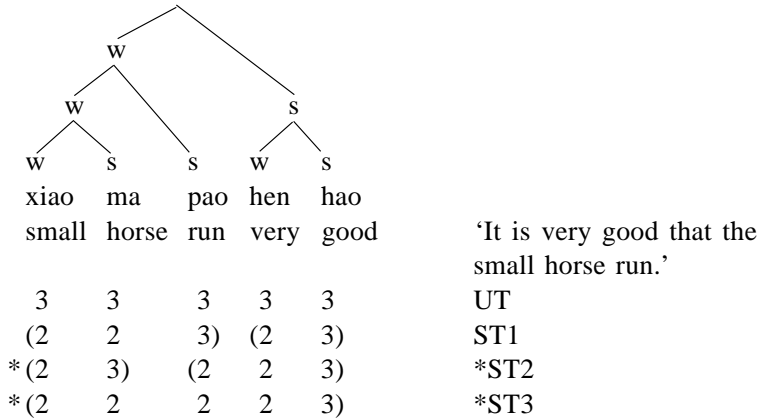
w	s				
w	s	w	w	s	
Lao	Li	mai	hao	shu	
Lao	Li	buy	good	book	‘Lao Li buys good books.’
3	3	3	3	1	UT
*(2	2	3)	(3	1)	*ST1
(2	3)	(2	3	1)	ST2
(2	2	2	3	1)	ST3

(65) Tone Sandhi Domains for (64):

$\underline{wS} \ w \ \underline{wS}$	PTAS	*33	PTRS	Align-Di-L	Max
$(2 \ 2 \ 3)(31)$		*!	*		*
$(3)(2 \ 2 \ 31)$			*	**!	*
$\leftarrow (2 \ 3)(2 \ 3 \ 1)$				*	*
$\leftarrow (22 \ 2 \ 31)$			*		*
$(3)(2 \ 3)(31)$			*	*!	

Now I turn to the structure $[[[\sigma][\sigma][\sigma]]]$, which has different TS domains from that of the five-syllable forms discussed above in (60), (62), and (64).

(66)



UT
ST1
*ST2
*ST3

‘It is very good that the small horse run.’

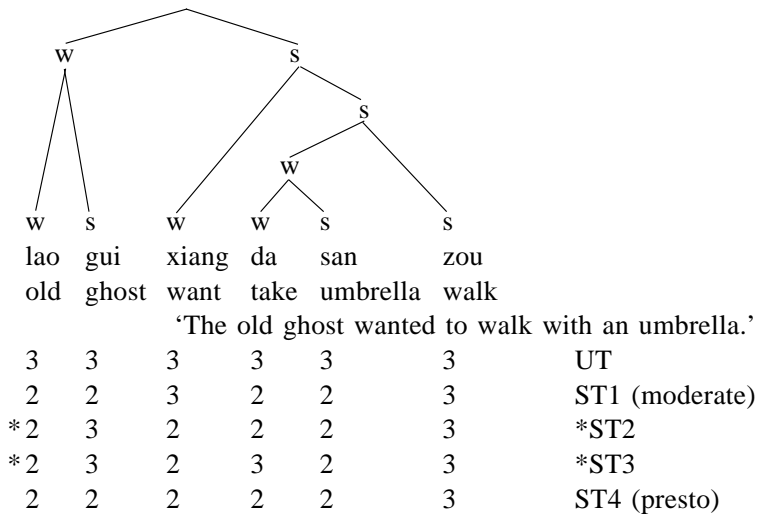
(67) Tone Sandhi Domains for (66):

	<u>ws</u> s <u>wS</u>	PTAS	*33	PTRS	Align-Di-L	Max
☞ a.	(<u>2 2</u> 3)(<u>23</u>)			*		*
b.	(<u>3</u>)(<u>2 2</u> <u>23</u>)			**!	**	*
c.	(<u>2 3</u>)(<u>2 2 3</u>)			*	*!	*
d.	(<u>22</u> <u>2 23</u>)			**!		*
e.	(<u>3</u>)(<u>23</u>)(<u>23</u>)			*	*!	

Only (67a) is acceptable; other forms either invoke too many PTRS violations or violate both PTRS and Align-Di-L.

