

Derived Domains and Mandarin Third Tone Sandhi

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1. Introduction

Third tone sandhi (3TS) is a process in Mandarin Chinese that changes a third tone (3) into a second tone (2) when it is immediately followed by a third tone. However, 3TS does not apply across the board. An important issue of frequent discussion in the literature is whether 3TS is sensitive to syntactic structure, prosodic structure or a combination of both. Cheng, C (1973) and Kaisse (1985) propose that the domain for 3TS is determined directly from the syntactic structure, while Shih (1985) proposes that prosodic structure determines the domain for 3TS.

In this paper, I extend Shih's proposal by showing that 3TS is sensitive to prosodic structure. Following Selkirk (1986), I propose that 3TS in Mandarin applies to domains derived from end-settings. However, Selkirk's model is inadequate in that it does not account for all languages. In particular, the Mandarin data show that branchingness is a necessary parameter which must be included in Universal Grammar in order that the generalizations in the end-based theory be maintained.

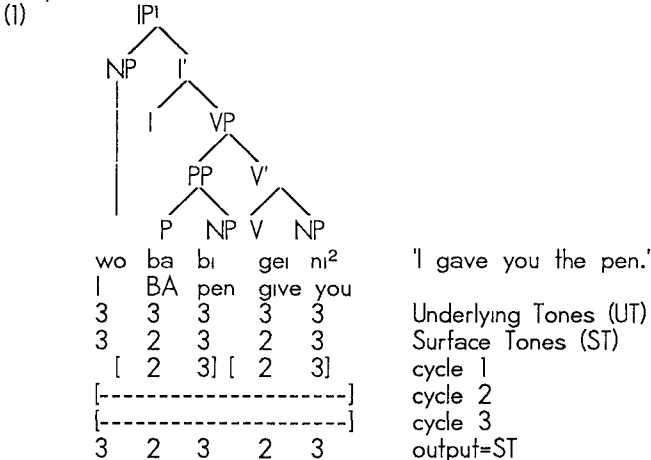
2. Previous Analyses

2.1. Direct mapping between syntax and phonology

Both Cheng, C (1973) and Kaisse (1985) maintain that the domain of 3TS application is syntactically determined. They propose that 3TS applies directly to syntactic structures in a cyclic fashion.

2.1.1. The cyclic approach (Cheng, C 1973)

In the cyclic approach, the 3TS rule applies cyclically, that is, it first applies to the smallest syntactic phrases and then progressively to larger phrases. Thus, the rule starts from the most embedded constituent and it observes syntactic constituency. For example, the sentence [wo ba bi gei ni] 'I gave you the pen' has the structure in (1).

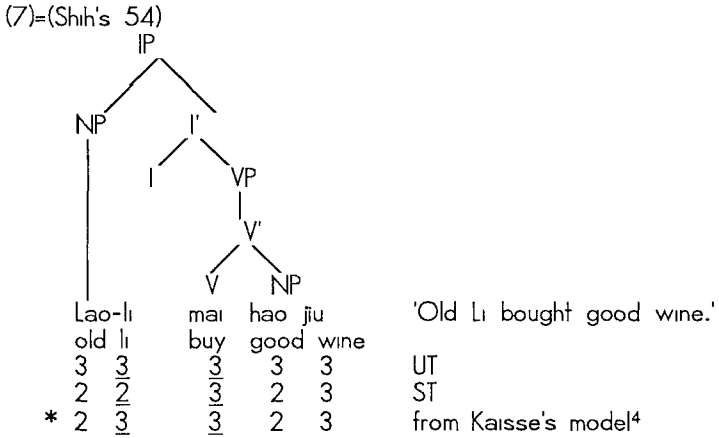




The tone sandhi pair (a, b) in structure (5) does not satisfy the Branch Condition because a and b are not edges. Therefore, 3TS cannot apply to (5). However, as Shih (1985) points out, the Branch Condition wrongly predicts that 3TS does not apply to the tone sandhi pair underlined in (7) because the tone sandhi pair does not lie on the edge of any constituent. Both syntactic approaches, Cheng's and Kaisse's, suffer from undergeneration. The mapping between syntax and phonology does not appear to be direct. That is, the domain for the application of 3TS is not directly determined by syntactic structure.

