Morpheme-level Features: Chaoyang Syllable Structure and Nasalization

Moira Yip
University of California, Irvine

In Chaoyang, the features [constricted glottis] ([c.g.]) and [nasal] are specified at the level of the morpheme, and distributed within the syllable in conformity with a set of ranked and violable output constraints. Coda consonants consist of Place features alone, and surface as voiceless glottalized stops if the syllable carries [c.g.], and as nasals if the syllable is not [c.g.]. The constraints governing [nasal] require that [nasal] be realized, that rhymes and syllables harmonize for [nasal], but that [nasal] may not associate to segments unmarked for [voice]. The interaction of these constraints means that in certain syllable types nasality surfaces on the entire syllable, in others on the rhyme only, in others on the onset only, and that in a final class nasality does not surface at all. The analysis of [c..g.] and [nasal] as morpheme-level features explains a pattern of segment loss in reduplication, where it is shown that the retained features of tone, [c.g.], and [nasal] are exactly the morpheme-level features of the language.

The analysis is worked out in Optimality Theory (OT), and it is argued that an OT analysis avoids the familiar "conspiracy" problem, where MSC's and rules converge on a single output in both underlying and derived forms. It is also argued that MSC's or rules would be forced to state rules non-locally, to explain an interaction between onset nasalization and the presence vs. absence of a coda, but that OT offers a straightforward local constraint interaction account of these facts.

The paper is organized as follows. After a brief summary of Chaoyang syllable structure, section 2 offer an analysis of glottalization which has as a surprising consequence the result that 'nasal' codas are not phonologically [nasal] (or [voice]), but allophones of final stops found in the absence of [c.g.]. This conclusion plays a major role in the analysis of [nasal] that follows. Section 3 provides a description of the [nasal] facts, and a preliminary analysis. Section 4 summarizes the essentials of Optimality Theory. and section 5 gives a formal OT analysis. Section 6 discusses the advantages of the OT analysis over an MSC or rule-based account. Section 7 introduces the reduplication data, which offers striking support for the morpheme-level nature of [c.g.] and [nasal]. The data is drawn from several papers by Zhang, also Zhu (1982) and Chiang (1991).

1. Introduction:

Chaoyang[1] has five phonemic vowels, /i,u,e,o,a/. Each also has a nasalized counterpart. The consonant phonemes are /p, pʰ, b, m, t, tʰ, l, n, ts, tsʰ, s, z, k, kʰ, g, ŋ, h/. Final consonants may be [m,ŋ, p,k]. Syllables may also end in a glottal stop. There are eight tones. Chaoyang syllables may be:

(1) Open Syllables: (C) (G) V (G) (ʔ)
Closed Syllables: (C) (G) V C

where G stands for glide. Open syllables may have oral or nasal vowels. It is probable (but not stated in the sources) that CV syllables are actually long, as they are in all Chinese dialects for which we have sufficient data. Some examples are given below:

(2)	pou^{11}	'chew'		pʰaŋ^{33}	'fragrant'	mẽ:^{53}	'fast'	tsi:ʔ^{55}	'stone'
	ŋiam^{55}	'surname'	bi:ʔ^{11}	'hide'		lok^{11}	'shake'	siap^{11}	'forty'
	oiʔ^{55}	'narrow'	lauʔ^{11}	'lick'		iãũʔ^{11}	'fold'		

2. Glottalization:

I have called syllables ending in glottal stop or a glide "open", in contrast to syllables ending in an orally articulated consonant. I wish to argue that [ʔ] is actually a feature [constricted glottis] ([c.g.]), not a full segment, and that it does not act as a coda to close the syllable.

Glottal stop is not reported to occur after a consonantal coda, but it can occur following a glide, in rhymes like [auʔ]. If we consider [ʔ] to be a coda, on a par with [p, k], then we must correspondingly extend the syllable template to include CVGC syllables. But in that case we cannot explain the absence of rhymes like *[auk] or *[aim]. I therefore suggest that what is transcribed as [ʔ] is not a full segment, but rather a glottalization feature that may occur on [-cons] segments; further, only the second position in a rhyme may contain a glottalized vowel. Some such restriction is necessary to explain the impossibility of glottalization on vowels in rhymes like [ak]. Following Zec (1988), this second position can be considered the weak mora, or non-nuclear mora in the sense of Shaw (1992, 1993). In simple CV syllables I shall assume, following Duanmu (1990), that the rhyme is long, and the glottalization resides on the second position occupied by the long vowel.[2] The result is that all Chaoyang rhymes may be characterized as having exactly two moras (assuming that the pre-nuclear glide is in the onset):

(3)	VV	a:	a:ʔ	VC	am	ap
		ai	aiʔ			

This fixed two-mora rhyme is in line with the claim of Duanmu (1990) that all Chinese dialects require syllables to be bi-moraic..