(68) and (70) are six-syllable forms with the structure [[σ][σ[[σσ]σ]]].

(68)



UT
ST1 (moderate)
*ST2
*ST3
ST4 (presto)

‘The old ghost wanted to walk with an umbrella.’

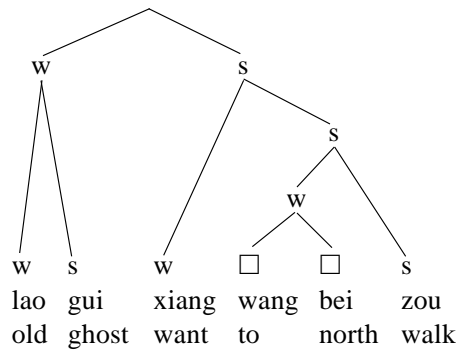
(69) Tone Sandhi Domains for (68) (without a PP and clitic):

	<u>ws</u> w <u>ws</u> S	PTAS	*33	PTRS	Align-Di-L	Max
a.	(<u>23</u>)(3)(<u>223</u>)		*!	*		*
b.	(<u>23</u>)(<u>2223</u>)			*	*!	*
☞ c.	(<u>2</u> <u>23</u>)(<u>223</u>)			**		**
☞ d.	(<u>22</u> <u>2</u> <u>223</u>)			**		*
e.	(<u>23</u>)(<u>23</u>)(<u>23</u>)			*	*!	

In Tableau (69), (c) and (d) defeat (b) and (e) in that they violate only one of the constraints which are not ranked with respect to each other, i.e., PTRS and Align-Di-L, while (b) and (e) violate them both.⁹ This tableau also indicates that pattern (c), (223)(223) and (d), (222223), i.e., ST1 and ST4, are not same: the former violates Max twice but in a minor degree each time (one syllable larger than a normal TS domain which contains two syllables), while the latter violates Max only once but in a more serious degree (four syllables larger than a normal TS domain). Here I simply treat them both as optimal representations.

If a PP is involved in the same structure, there are two unspecified s/w nodes in the constituent strength representation.

(70)



‘The old ghost wanted to walk to the north.’

3	3	3	3	3	3	UT
2	2	3	2	2	3	ST1
*2	3	2	2	2	3	*ST2
2	3	2	3	2	3	ST3

If the PP is ws, the constituent strength is ws w ws S. In such cases, the STs are as same as the above. If the PP is sw, we have the following analysis. Thus ST3 is derived.

(71) Tone Sandhi Domains for (70) (with a PP but no clitic):

<u>ws</u> w <u>sw</u> S	PTAS	*33	PTRS	Align-Di-L	Max
a. (23)(3)(223)		*!	*		*
b. (23)(2223)			*	*!	*
c. (2 23)(223)			**!		**
d. (222223)			**!		*
e. (23)(23)(23)				*	

Notice that in this tableau, pattern (223)(223), i.e., ST1 of (70), is ruled out. The acceptance of this pattern for (70) obtains not from (71) but from a tableau like (69) when PP is *ws*.

(68) and (70) show us another contrast between a preposition and other categories in the structure $[[_{XP}\sigma^a\sigma^b]\sigma]$. *Da* ‘take’ in (68) must be T2 while *wang* ‘to’ in (70) can be either T2 or T3. Our constraint-based approach once more, accounts for this contrast.

From the above analyses we can see how surface tone representations are derived from the interactions of the prosodic and syntactic-semantic constraints. Basically, prepositions pattern with verbs and other categories in some structures but not in others. For example, the contrast between a preposition and other categories is always shown in the structure $[[\sigma^a\sigma^b]\sigma^c]$. In his structure, if σ^a is a preposition and its complement σ^b is not a pronoun, it can resist TS; otherwise, it must undergo TS. TS avoidance is found in some structures but not in others regardless of category. For example, in the structure $[\sigma^d[[_{XP}\sigma^a\sigma^b][\sigma^c\sigma^e]]]$, the second syllable σ^a must undergo TS, regardless of its category. The use of violable constraints allows an account of these facts. In the next section I will compare the present approach with a rule-ordering approach.