2.2. A prosodic approach (Shih 1985)

Shih (1985) proposes an analysis where 3TS occurs within prosodic structures derived from syntactic structures, maintaining that "tone sandhi operates on 'prosodic



structures' which are sensitive to, but by no means isomorphic to syntactic structures." (p.107)

She proposes that levels of foot, superfoot, and phrase are necessary to predict the correct application of 3TS. Foot formation is accomplished by the rule in (8).

(8) Foot Formation Rule (FFR)

i) Foot (f) construction

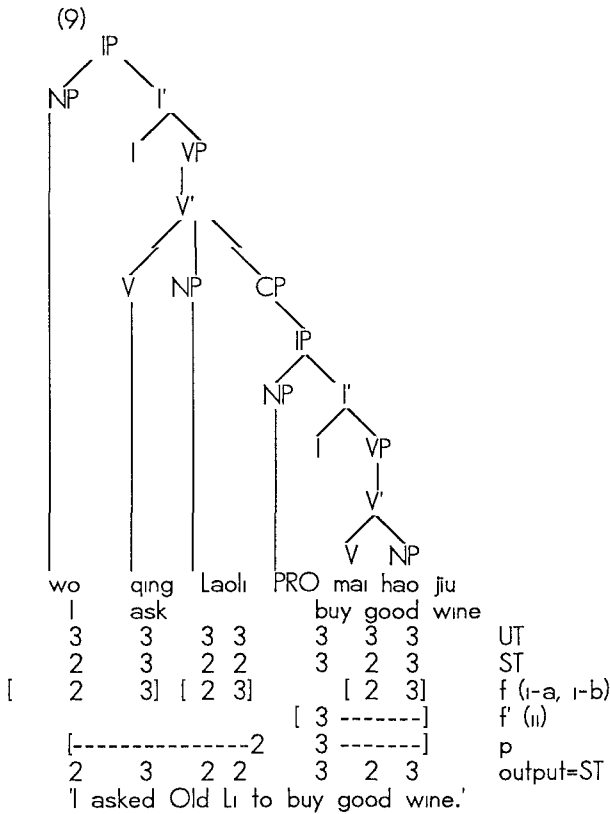
a. IC (Immediate Constituency) Link immediate constituents into disyllabic feet.

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 left over monosyllables to a neighboring binary foot according to the direction of syntactic branching.

Thus, 3TS applies cyclically, first to feet (f), then to super-feet (f') and finally to phrases (p). The application of 3TS under Shih's model is shown in (9).



The prosodic structure in (9) is not isomorphic to the syntactic structures since the word 'I' and the verb [qing] 'ask' are not one constituent but at the prosodic structure shown above, they behave as a single constituent.

Shih also points out that in prepositional phrases (PP's), pronouns behave differently from nouns. Thus, she proposes that FFR-IC does not apply to PP's with full NP's. Instead, FFR-DM applies directly to these PP's. However, it should be noted that with only FFR-DM applying to PP's with full NP's, the correct tone pattern for sentences such as (10) cannot be generated.

(10) Ni de gou ba niao yao-shang le.

you	COMP	dog	BA	bird	bit-wounded	ASP	
3	0	3 3	3	3	1	0	UT
3	0	3 2	2	3	1	0	ST
[ 3	0]	[ 2 3]	[ 2	3]	[ 1	0]	FFR-DM
[-----]							p
* 3	0	2 3	2	3	1	0	output≠ ST

In other words, although Shih's model accounts for the discrepancies between syntactic structures and the natural tonal patterns, it also has problems of undergeneration.