Although glottal-final syllables have been argued above to be open, in one respect they form a natural class with stop-final syllables, in that neither syllable-type may carry a contour tone. Below in (a) I show the three underlying contour tones found on unglottalized syllables only, and in (b) I show the level tones found on all syllable types.

(4)	a.	taŋ	53	'political party'			
		taŋ	313	'heavy'			
		taŋ	31	'jellied meat'			
	b.	taŋ	33	'east'			
		taŋ	11	'cave'		ti:ʔ 11	'drop'
		taŋ	55	'bronze'	tak 55	'poison'	

This is typical of Chinese dialects, and has received various explanations in the literature. One possibility is that phonologically all syllables, including those in the right-hand column of (4)b, may have contour tones, but the second part of the contour cannot surface phonetically on a final stop. This view has been argued by Duanmu (1990) for other dialects. Chaoyang rhymes like [auʔ] make this approach dubious, since there is no obvious reason why a contour tone could not surface on this diphthong, just as it can surface on non-glottalized diphthongs like [au]. Instead, I shall explore the possibility that stop-final and [c.g.] syllables have only one tone-bearing unit (TBU), and contour tones require two TBU's. (Duanmu 1990, Steriade 1990, Hyman 1993.) It is then necessary to define the TBU in Chaoyang.

The question then is: how do we group together the non-tone-bearing glottalized [auʔ] and stopped [ap] as opposed to the tone-bearing non-glottalized [au], and how is this difference characterized formally? Final stops in Chinese are usually unreleased, and frequently accompanied by glottal closure. In other words, [ap] could more narrowly be transcribed as [apʔ]. I suggest, then, that [auʔ] and [apʔ] share the property of glottalization, in contrast to [au]. The class of TBU's is then the class of non-glottalized elements (see Zec 1988 on Kwakwala) in the rhyme.

Unlike final vowels and glides, which may or may not be glottalized, final oral stops appear to get glottalization obligatorily; this is shown by the fact that such syllables *always* behave as one TBU. In contrast, final nasals are never glottalized. Given this complementary distribution of final stops and nasals, we may analyze them as being one phoneme, with oral stops as the [c.g.] allophone, and nasals as the default allophone. (I assume here a theory of privative laryngeal features like that of Lombardi (1991).) Under this view, then, final orally articulated consonants must be unspecified for the features in which they differ, i.e. [nasal], [sonorant], and [voice], and indeed they plausibly consist of nothing but a [+cons] root node and a set of Place features, Labial or Dorsal. On positional underspecification, see Steriade (1994).[3]

We must now determine the origins of this [c.g.] specification. In Chinese, morphemes are overwhelmingly mono-syllabic. Any specification at the level of the morpheme will thus surface somewhere within that single syllable. Onsets in Chaoyang cannot be glottalized, and we have already seen that within the rhyme [c.g.] appears only on the final mora. Since this positioning is predictable, [c.g.] may indeed be specified at the level of the morpheme, and migrate to its surface position under the influence of licensing constraints. The next task is to formulate those constraints.

Notice that if (i) every syllable must contain at least one TBU[4], and (ii) this must be the head mora, and (iii) glottalized segments are not possible TBU's, then the association of glottalization to the weak mora is the only possible one, and need not be stipulated. The three conditions below will achieve the desired result; note that they include a requirement that input features be parsed. For [c.g.], only association to the non-head mora will result in licensing, and. I assume a theory of licensing along the lines of Goldsmith (1990), Itô, Mester and Padgett (1993), in which licensing is necessary for parsing.

(5) a. Head moras license tone only.
b. Moras license tone or [c.g.].
c. Input (laryngeal) features must be parsed.

Below I give the representations I have argued for above. Underlined moras are TBU's. ʔ stands for [+c.g.]. The specification Lab stands for the [+cons, Lab] archiphoneme m/p.