6. RULE-ORDERING APPROACH VERSUS CONSTRAINT-BASED APPROACH

I have assumed that prepositions, unlike other categories, are not uniquely specified for constituent strength. I call this the non-specification hypothesis. This hypothesis is descriptively superior to other special treatment of PP reviewed in section 2. First, it does not make an unconvincing claim, as the Special Circumstance (section 2.2), the Sense Unit (section 2.3) and Semantic-Pragmatic Effect (section 2.5) approaches do. A Sense Unit is supposed to be either a subject-predicate unit or a modifier-head unit. But to group an NP with a following P into a unit does not meet the criterion of the formation of a sense unit. The Semantic-Pragmatic Effect approach

does not explain the category and structure dependency of TS avoidance. Second, the non-specification hypothesis avoids the wrong predictions made by the Functor approach (section 2.4) and the Clitic approach (section 2.6) since an unspecified strength is only relevant to PPs, not to pronouns and other categories. In this section, we will see that the non-specification approach coupled with the constraint-based approach argued for in this paper is also superior to a rule-ordering approach.

Since constituent strength assignment is mapped from syntactic structures, and TS domains are related to the constituent strength representation by constraints such as PTAS and PTRS, our approach *indirectly* relates TS domains to syntactic structures via the constituent strength representation. In Shih's (1986) Foot Formation Rule (FFR) approach, IC (Immediate Constituent) is *directly* used in TS domain analysis, and it is always applied before other processes such as DM (Duple Meter). At this point, both FFR and our approach are syntactically related. However, in the case of prepositions, IC plays no role in FFR. In the present approach, syntactic information is not skipped in the case of prepositions.

The discussion so far has shown that prepositions are special in tone sandhi in certain contexts. One might take a position similar to FFR and claim that in $[\sigma^d[[_{XP}\sigma^a\sigma^b]\sigma^c]]$, if σ^a is a preposition and σ^b is not a pronoun, DM applies earlier than IC (72a) (in fact, after DM, IC is blocked in four-syllable phrases), while in all other cases, IC precedes DM ((72b)).

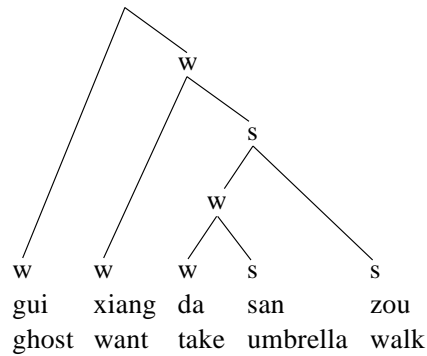
(72) a.	gou	[[bi	ma]	xiao]	
	dog	than	horse	small	'A dog is smaller than a horse.'
	3	3	3	3	UT
	(	)	(	)	DM
					IC (reordered and blocked)
	(2	3)	(2	3)	ST
b.	ma	[[hen	shao]	hou]	
	horse	very	rare	roar	'Horses rarely roar.'
	3	3	3	3	UT
		(	)		IC
					DM (blocked)
	(			)	f'
	(2	2	2	3)	ST

This is a rule-reordering approach. For these data, it seems to work as well as the constraint-based approach taken in this paper. (See (34) and (36) for the Optimality Theory approach to these examples.) But when we examine phrases longer than $[\sigma^d[[_{XP}\sigma^a\sigma^b]\sigma^c]]$, especially those with an odd

number of syllables, we will find that these two approaches predict different TS domains. I begin with my analysis with right-branching five-syllable forms.

If UT is 33333 and there is no clitic, STs of forms without a PP and with a PP are shown in (73) and (75) respectively.

(73) Constraint-based analysis:



‘The ghost wanted to walk with an umbrella.’