### 3. The End-based Theory (Selkirk 1986)

Selkirk (1986) proposes an end-based theory for derived domains in sentence phonology. She maintains that the end-based theory will define a class of possible end-settings  $\alpha$  and  $\beta$  for derived domains. That is, "a setting for the category  $\alpha$  and for right or left end (the direction of the bracket) constitute the setting of a parameter in syntax-phonology domain-deriving component of a language". (Selkirk 1986, p.32)

Further, only prosodic structure above the foot and below the intonational phrase is defined in terms of ends of syntactic constituents of a designated type, because (a) syllabification and 'foot construction' require a separate subtheory of the syntax-phonology relation, and (b) intonational phrasing appears to be subject to semantic well-formedness conditions (Selkirk 1984).

At the phonological word level (PWd), the distinction between content words and function words is crucial. The setting at the PWd level is sensitive to the left or right end of a content word. Since function words are not considered as real words, they are incorporated with content words into PWd's. At the phonological phrase level (PPh), either  $\chi^{\max}$  or  $\chi^{\text{head}}$  is the crucial element in defining proper domains. In other words, the setting is sensitive to the left or right end of either  $\chi^{\max}$  or  $\chi^{\text{head}}$

The End Parameter Settings Selkirk proposes are summarized in (11).

(11)	End Parameter Settings			
	PWd---(i)a. ]	word	b.	word [
	PPh----(ii)a. ]	$\chi^{\max}$	b.	$\chi^{\max}$ [
	-----(iii)a. ]	$\chi^{\text{head}}$	b.	$\chi^{\text{head}}$ [

Thus, at the PWd level, languages differ in the end of content word used in deriving phonological words. At the PPh level, languages may differ in the type of syntactic constituent and in the end of constituent used for deriving phonological phrases.

### 4. Mandarin 3TS and derived domains

Mandarin 3TS applies at both the lexical level and the sentential level. In section 4.1, I will show that 3TS can apply in the lexicon as predicted by the Strong Domain Hypothesis of lexical phonology (Kiparsky 1984) (i.e. a rule applies if it can until it is turned off). In section 4.2, I will discuss derived domains at the sentential level.

#### 4.1. The Lexical Level

According to the lexical phonology model, phonological rules apply cyclically in the lexicon. I assume that Mandarin compounding is a lexical process. Tone sandhi is sensitive to the internal structure of compounds, as

shown in the example in (12) and (13).

- (12) a. zu-zhang  
 'manager of a department'  
 group manager  
 3 3 UT  
 2 3 ST
- b. zong-[zu-zhang] 'general manager'  
 general group manager  
 3 3 3 UT  
 3 2 3 ST
- (13) a. zhan-lan 'exhibition'  
 show see  
 3 3 UT  
 2 3 ST
- b. [zhan-lan]-chang 'exhibition place'  
 exhibition place  
 3 3 3 UT  
 2 2 3 ST

The compounds in (12a) and (13a) show that 3TS applies within compounds. When a compound is further compounded with another lexical item, the original compound belongs to a separate domain from the new compounded element. Thus, in (12b), [zu-zhang] 'manager of a department' and [zong] 'general' are in separate domains. Similarly, [zhan-lan] 'exhibition' in (13b) shows that 3TS applies within the compounds which define a separate domain.

The correct tone patterns of the compounds in (12b) and (13b) are easily derived if 3TS applies cyclically in the lexicon. An alternative explanation is also possible. If the Lexical Phonology is not cyclic, the end-based theory can be used to provide the correct domain.<sup>5</sup>

## 2. Syntactic level

I will now turn to the application of 3TS postlexically. Because 3TS applies between words but not between all words, the question of how the correct prosodic structure is formed becomes relevant. I will first consider the level of PWD by examining some simple sentences.

- (14) Xiaomei da wo. 'Xiaomei hit me.'  
           hit me  
       3 3 3 3 UT  
       2 3 2 3 ST
- (15) Ni da wo. 'You hit me.'  
       you hit me  
       3 3 3 UT  
       3 2 3 ST
- (16) Xiaohu da Xiaoming. 'Xiaohu hit Xiaoming.'  
           hit  
       3 3 3 3 2 UT  
       2 3 2 3 2 ST

[ni] 'you' and [wo] 'I' in (14) and (15) are pronouns (i.e. function words). Therefore, at the PWd level, as defined by Selkirk, they are not considered as real words. [Xiaomei] in (14), [Xiaohu] and [Xiaoming] in (16) are compound nouns. Thus, at the lexical level, 3TS applied to these words when the structural description is met.