(6)	a:	au	am	a:ʔ	auʔ	ap
	σ	σ	σ	σ	σ	σ
	/ \	/ \	/ \	/ \	/ \	/ \
	μ μ	μ μ	μ μ	μ μ	μ μ	μ μ
	\ /	| |	| |	|/ |	| |\	| | \
	a	a u	a Lab	a ʔ	a u ʔ	a Lab ʔ

A major conclusion of this section is that final consonantal codas are specified only for Place; in section 3, their lack of specifications for [voice] and [nasal] will play a central role in the analysis of nasalization.

The analysis outlined above in many ways makes the [c.g.] feature look like a tonal feature in that it enjoys a high degree of independence from the segmental features. In particular, I have suggested that the difference between the nasal-final and stop-final syllables is not strictly segmental, but derived from this floating [c.g.] feature. In other words, the oral stops are "tonally conditioned", rather than the tones being conditioned by the stops. There has been a long debate among Chinese phonologists on this point, and Chaoyang appears to weigh in on the side of those who consider the Ru Sheng (stop-final and glottal-final syllables) to be a "tonal", or at least laryngeal, category, rather than a segmental one. Of particular interest here is a further point. It cannot be chance that the feature that removes a mora from the class of TBU's is the laryngeal feature [c.g.], rather than a supra-laryngeal feature of some kind. This observation suggests another way of viewing the data. Suppose that the reason [c.g.] moras are not TBU's is because the [c.g.] feature is taking up the tonal "slot", so to speak, leaving no further room for tone. Under this view all moras are TBU's, but they might perhaps be renamed Laryngeal Bearing Units, or LBU's, since the relevant feature may be either [c.g.] or a pitch feature.

3. Nasalization:

3.1 Nasalization in the Rhyme

The next issue is the treatment of nasalization. Virtually all the open syllables have nasalized counterparts, but CVC syllables have only oral vowels. We thus find [a:], [aːʔ], [au], [auʔ] vs. [ã:], [ãːʔ], [ãũ], and [ãũʔ]. The sources show nasalization on the nuclear vowel, not the off-glide, but both Zhang and Zhu note carefully that the entire rhyme is phonetically nasalized, and I have so shown it in this paper.

(7)	pou11	'chew'	iãũʔ11	'fold'
	lauʔ11	'lick'	mẽ:53	'fast'

In most cases this nasalization arose historically from the loss of a final nasal, usually /n/ (Chen and Wang 1975, Norman 1988), and one possibility is that in underlying representation these syllables still have a coronal nasal coda, which is lost but leaves its nasality behind. The problem with this is that we have to admit syllables of the form /aun/ into the underlying inventory to explain surface [ãũ], and then we would expect to find the non-existent /auŋ/ as well. Instead, my analysis rests on the observation that nasality has a very similar distribution to glottalization; let us therefore suppose that nasalization is also a floating feature, specified at the level of the mono-syllabic morpheme, from whence it migrates to various positions within that syllable.

I begin by assuming that the distribution of nasality is to be handled by Morpheme Structure Constraints (MSC's), but we will see shortly that the distribution of nasality is the same in derived forms as in underlying forms, rendering MSC's alone inadequate. I will then show that if the constraints are instead understood as output constraints, and if these constraints are ranked and violable, as proposed in Optimality Theory, the facts follow straightforwardly.

Within the rhyme, nasal harmony is the norm, so I will posit a constraint that prefers harmonic rhymes.[5]

(8) **RHYME HARMONY**: All segments in the rhyme must share any nasal specification.

However, we must explain why syllables ending in nasal oral consonants never have nasal vowels: [ãm] and [ãp] do not exist. Recall that I have argued that nasal codas are not phonologically nasal, but simply codas that lack [c.g.]. Thus despite surface appearances to the contrary, both the non-existent [ãm] and [ãp] would be disharmonic for nasality. Still, even if "nasal" codas are not always phonologically nasal, one might reasonably expect that they *could* be, in which case there would also be a version of [ãm] in which the whole rhyme was phonologically nasal. Since this would wrongly predict the existence of surface [ãm], I posit a second constraint:

(9) *** CODA-NASAL** (provisional): Codas may not license [nasal].

(This constraint will turn out to be superfluous, since its effects can be attributed to a more general constraint, but I use it here for expository purposes.) The conjunction of these two constraints correctly rules out nasalized vowels before codas. Let me re-emphasize that under this view "nasal" codas are not phonologically nasal at all, but simply [+cons], and not [c.g.].