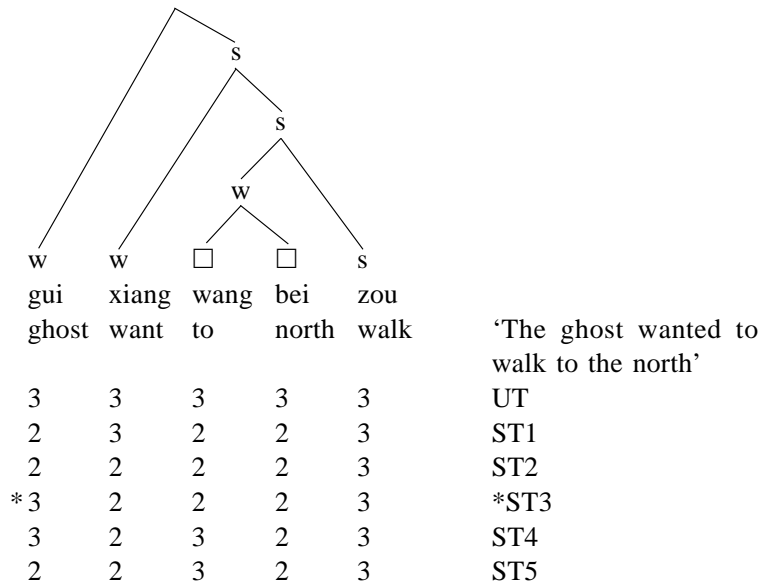
3	3	3	3	3	UT
2	3	2	2	3	ST1
2	2	2	2	3	ST2
*3	2	2	2	3	*ST3
*3	2	3	2	3	*ST4
*2	2	3	2	3	*ST5

(74) Tone Sandhi Domains for (73) (without a PP and clitic):

w w <u>ws</u> S	PTAS	*33	PTRS	Align-Di-L	Max
☞ (2 3)(<u>22</u> 3)			*		*
(22 <u>3</u>)(<u>2</u> 3)			*	*!	*
☞ (2 2 <u>2</u> <u>2</u> 3)			*		*
(3)(2 <u>3</u>)(<u>2</u> 3)			*	*!	
(3)(2 <u>2</u> <u>2</u> 3)			*	*!	*

When a PP is involved, there are two unspecified s/w nodes in the constituent strength representation.

(75)



If the PP is *ws*, the constituent strength is *ww* *ws* *S*. In such cases, the ST is as same as the above, and ST1 and ST2 are derived. If the PP is *sw*, we have the following analysis, and thus ST4 is derived. However, ST4 is not allowed in (73).

(76) Tone Sandhi Domains for the above form (with a PP but no clitic):

w w <u>sw</u> S	PTAS	*33	PTRS	Align-Di-L	Max
a. (2 3)(<u>223</u>)			*		*!
b. (<u>22 3</u>)(<u>23</u>)				*	*!
c. (<u>22 223</u>)			*		*!
☞ d. (3)(<u>23</u>)(<u>23</u>)				*	
e. (3)(<u>2223</u>)			*	*!	*

From this tableau we can see that (a)–(d), i.e., ST1, ST5, ST2, and ST4, each violate one of the constraints PTRS and Align-Di-L once, which are equally ranked. (a)–(c) differ from (d) only in their violation of Max. The acceptance of patterns (a)–(c) obtains from the satisfaction of Max which allows a larger domain in a more casual or faster style of speaking.

Now consider the rule-reordering analysis, illustrated in (77):

(77) a.	gui	[xiang	[[da	san]	zou]]	
	ghost	want	take	umbrella	walk	‘The ghost wanted to walk with an umbrella’
	3	3	3	3	3	UT
	(	)	(	)		IC
	(	)	(	)	f’	DM
	(2	3)	(2	2	3)	ST
b.	gui	[xiang	[[wang	bei]	zou]]	
	ghost	want	to	north	walk	‘The ghost wanted to walk to the north’
	3	3	3	3	3	UT
	(	)	(	)		DM
			(	)		IC (reordered)
			(	)		f’
	(2	3)	(2	2	3)	ST1 (predicted by FFR)
	(3)	(2	3)	(2	3)	ST2 (not predicted by FFR)

The rule-ordering approach gets the same result for both (a) and (b) of (77), and thus it cannot predict ST2 of (77b). The contrast between the impossibility of T3 for *da* ‘take’ in (77a) and the possibility of T3 for *wang* ‘to’ in (77b) is not accounted for. The constraint-based approach, on the contrary, does account for this contrast.