From the sentences (14)-(16), it is clear that 3TS applies within the PWd and that the end-setting at this level is sensitive to the left end instead of the right end of a content word. The derivations in (17) show that if the end-setting identifies the right end of a content word, correct surface tones for (17) cannot be generated (17a), but if the setting is the left end, the correct form is generated (17b).

(17)a.	right-end setting	
	Ni da wo	'You hit me.'
	3 3 3	UT
	3 2 3	ST
	3 3 3	lexical level
w	2 2] 3]	PWd level
*	2 2 3	output≠ST
b.	left-end setting	
	Ni da wo	'You hit me.'
	3 3 3	UT
	3 2 3	ST
	3 3 3	lexical level
w	[ 3 [2 3	PWd level
	3 2 3	output=ST

Since [ni] 'you' is a function word, in (17a), the end-setting will identify the end of [da] 'hit', which is a content word. Thus, [ni] and [da] are grouped together as one PWd. The third tone of [ni] is changed to a second tone. However, the correct surface tone of [ni] in (15) is a third tone. The right-end setting therefore gives the wrong prediction. In contrast, with a left-end setting, [da] 'hit' and the following function word [wo] 'I' are grouped together as a PWd. The tones derived from this setting give the correct predictions.

Consider now the setting for PPh in Mandarin. There are four possible settings. As Selkirk (1986) points out, there is probably some relation between the choice of end-settings for derived domains and the general properties of syntactic structure in the language. Although the properties of syntactic structures in the language which determine the choice of derived domains are unknown, it is likely that the headedness of the language plays a major role. For instance, syntactic structures in Mandarin are generally left-headed, except for the NP. It would therefore be unlikely for the choice of derived domains to be sensitive to the right end of either  $X^{\max}$  or  $X^{\text{head}}$ .<sup>6</sup> Thus, let us consider a left end setting on  $X^{\max}$  and  $X^{\text{head}}$ . Both  $X^{\max}$  or  $X^{\text{head}}$  settings at the PPh level are given in (18a).

18)a.

	Xiaomei		vp <sub>pp</sub> [ba bi]	v [gei]	np [Xiaoming]]			
			BA	pen	give			
	3	3	3	3	3	3	2	UT
	2	3	2	3	2	3	2	ST
	2	3	3	3	3	3	2	lexical level
w[	2	3	[3	[3	[3	[3	2	PWd level
χ <sup>max</sup> [	2	3	[3	[2	3	[3	2	χ <sup>max</sup> -PPh
χ <sup>head</sup> [	2	3	[3	[3	[3	[3	2	χ <sup>head</sup> -PPh

'Xiaomei gave Xiaoming a pen.'

Note that the surface tone pattern for the sentence in (18a) shows that there is a boundary between [bi] 'pen' and the verb [gei] 'give' and also between [Xiaomei] and [ba]. With the  $\chi^{\max}$  setting, the boundary between [bi] 'pen' and the verb [gei] 'give' does not constitute a left edge of  $\chi^{\max}$ , so they will be in the same domain. Thus, the correct surface tone pattern of (18a) cannot be generated by an  $\chi^{\max}$  setting. On the other hand, given an  $\chi^{\text{head}}$  setting, a left edge of  $\chi^{\text{head}}$  does fall between [bi] 'pen' and [gei] 'give' and between [Xiaomei] and [ba].

From the tone pattern generated by PPh with  $\chi^{\text{head}}$  setting in (18a), it is clear that there are still some adjacent third tones. One might appeal to a higher level of structure to solve this problem. As discussed in the next section, there is a level of intonational phrase (IPh) in Mandarin Chinese. However, if the IPh is built directly from the PPh as defined by  $\chi^{\text{head}}$ , the correct surface tone pattern is not generated. This can be seen in (18b), where the two possible outputs obtained from IPh are shown.