3.2 Onsets and Nasalization:

Nasalization interacts in interesting ways with onset consonants. After voiceless onsets, or in onsetless syllables, nasality on the final is phonemic. We find contrasts like

(10)	i	'he'	ĩ	'chair'
	koi?	'squeeze'	tsʰõĩ?	'cry'

The oral voiced consonants [b,l,g] ([l] functions as a voiced coronal stop within the system), are in complementary distribution with the

nasal stops [m,n,ŋ] before open rhymes, with the oral stops occurring before oral vowels, and the nasal stops before nasal vowels.

(11)	bue	'tail'	muẽ	'porridge'	
	lai	'inside'	nã	'basket'	
	gueʔ	'month'	ŋiã	'elegant'	

We see here a type of syllable-level nasal harmony, parallel to the rhyme harmony discussed above, and for which I propose a parallel constraint:

(12) **SYLLABLE HARMONY**
All segments within the syllable must share any [nasal] specification.

Suprisingly, though, before closed rhymes both series of consonants are found, and the vowels are always oral:[6]

(13)	guk	'sleep'	mak	'eye'
	laŋ	'deaf'	naŋ	'person'

This situation is tabulated below, using representative rhymes and onsets of each type:

(14) Nasality on Onsets and Rhymes:

	A	B	C	D
	a: au a:ʔ auʔ	ã: ãũ ã:ʔ ãũʔ	aŋ akʔ	ãŋ ãkʔ
p,pʰ,∅	+	+	+	-
b	+	-	+	-
m	-	+	+	-

3.3 The Duplication Problem: Why MSC's alone are inadequate

The behavior of nasalization in reduplication shows that MSC's alone will not suffice. In various types of predicate complement reduplication, and in onomatopoeia, underlying onsets may get replaced by /l/. In certain contexts this /l/ nasalizes to /n/. The general rule is that the onset of the second syllable becomes [l], as in (15a), but it becomes [n] (underlined below) if the input has a nasalized onset (15b) or a nasalized vowel (15c):

(15) (eg from Chiang 1991:191, Zhu 1982:177)

(a)	kuaʔ luaʔ tŋ	'cut off'	
(b) original onset is [nasal] (and vowel is oral):			
	ŋaŋ n̲aŋ tiau	'use a fingernail to scoop something out'	
(c) original rhyme has nasalized vowel:			
	kiã n̲iã lai	'walk-come'	kiã k̲iã -> kiã l̲iã -> kiã n̲iã
	ĩ ũãi n̲ũãi kio	'creak'	ũãi ũãi -> ũãi l̲ũãi ->ũãi n̲ũãi

In (15a) we see preservation of the underlying nasality of the onset. More relevant here is the spreading of nasalization from rhyme to onset observed in (15b). It provides further evidence that nasal harmony is active in derived as well as underlying forms, which would seem to point to the need for rules of harmony in addition to MSC's. This collusion between MSC's and rules is a common problem, discussed in the work of Kisseberth 1970, 1972, and subsequently by many others.

3.4 The Non-locality Problem

Both MSC and rule-based accounts must distinguish somehow between the non-nasal vowels of /au/ and /am/. This is because we find only oral voiced stops before the non-nasal vowel of /au/, in conformity with the expectations of syllable harmony, but both voiced oral and nasal stops before the non-nasal vowel of /am/, showing that syllable harmony has not applied. A rule or MSC would thus have to refer to the non-local context of the presence or absence of a following consonant to ensure its application in [lau] and [nãũ], but not in [nam].[7]

The solution to both these problems lies, I suggest, in theories of phonology that are constraint-based, such as Optimality Theory (Prince and Smolensky 1993, McCarthy and Prince 1993a,b, Prince 1993, and an increasing number of other works too numerous to mention here). Such an account can explain both the "conspiracy" effect of rules and MSC's, and the non-locality effect. Some essential characteristics of OT are summarized here.

4. Optimality Theory

The input-output pairs are produced not by rules, but by an evaluation procedure that checks all the possible outputs of some input against a set of constraints, and determines which output best satisfies those constraints. The constraints are universal, and not necessarily surface true. Surface violations may be produced by the need to satisfy some conflicting and more important (i.e. more highly ranked) constraint. Language variation is attributed to different rankings of constraints. The grammar consists of three modules, GEN, CON and EVAL.

