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Using local constraint conjunction to discover constraints: the case of Mandarin Chinese*

1 Introduction

This paper, inspired by the collection of papers in Wang & Smith (1997), discusses a restriction in synchronic Mandarin Chinese which involves voiced stops, rising tone and nasal codas. The paper argues that this restriction can be described only as the result of the combined action of two constraints, i.e. a 'local constraint conjunction'. We discuss the exact formulation of this conjunction and note that, in Optimality Theory, the two constraints in a conjunction should also be instantiated separately. In this way, local constraint conjunctions provide a novel way of discovering constraints.

The paper is organized as follows. Section 2 will give some brief background information on the relevant phonology of Mandarin Chinese, illustrate the basic facts and describe the generalization. Section 3 will introduce local constraint conjunction, and show how the relevant generalization can be captured in Optimality Theory (Prince & Smolensky 1993 [2004]; OT). Section 4 discusses the implications of this strategy and concludes by identifying areas for further research.

2 Background on Mandarin Chinese

2.1 Segments, tones and syllable structure

The exact consonantal and vocalic inventory of Mandarin Chinese (MC) is a matter of some dispute (see contributions to Wang & Smith (1997), Li (2002)

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* This paper is dedicated to Norval Smith, with fond memories of the happy hours we spent in many contexts, in the early days of the Holland Institute of Generative Linguistics, on many a TIN-dag, and in many other places. For me, Norval's monumental knowledge, as well as deep understanding of all things phonological has set a standard that is always worth striving for, but can never be attained.

and Duanmu (2007) and many other sources for discussion). Here we will focus on those aspects that are uncontroversial and that are relevant to the main point to be made. As is well known, MC has a contrast between voiced and voiceless stops (including affricates) in the onset. Alternatively and more accurate phonetically, the relevant contrast is between voiceless unaspirated and voiceless aspirated stops, see e.g. Xu & Xu (2004). The standard pinyin transcription of Chinese characters uses voiced stop symbols like *b*, *d*, *g*, which we will also adopt here.

There is a four-way tone contrast in MC: high level (tone 1), rising (tone 2), a dipping contour (tone 3) and falling (tone 4). Figure 1 gives a graphic display of the various tone contours:

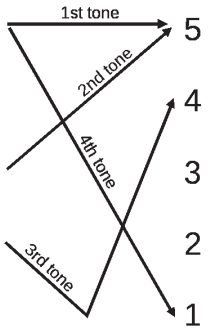


Figure 1: Mandarin tone chart

The four tones contrast in many lexical items. The examples in (1) are intended to illustrate this fact, as well as the fact that codas are limited to alveolar or velar nasals (the examples also show that characters that sound alike sometimes have a 'sound radical' in common):

(1)	帆	fan1	'sail'	芳	fang1	'perfume'
	凡	fan2	'ordinary'	房	fang2	'room'
	反	fan3	'turn over'	纺	fang3	'spin, weave'
	饭	fan4	'rice, food'	放	fang4	'put'

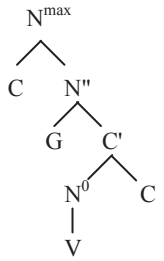
There are no complex onsets, although a glide may follow the initial consonant:

(2)	票	piao4	'ticket'
	牛	niu2	'ox, cow'
	快	kuai4	'fast, sharp'
	元	yuan2	'dollar' (phonetically [jw])

These glides have been analysed in different ways — either as secondary articulations on the onset, or as the initial part of diphthongs (see e.g. Duanmu 1999, 2007, 2008; Yip 2003, and references cited there), among

other possibilities. In Van de Weijer & Zhang (2008) we analyse the syllable structure of Chinese as an X-bar-structure, in which the glide occupies the specifier position of the nuclear vowel:

(3)



Particularly in combination with OT, this structure makes it possible to capture a number of generalizations with respect to Chinese syllable structure. For one, it makes it possible to distinguish between obligatory and optional positions. Only the N^0 position, as the head of the syllable, is obligatory (it is also the only position that can be complex, since diphthongs such as /ai/ are allowed, illustrating a head–dependent asymmetry in the sense of Dresher & Van der Hulst (1998)).[1] All other (non-head) positions are optional and subject to high-ranked *COMPLEX: the initial C-position is limited to one consonant, the position marked "G" is limited to one glide, and the final C-position is limited to a nasal (though see below for a discussion of final [-r] in diminutive formation). Furthermore, different domains in this structure can be identified with different phonological functions: the N'' position can be identified with the 'Final', a part of the syllable which is well-supported in traditional accounts of Chinese phonology (see Wang & Smith (1997), Van de Weijer & Zhang (2008) for discussion). The nucleus of the syllable itself (N') is the domain for tone assignment.