18)b.

	Xiaomei		vp <sub>pp</sub> [ba bi]	v [gei]	np [Xiaoming]]			
			BA	pen	give			
	3	3	3	3	3	3	2	UT
	2	3	2	3	2	3	2	ST
	2	3	3	3	3	3	2	lexical level
w[	2	3	[3	[3	[3	[3	2	PWd level
χ <sup>head</sup> [	2	3	3	3	3	[3	2	PPh
*[	2	2	2	2	2	3	2	IPh-1
*[	2	3	2	2	2	3	2	IPh-2

'Xiaomei gave Xiaoming a pen.'

18b) shows that while  $\chi^{\text{head}}$  appears to be the correct setting, it alone is not enough.

Cowper and Rice (forthcoming), in revising Selkirk's end parameter settings, propose that branchingness is a parameter for the determination of Ph. Sentence (18) shows that branchingness is also relevant in Mandarin. In (18), both [gei] and [ba] are heads of a phrase that branches. In contrast, the P's in the sentence, [Xiaomei], [Xiaoming] and [bi], although containing a head, are not branching. Thus, the data in Mandarin support this hypothesis in that Mandarin branchingness is a necessary parameter at the level of PPh. (19)

shows the derivation with the setting of  $X^{\text{head}}$ , where  $X^{\text{max}}$  branches.

(19)	Xiaomei			$v_{pp}$ [ba bi]	$v_{\text{gei}}$	$np$ [Xiaoming]]		
				BA	pen	give		
	3	3	3	3	3	3	2	UT
	2	3	2	3	2	3	2	ST
	2	3	3	3	3	3	2	lexical level
w[	2	3	3	3	3	3	2	PWd level
$X^{\text{head}}$	2	3	2	3	2	3	2	PPh level
	2	3	2	3	2	3	2	IPh
	2	3	2	3	2	3	2	output=ST

While Cowper and Rice suggest that branchingness is relevant at the level of the PPh, data from Biblical Hebrew (Dresher 1986) and Mandarin raise the question of whether branching is relevant at other levels of phrase phonology. Since 3TS in Mandarin makes crucial reference to the level of PWd, as shown in (17), let us re-examine the domains for 3TS application at the PWd level. I have shown in (15) that the end setting at the PWd level is sensitive to the left-end of content words. However, sentences (20) and (21) show that correct surface tones cannot be generated given this setting.

(20)	Wo da Xiaoming.	'I hit Xiaoming.'			
	l	hit			
	3	3	3	2	UT
	2	2	3	2	ST
	3	3	3	2	lexical level
w[	3	3	3	2	PWd level
$X^{\text{head}}$	3	2	3	2	PPh level
*	3	2	3	2	output≠ST

(21)	Wo zhao Xiaoming	$ip$ [PRO da ni]			
	l	ask	hit you		
	3	3	3	2	3
	2	2	3	2	3
	3	3	3	2	3
w[	3	3	3	2	3
$X^{\text{head}}$	3	2	3	2	3
*	3	2	3	2	3
	'I ask Xiaoming to hit you.'				output≠ST

Sentences (20) and (21) show that when a sentence has a sequence as in (22), the FW preceding CW1 is grouped with CW1 as a PWd. (FW=function word, CW=content word) However, as we have seen in (17), with a sequence as in (23), the function word (FW1) preceding the CW1 is not grouped with the CW1.

(22) FW-CW1-CW2

(23) FW1-CW1-FW2

w[ [                    ]                    ]                    ] PWd level

Therefore, it appears that PWD's in Mandarin must be branching if possible. In other words, in a sequence such as (22), the PWD with CW1 can be made branching by including the preceding function word. The PWD structure of (22) is shown in (24).