A similar group of examples are the following, which have seven syllables. I start with a constraint-based analysis:

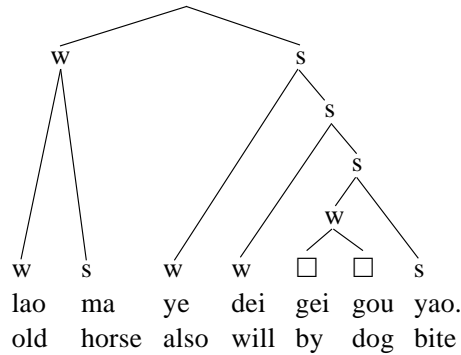
(78)

w	s	w	w	w	s	s	
lao	gui	ye	xiang	da	san	zou	
old	ghost	also	want	take	umbrella	walk	
							‘The old ghost also wanted to walk with an umbrella’
3	3	3	3	3	3	3	UT
2	3	2	3	2	2	3	ST

(79) Tone Sandhi Domains for (78):

<u>ws</u> ww <u>ws</u> S	PTAS	*33	PTRS	Align-Di-L	Max
(<u>2</u> 3)(22 <u>3</u>)(<u>2</u> 3)			*	*!	*
☞ (<u>23</u>)(2 3)(<u>22</u> 3)			*		*
(<u>223</u>)(2 <u>3</u>)(<u>2</u> 3)			**!	*	*
(<u>22</u> 3)(<u>22</u> <u>2</u> 3)			**!	*	**
(<u>23</u>)(22 <u>22</u> 3)			*	*!	*
(<u>3</u>)(<u>2</u> 3)(2 <u>3</u>)(<u>2</u> 3)			**!	**	

(80)



‘The old horse will also be bitten by a dog.’

3	3	3	3	3	3	3	UT
2	3	2	3	2	2	3	ST1
2	3	2	2	3	2	3	ST2

If the PP is ws, the constituent strength is ws ww ws S. In such cases, the ST is as same as the above. Thus ST1 is derived. If the PP is sw, we have the following analysis. We can see that both ST1 and ST2 are derived.

(81) Tone Sandhi Domains for (80):

<u>ws</u> ww <u>sw</u> S	PTAS	*33	PTRS	Align-Di-L	Max
☞ (<u>23</u>)(22 <u>3</u>)(<u>2</u> 3)				*	*
☞ (<u>23</u>)(2 3)(<u>22</u> 3)			*		*
(<u>223</u>)(2 <u>3</u>)(<u>2</u> 3)			*	*!	*
(<u>22</u> 3)(<u>22</u> <u>2</u> 3)			**!	*	**
(<u>3</u>)(<u>2</u> 23)(<u>22</u> 3)			**!	*	**
(<u>3</u>)(<u>2</u> 3)(2 <u>3</u>)(<u>2</u> 3)			*	*!*	

Now consider the rule-reordering analysis, illustrated in (82):

(82) a.	[lao	gui]	[ye	[xiang	[da	san]	zou]]]	
	old	ghost	also	want	take	umbrella	walk	
	‘The old ghost also wanted to walk with an umbrella’							
	3	3	3	3	3	3	3	UT
	(	)			(	)		IC
			(	)				DM
					(	)		f’
	(2	3)	(2	3)	(2	2	3)	ST
b.	xiao	ma	ye	dei	gei	gou	yao.	
	old	horse	also	will	by	dog	bite	
	‘The old horse will also be bitten by the dog.’							
	3	3	3	3	3	3	3	UT
	(	)	(	)	(	)		DM
	(	)			(	)		IC (reordered)
					(	)		f’
	(2	3)	(2	3)	(2	2	3)	ST1 (predicted by FFR)
	(2	3)	(2	2	3)	(2	3)	ST2 (not predicted by FFR)

It is obvious that a rule-ordering approach cannot predict the contrast between a structure which contains a preposition and a structure which does not contain a preposition, while the constraint-based approach can. We have seen that descriptively the constraint-based approach is superior to the rule-reordering approach.

7. SUMMARY AND CONCLUSIONS

The present account of third TS in Mandarin has two main characteristics. First, it makes use of ranked, violable constraints. Although constraints such as Maximal Domain and Clitic Dependency have generally been assumed in the Mandarin tone sandhi literature, their relationship to each other has not been studied. I have argued that their interactions are important and that third tone sandhi domains, their variability, and the possibility of tone sandhi avoidance are the result of the interactions of the proposed constraints.