2.2 A restriction on tone 2

Not all combinations of tones and all syllable structures are permitted in MC. In particular, if a syllable begins with a voiced stop (as pointed out above: more accurate phonetically these are voiceless unaspirated stops) in the onset and is closed by a nasal, the rising tone (tone 2) is not permitted: syllables such as **bán*, **dán*, **gán*, **jín*, or **bíng*, **dóng*, **zháng* are not found or very

[1] Note that if the nucleus is complex, then there cannot be a coda (**-ain*, **-aoŋ*), a constraint on N'.

infrequent.[2] The prohibition is rooted in a complicated set of changes in Mandarin around a thousand years ago, in which, among other things, voiced stops became voiceless unaspirated stops. Also, syllables with tone 2 in the high register (so-called *yangshang* tones, which were basically allotones of tone 1) became tone 4 after voiced stops. The full set of changes is controversial and cannot be done justice to here; see e.g. Wang (1985) for an overview. Informal observation suggests that the prohibition is synchronically active psycholinguistically, since native speakers reject putative names such as *Béng* for putative foreign products as possible words. As a reviewer rightly points out, this needs to be checked more carefully in further investigation, especially in comparison to other unattested patterns.

If any other type of consonant apart from voiceless unaspirated stop appears in the onset (including nasals or glides), then the rising tone is permitted on the vowel. If there is no nasal coda, tone 2 is also permitted. These two possibilities are illustrated in (4):

(4) a. Tone 2 is permitted after consonants other than voiced stops before a nasal coda:

糖	tang2	'sugar'	王	wang2	'king'
燃	ran2	'to burn, ignite'	盘	pan2	'disk, tray'
平	ping2	'level, even'	蒙	meng2	'to cover'
人	ren2	'person'	寻	xun2	'to seek'
羊	yang2	'sheep'	零	ling2	'zero'

b. Tone 2 is permitted after voiced stops if there is no nasal coda:

拔	ba2	'raise, pull'	达	da2	'reach, arrive'
隔	ge2	'to separate'	打	da2	'hit, get, play'
鼻	bi2	'nose'	敌	di2	'enemy'
极	ji2	'extreme'	轴	zhou2	'axis, spool'

The words in (4b) had various tones in Middle Chinese — we will not be concerned here with their historical development, but focus on the synchronic situation.

Note that there are very few — if any — good examples of onsetless words which have tone 2 and a final nasal (cf. 昂 *ang2* in 昂首 *ang2shou3* 'hold one's head high; high, soaring'). Perhaps this is a subregularity that will need to be looked into in the future.

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[2] An interesting exception is 甭 [béng], 'there's no need to', which is a contraction (orthographically as well as phonologically) of the characters 不 (*bu2/4*) 'no' and 用 (*yong4*) 'need' (thanks to Zhu Lei for pointing this out to me). A reviewer additionally notes the colloquial forms 哏 (*gen2*) 'comical' and 咱 (*zan2*) as in 咱们 (*zan2men*) 'we'.

The condition against tone 2 illustrated by the examples in (4) can be formalized as in (5):

(5) $$* \begin{bmatrix} -\text{son} \\ +\text{voice} \end{bmatrix} \text{V}_{\text{Tone 2}} \begin{bmatrix} +\text{cons} \\ +\text{nasal} \end{bmatrix}]_{\sigma}$$

The phonetic motivation for a condition such as (5) is relatively well understood. Voiced obstruents are well-known to be associated with relatively lower tonal registers (Hombert 1978; Bradshaw 1999). This is seen particularly well in processes of tonogenesis (e.g. Haudricourt 1954; Hyslop 2009). Thus, voiced stops and high (or here: rising) tone are natural antagonists. See below for further discussion.