(24) FW-CW1-CW2  
 $w[ \quad [ \quad \quad ]$  PWD level

With a sequence such as (23), the PWD [CW1-FW2] is already branching because of FW2. Thus, the function word preceding it is not grouped into the same PWD. It should be noted that two content words cannot be grouped into one PWD. Thus, given a sequence in (25), none of the PWD's can be made branching.

(25) CW-CW-CW  
 $w[ \quad [ \quad [ \quad \quad ]$  PWD level

With obligatory branching PWD's, (20) and (21) have the structures in (26) and (27).

(26) Wo da Xiaoming. 'I hit Xiaoming.'  

	I	da	Xiaoming.		
	3	3	3	2	UT
	2	2	3	2	ST
	3	3	3	2	lexical level
w[	2	3	3	2	PWD level
xhead[	2	2	3	2	PPH level
	2	2	3	2	output

(27) Wo zhao Xiaoming ip[PRO da ni]  

	I	ask	hit	you		
	3	3	3	2	3	3
	2	2	3	2	2	3
	3	3	3	2	3	3
w[	2	3	3	2	2	3
xhead[	2	2	3	2	2	3
	2	2	3	2	2	3

'I ask Xiaoming to hit you.'

From the above data, it is clear that branchingness is available not only at the PPh level, but also at the PWD level. Hence, I propose that branching should be an additional parameter in the End parameter settings for derived domains in general. The revised end parameter settings are stated in (28).

(28) Revised End Parameter Settings

i) PWD	a.	$]_{word}$	b.	$word[$	Branchingness [ $\pm$ ]
ii) PPh-1	a.	$]_{X^{max}}$	b.	$X^{max}[$	Branchingness [ $\pm$ ]
- 2	a.	$]_{X^{head}}$	b.	$X^{head}$	

The end-settings in Mandarin have the b-setting at the level of PWd and 2b-setting at the level of PPh. Both levels have the plus value for the branchingness parameter, as summarized in (29).

(29) Mandarin End Settings		
PWd-	word[ ,	[branchingness +]
PPh-	X <sup>head</sup> [ ,	[branchingness +]

#### 4.3. Variations in Tone patterns

In the previous section, I pointed out that after the PPh level, 3TS applies at the level of IPh to change remaining adjacent third tones after the application of 3TS at the PPh level. In this section, I look briefly at the IPh in order to account for the facts of 3TS. It appears that either the entire sentence can be an IPh on its own or the subject can itself be an IPh. Consider sentences (30) to (32).

(30) Xiaohu da		Zhangsan.			
		hit			
	3	3	3	1	1
	2	2	3	1	1
	2	3	3	1	1
w[	2	3	3	1	1
X <sup>head</sup> [	2	3	3	1	1
	2	2	3	1	1
	'Xiaohu hit Zhangsan.'				

(31)	Xiaomei	xiang	ip[PRO da ta]		
		want	hit him		
	3	3	3	3	1
	2	2	2	3	1
	2	3	2	3	1
	'Xiaomei wants to hit him.'				

(32)	Xiaohu	xiang	ip[ PRO mai jizhi	gou].		
		want	buy	several dog		
	3	3	3	3	3	1
	2	2	2	3	1	3
	2	3	2	2	3	1
	'Xiaohu wants to buy several dogs.'					

From the surface tone pattern of (30), it is clear that the application of 3TS at this higher level changes the third tone of [hu] to a second tone. The IPh in (30) can take the whole phrase as a single domain. The surface tone patterns for (31) and (32), on the other hand, are variable. The variations are not due to variations in the levels prior to the level of IPh. The derivations of (31) and (32) are shown in (33) and (34).

(33)	Xiaomei	xiang	ip[PRO	da	ta]		
		want	hit	him			
	3	3	3	3	1		UT
	2	2	2	3	1		ST1
	2	3	2	3	1		ST2
	2	3	3	3	1		lexical level
w[	2	3	3	3	1		PWd
xhead[	2	3	3	3	1		PPh
a.[	2	2	2	3	1]		IPh7
b.[	2	3	2	3	1]		IPh

'Xiaomei wants to hit him.'