The second characteristic of this research involves the use of constituent strength, following Cinque (1993). Constituent strength is brought to the TS domain analysis in order to settle the long-standing problem of TS resistance of PPs in certain contexts. This method indirectly uses syntactic

information in defining the TS domain via constituent strength, rather than using syntactic information of Immediate Constituent directly. By assuming a non-specified constituent strength representation for a PP, two choices are made available: *sw* and *ws*. This involves a revision of the Null Theory, which claims that when a head is not followed by a complement, the head is *s*; but when a head is followed by a complement, the head is *w* and the complement is *s*. In other words, my approach allows a prepositional head to be a strong constituent when it followed by a referential NP complement. This assumption is based on the description of the TS properties of Chinese prepositions.

Our work on TS avoidance covers both prepositions and other categories. On the one hand, a preposition, but not other categories, can resist TS in certain structures such as $[[_{XP}\sigma^a\sigma^b]\sigma]$. In this structure, if σ^a is a preposition, i.e., if XP is PP and if its complement σ^b is not a pronoun, it can resist TS; otherwise, it must undergo TS. On the other hand, the contrast between a preposition and other categories is neutralized in many other structures: either TS is obligatory for both of them, or TS avoidance is allowed for both of them. The category- and structure-dependent properties of TS avoidance are the result of interactions of the constraints. Various apparently unrelated types of TS avoidance can be accounted for by the unified ranking of the constraints. The constraint-based approach can also account for the surface tone pattern variations of a phrase. The variations are derived if there are two or more optimal outputs from a competition or if there is an unspecified constituent strength node which leads to two kinds of competition.

The constraint-based analysis together with the non-specification hypothesis are descriptively superior to the rule-ordering approach, providing further evidence for the theoretical importance of violable constraints.

NOTES

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¹ There are five tones in Mandarin Chinese: T1 (High), T2 (Rising), T3 (Low), T4 (Falling), and a neutral tone.

² Although previous studies of TS acknowledged cases like (1a), phrases involving a preposition with different structures have not been observed or studied.

³ Shih (1989) and Jin (1992) show that in casual fast speaking, the maximal TS domain in Mandarin is an intonational phrase, which roughly corresponds to a syntactic clause, rather than a phrase.

⁴ *deng jiu-dian zheng* is unnatural to me and my informants, compared to the usual expression *deng dao jiu-dian zheng*, where *dao* means 'until'. Thus I will not make any comment on the ST of (8). A more appropriate example would be (1b).

⁵ One reviewer pointed out that it is possible to say:

- (i) bei-bian, gou wang nar qu le.
 north-side, dog to there go ASP
 'North, the dog has gone there.'
- (ii) Ben, wo bi ta gao.
 Ben, I than he tall
 'Ben, I am taller than him.'

This reviewer claims that topicalization might impose different rules on different 'verb-like' elements. Notice that in these sentences, the proforms are obligatory. This kind of topicalization is the outcome of adjunction merges rather than of movement.

⁶ See (38) and (46) for analyses of (13a) and (14) respectively.

⁷ Notice that in this analysis, prepositions as functional words are counted in *strength* assignment. In Halle and Vergnaud (1987) and Cinque (1993), English prepositions (usually monosyllabic prepositions only) are skipped in phrasal *stress* assignment. Since constituent strength is related to syntactic structure, and a preposition has its syntactic status, a preposition is not skipped in constituent strength analysis.

⁸ Some other constraints are required in Mandarin third TS. For instance, the changed tone is T2 rather than other tones, and the trigger tone, which keeps its underlying T3, cannot be to the left of the tone which is triggered to undergo the change. Since these constraints define TS rather than restrict the scope of TS domains, I do not discuss them in this paper.

⁹ I am assuming that it is worse to violate two equally ranked constraints than to multiply violate just one of those equally ranked constraints ((69)). In (43), only a single constraint is violated in (b), (c), and (d). But (43c, d) are preferred because they exhibit only a single violation, while (43b) has two violations of a single constraint.

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