A number of comments on (5) are in order. First of all, since MC does not permit voiced fricatives in the onset, it is not necessary to specify [–cont] in the left-hand side of the condition. Note that Duanmu (2007: 24) regards initial [r] as a (voiced) fricative, transcribed [ʑ], on the basis of (one of) the phonetic realizations of this sound. However, since /r/ seems to pattern with the sonorants, at least for the process discussed here (and also because it is the only other sound permitted in the coda in morphologically complex words, involving the diminutive suffix 儿 (pinyin: *er2*)), we will assume that phonologically it is a sonorant. Secondly, we have used "Tone 2" specifically in the condition, to underscore the fact that other tones, in particular tone 1 (level-high) and tone 3 (dipping), which also involve a high component, are not subject to the condition. Third, recall that voiced stops are phonetically voiceless unaspirated stops; we might therefore have to read [–voice, –spread glottis] for [+voice] in this constraint. Fourth and most important, we need to discuss whether the right-hand side of the constraint is properly characterized. Since the only closed syllables in MC are those closed with a nasal, it would be possible to leave out the [+nasal] specification. Why should tone 2 be forbidden in syllables ending with a nasal? The effect of nasals, and sonorants in general, on tone in tonogenesis is not so well understood as that of obstruents on tone (but see, recently, Hyslop (2009) for discussion). Since nasals are voiced, they might also be regarded as antagonistic to high tone. Alternatively, the relevant interaction here is not between nasality and tone, but between syllable structure and tone. On this account, tone 2 is not permitted after voiced obstruents in a closed syllable and the condition in (5) could be simplified, as shown in (6):

(6) $$* \begin{bmatrix} -\text{son} \\ +\text{voice} \end{bmatrix} \text{V}_{\text{Tone 2}} \quad [+\text{cons}] \quad]_{\sigma}$$

If characterized in this way, the question would be why tone 2 is forbidden in closed syllables. There are some parallels in other (Chinese) languages where a particular tone does not occur in particular syllable types (see Gordon

(2002) for a discussion of restrictions on contour tones in particular syllable types). A case in point is Shanghainese, where tones 4 and 5 occur in 'checked' syllables only, i.e. syllables closed by a glottal stop (see e.g. Zee & Maddieson (1979)) and tones 1-3, therefore, are not permitted. A similar situation obtains in Cantonese, where only three of the seven tones occur in syllables closed by a stop (Yip 2002: 174), all of them level tones.

One further source of data that bears on this question comes from (Beijing) MC diminutive formation, which causes syllables to become closed in the morphology by a final [-r] (see Duanmu (2007: Chapter 9)).[3] Duanmu (2007: 223) explicitly discusses the interaction between suffixation and tone, but notes only that in some pairs of words the contrast between tones 3 and 4 is lost. So, tone 2 is preserved in syllables closed by a diminutive [-r]. This is also confirmed by the following examples (collected with kind help from the Friday Linguistics Salon at Shanghai International Studies University):

(7)

Root			Diminutive		
角	jue2	'actor, role'	角儿	juer2	'id-DIM.'
侄	zhi2	'nephew'	侄儿	zhir2	'id-DIM.'
拔	ba2	'raise, pull'	拔儿	bar2	'id-DIM.'
葱白	cong1bái2	'onion'	葱白儿	cong1bair2	'id-DIM.'
嗝	ge2	'hiccup'	打嗝儿	da3 ger2	'have the hiccups'

This indicates that if we wish to interpret the condition in (5) above strictly as an output condition, as in standard OT, it must include the specification of nasality, and cannot just refer to the fact that the syllable must be closed.

We will therefore continue to adopt the definition of the constraint in (5) for the discussion below.

3 Local constraint conjunction

The constraint on the occurrence of tone 2 (rising tone) in MC can be understood as two conditions: the first is a condition against tone 2 after voiced obstruents and the second is a prohibition of the same tone in syllables closed by a nasal. Separately, these constraints are not strong enough to prevent rising tone in MC words that either start with a voiced stop (recall the data in (4a)) or in words that end in a nasal (see the data in (4b)). However, when

[3] Alternatively, the final [r] can be analysed as part of the nucleus, rhotacizing the vowel.

both conditions are violated at the same time, high tone (or rather rising tone) is ruled out.