(16) **GEN**: Produces an (infinite) set of possible outputs for any given input.
CON: A set of UG constraints, ranked for each language
EVAL: A procedure for selecting the optimal output given a set of outputs and a ranked CON.

To illustrate with a simple example, consider the case of Maori final consonant deletion (for data and an alternative analysis, see Hale 1973). UG includes a constraint blocking codas, called -CODA, and a constraint requiring that input material be parsed (i.e. not deleted), called PARSE (Prince & Smolensky 1993, McCarthy & Prince 1993, Itô and Mester 1993). Ignoring the option of epenthesis, if these two constraints are ranked so that avoiding codas is more important than avoiding deletion, we get the desired result. Note that PARSE is violated on the surface, because it is out-ranked by -CODA, i.e. -CODA >> PARSE where >> means "outranks". Below, I assess only two of the infinite number of outputs of GEN:

(17) A Micro-grammar of Maori:
CON: ... -CODA >> PARSE ....
GEN (hopuk) = {... ho.puk. ; ho.pu.<k> ...}
EVAL:

	-CODA	**PARSE**
ho.puk.	*!	
☞ ho.pu.<k>		*

Legend: Angled brackst, <>, enclose unparsed segments. Periods mark syllable boundaries. The pointing hand, ☞, denotes the optimal candidate. ! marks the fatal violation. Once a constraint has decided matters, subsequent cells are shaded.

The function GEN is obviously extremely powerful, but it is constrained by certain principles, given below:

(18) Principles governing **GEN**:
a. Freedom of Analysis: Any amount of structure may be posited.
b. Containment: No element may be literally removed from the input form. Every candidate form thus contains the input as an identifiable sub-part.
c. Consistency of Exponence: No changes in the exponence of a phonologically specified morpheme are permitted.[8]

The conservative nature of the grammar is captured by the principles of Containment and Consistency of Exponence. Containment, which requires that all outputs include the input as an identifiable sub-part, plays an important role in that it allows each output to be assessed by EVAL without comparing it to the input.

Returning to nasality, suppose that the harmony constraints proposed above have power beyond the lexicon, and instead act as well-formedness constraints on outputs. They can then have the effect of forcing spreading of nasality, without the need for a rule as such. The "conspiracy" effect is then understandable as an attempt to achieve well-formed outputs. This insight goes back to Kisseberth (1970, 1972). OT does more, however; it accounts for the particular means used in the quest for well-formedness in terms of the interaction of a set of constraints. In the next section I offer such an analysis.

5. Analysis:

I begin by assuming that nasality is marked only for the morpheme (and hence the syllable, since in Chaoyang as in all Chinese dialects the syllable and the morpheme are largely co-extensive), not for individual segments. I only consider representations with a maximum of one specification of [nasal] per morpheme; representations with multiple instances of [nasal] would, I assume, be quickly ruled out by a high-ranked OCP.

The distribution that must be accounted for is shown below in a slightly different form:[9]

(19)

UR		**PR**	**Position of [nasal] in PR**
tau	[nasal]	tãũ	entire rhyme
lau	[nasal]	nãũ	entire syllable
tak	[nasal]	tak	does not surface
lak	[nasal]	nak	onset only

This surface distribution is the result of the interaction of a set of ranked constraints, the first two of which were proposed earlier as MSC's, and are repeated here, re-interpreted as output constraints:

(20) **RHYME HARMONY**
All segments in the rhyme must share any nasal specification.

(21) **SYLLABLE HARMONY**
All segments in the syllable must share any nasal specification.

Surface violations of SYLLABLE HARMONY result because (i) codas cannot be [nasal], due to the constraint proposed earlier as (9) *CODA-NAS, or because (ii) voiceless onsets cannot be [nasal]. The latter fact can be handled by introducing the constraint in (22), to be interpreted as "the presence of [nasal] implies the presence of [voice]".

(22) **NAS-VOI** (Itô, Mester and Padgett 1993)
[nasal] -> [voice]

Itô, Mester and Padgett invoke this in a rather subtle way to achieve linking of [voice] to [nasal] segments in homorganic clusters in Japanese. Here, it is used to block the linking of [nasal] to a voiceless segment. It has the satisfactory side-effect of rendering the *CODA-NAS constraint unnecessary; since coda consonants are not marked for [voice], as argued in section 2, the NAS-VOI constraint will bar linking [nasal] to them.[10]

Finally, I assume that nasality must be realized (i.e. parsed) if possible, which I formulate as the following constraint.