(34)	Xiaohu	xiang	ip[PRO	mai	jizhi	gou].	
		want	buy	several	dog		
	3	3	3	3	3	1	3
	2	2	2	2	3	1	3
	2	3	2	2	3	1	3
	2	3	3	3	3	1	3
w[	2	3	3	3	3	1	3
xhead[	2	3	3	3	3	1	3
a.[	2	2	2	2	3	1	3]
b.[	2	3	2	2	3	1	3]

'Xiaohu wants to buy several dogs.'

After the application of 3TS at the PPh level, there are still third tones adjacent to each other. If IPh does not have any structure, in other words, if the whole phrase is considered as a single domain, the derived tone patterns will be those in ST1 for both (31) and (32), as shown in (33a) and (34a). However, it appears that there can be a boundary between the matrix subject and the matrix verb. Thus, the subject NP may be considered as one single domain while the whole VP is another domain, as shown in (33b) and (34b).

Both tone patterns are acceptable. Native speakers do not seem to find any semantic difference between them. More controlled data are required in order to test whether the different tone patterns correlate with any semantic difference between the sentences. Cheng, C (1973) and Shih (1985) claim that rate of speech is the governing factor for variations. However, slight differences in rate of speech are difficult to perceive. This claim requires further studies measuring the different tone patterns and rate of speech.

## 5. Conclusion

I have shown that 3TS in Mandarin applies to prosodic structures. The domains of 3TS application can be derived from the proper end-settings. I have proposed that the end parameter settings in Universal Grammar must be expanded to include a parameter of branchingness. This parameter is not at one single level. Instead, it is a parameter for derived domains in general. In

this paper, I have also shown that there are variations in tone patterns in Mandarin. The variations are attributed to variations in domains of 3TS application at the level of IPh. However, which properties determine the variations in domains are still in question. Future work on semantics of different tone patterns and on rate of speech may shed light on the exact properties governing these variations.

## NOTES

<sup>1</sup> In this paper, I assume the X-bar schema proposed in Chomsky (1986). It holds for both lexical and non-lexical categories. All maximal categories are projections of their zero-level categories. COMP is therefore the head of S', now the complementizer phrase (C') and INFL is the head of S, the INFL phrase (I').

<sup>2</sup> Ba is called a 'coverb' in traditional terms. Cheng, L (1986) argues that ba is in fact a preposition.

<sup>3</sup> It should be noted that empty nodes (CP) and the empty category are not being considered here since they are phonologically null.

<sup>4</sup> This tone pattern is only acceptable when there is a pause between [li] and [mai].

<sup>5</sup> A left-end setting at the lexical level can also generate the correct tone pattern. However, details need to be worked out.

<sup>6</sup> The following examples show that a right end setting of  $X^{\max}$  or  $X^{\text{head}}$  generate incorrect surface tone patterns.

	a.	Xiaomei	zhao	ni	PRO	da	Xiaoming.		
		ask	you		hit				
		3	3	3	3	3	2	UT	
		2	3	2	3	2	3	2	
		2	3	3	3	3	3	2	
		2	3	2	3	3	3	2	
								lexical level	
								PWd level	
*		2	3]	2	2	2	3	2	
		'Xiaomei asked you to hit Xiaoming.'							PPh- ]X <sup>max</sup>
	b.	Xiaomei	[	[ba	bi]	[gei	[Xiaoming]]		
		vp	pp	v	np				
		BA	pen	give					
		3	3	3	3	3	2	UT	
		2	3	2	3	2	3	2	
		2	3	3	3	3	3	2	
		2	3	3	3	3	3	2	
w[		2	3	3	3	3	3	2	
								lexical level	
								PWd level	
*		2	3]	3]	3]	3]	3	2]	
								PPh- ]X <sup>head1</sup>	
*		2	2	3]	2	3]	3	2]	
								PPh- ]X <sup>head2</sup>	
		'Xiaomei gave Xiaoming a pen.'							

<sup>7</sup> With a sequence of third tones, third tone sandhi applies simultaneously at the IPh level.

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