A situation like this can be elegantly captured by using constraint conjunction (Smolensky 1993, 1995, 2006; Kirchner 1996; Moreton & Smolensky 2002): the condition in (5) is the result of combining the two constraints in (8):

(8) a. *Voice/Rising: "No rising tone (tone 2) after a voiced onset"
b. *Nasal/Rising: "No rising tone (tone 2) in a syllable closed by a nasal"

The reasoning behind local constraint conjunction is that violating the combination of two markedness constraints is worse than violating either of them alone. High tone in a voiced-onset syllable is marked, but it is still permitted. A high tone in a syllable closed by a nasal is marked but also permitted. However, a high tone in a voiced onset syllable which is *also* closed by a nasal combines the 'worst of two worlds', and is not permitted. The combined constraint, already stated informally in (5) above, is stated as a conjoined constraint in (9):

(9) *Voice/Rising ∩ *Nasal/Rising (*VRNR)
"No rising tone in a syllable with a voiced onset and a nasal coda"

Both separate constraints are relatively low-ranked in MC, and at any rate lower than a tone faithfulness constraint which allows Tone 2 to surface, even in words with a voiced onset or a coda nasal. This is shown in the tableaux in (10):

(10) a. The conjoined constraint permits codaless words with voiced onsets

/dá/ 'reach'	*VRNR	Faith(Tone)	*Voice/Rising	*Nasal/Rising
☞ [dá]			*	
[dā]		*!		

b. The conjoined constraint rules out words with a voiced onset in a closed syllable

/dán/	*VRNR	Faith(Tone)	*Voice/Rising	*Nasal/Rising
[dán]	*!		*	*
☞ [dān]		*		

Other constraints (not discussed here) might determine the choice for another tone to surface in (10b). What remains to be shown is that in other languages a constraint like *Voice/Rising is highly ranked; this a topic for further research.

A second point that must be noted with respect to the constraint hierarchy of MC is that the combined constraint *VRNR is not inviolable, especially

when tone sandhi is taken into account: the well-known tone 3 sandhi role changes the first of a tone-3 syllable into tone 2 before another tone 3 syllable, which applies, for instance, in 管理 *guan3 li3* 'to manage' and will result in a phonetic syllable [guan2]. The tone sandhi constraint must therefore dominate VRNR.

Local constraint conjunction has been the topic of some controversy, since it adds considerable power to (OT) grammars. It has been a matter of debate, for instance, whether only two markedness constraints can be combined in this way (as in the case at hand) or if markedness and faithfulness can be similarly combined; see e.g. Moreton & Smolensky (2002) and references cited there. For the case of MC, however, it seems that the idea of local constraint conjunction is exactly right.

In this way, local constraint conjunction can even be said to serve a function in the discovery of the nature of the (putatively universal) constraint set: whenever a constraint conjunction is found of two constraints A ∩ B, then the separate constraints A and B must be part of the constraint set CON. Thus, cases like those in Mandarin force us to look for languages that instantiate either of the constraints in (8), instead of the more usual situation in which two well-established constraints are combined to result in a constraint conjunction.

6 Conclusion

The case of 'tonotactics' discussed here raises a number of questions. Why is the high level tone (tone 1) permitted in the environment in which the rising tone is ruled out? This might be related to the fact that rising tones take a longer time than level tones to pronounce, as suggested by Yip (2002) for Cantonese, and are therefore more difficult to "fit into" a closed syllable. However, for Mandarin this begs the question why tones 3 and 4, which also involve contours, are permitted in this environment, and why tone 2 is permitted in syllables closed by diminutive [-r]. Further phonetic investigation is necessary here, for instance with respect to the question whether there is a vowel length difference between vowels in closed syllables and in open syllables in this variety of Chinese.

From a theoretical perspective, the case of MC is interesting, because it illustrates a way of finding and arguing for Optimality constraints that is different than usual. The usual discussion in local constraint conjunction revolves around the question whether two separate, individually motivated constraints can be seen in action as a locally conjoined constraint. The

tonotactics of Mandarin clearly call for the combined action of two constraints; in such a situation both separate constraints also need to be valid constraints in OT.

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