(23) **PARSE** [nasal]

All these constraints are plausibly universal. The two harmony requirements could be restated as ALIGN constraints, requiring that [nasality] line up with the prosodic (i.e. moraic and syllabic) structure (see McCarthy and Prince 1993a,b on ALIGN constraints, also Kirchner 1993 for an alignment treatment of harmony, and Itô and Mester 1994 for the alignment of features with syllable structure). The NAS-VOI constraint was proposed for a typologically very different language, Japanese, where it is invoked to achieve linking of [voice] to [nasal] segments. In Chaoyang, it blocks linking of [nasal] to segments that lack voice.[11] Indeed, it is often suggested that phonologically voiceless nasals do not exist in any language. (Pulleyblank (n.d.)., Itô and Mester 1989, Lombardi 1991) Lastly, PARSE [nasal] is an instance of the family of PARSE constraints familiar in OT (see especially Prince and Smolensky 1993).

These constraints must be ranked as shown below; the ranking arguments are given immediately.

(24) **<u>Ranked Constraint Set evaluating [nasal]</u>**

a. **NAS-VOI**:[nasal] -> [voice]
b. **"RHYME" HARMONY**: All moraic segments must share any nasal specification.
>> c. **PARSE** [nasal]
>> d. **SYLLABLE HARMONY**: All segments in the syllable must share any nasal specification.

We may see that PARSE-nasal is more important than SYLLABLE HARMONY from the surface violations of the latter found in syllables with voiceless onsets, in (25), or voiced onsets and voiceless codas, as in (26). (The apparently idiosyncratic letters identifying each candidate are to allow cross-reference to later larger tableaux.)

(25) PARSE-nasal >> σ-HARMONY

/tau/ > [tãũ]	PARSE-nasal	σ-HARMONY
☞ d. tau | nas		*
f. tau <nas>	*!	

(26) PARSE-nasal >> σ-HARMONY

/lak/ > [nak]	PARSE-nasal	σ-HARMONY
☞ c. lak | nas		*
f. lak <nas>	*!	

The ranking of RHYME-HARMONY above PARSE-nasal is shown by the failure of nasality to surface on the vowel of rhymes with a voiceless coda; nasality on the entire rhyme would of course violate NAS-VOI:

(27) RHYME-HARMONY >>PARSE-nasal

/tak/ > [tak]	RHYME-HARMONY	PARSE-nasal
☞f. tak <nas>		*
b. tak | nas	*!	

The ranking of NAS-VOI above PARSE-nasal is shown by the failure of nasality to surface anywhere in syllables with a voiceless onset and voiceless coda :

(28) NAS-VOI >>PARSE-nasal

/tak/ > [tak]	NAS-VOI	PARSE-nasal
☞f. tak <nas>		*
d. tak | nas	*!	
e. tak \\| nas	**!	

The complete ranking is given below, for convenience:

(29) NAS-VOI, RHYME-HARMONY >> PARSE NAS >> SYLL-HARMONY

Below I give tableaux for each of the representative syllables /tau, lau, tak, lak/. For each input I consider the same six outputs:

(30) a. nasality associated just with the final segment
b. nasality associated just with the nuclear vowel
c. nasality associated just with the onset
d. nasality associated with the entire rhyme
e. nasality associated with the entire syllable
f. nasality unparsed

(31) [nasal] gives [tãũ]; no nasal gives [tau].

	NAS-VOI	R-HARMONY	PARSE-NAS	SYLL-HARMONY
a. tau | nas		*!		*
b. tau | nas		*!		*
c. tau | nas	*!			*
☞ d. tau | nas				*
e. tau \\| nas	*!			
f. tau <nas>			*!	

(32) [nasal] gives [nãũ]; no nasal gives [lau]

	NAS-VOI	R- HARMONY	PARSE-NAS	SYLL-HARMONY
a. lau | nas		*!		*
b. lau | nas		*!		*
c. lau | nas				*!
d. lau \\| nas				*!
☞ e. lau \\\| nas				
f. lau <nas>			*!	

(33) [nasal] or no nasal both give [tak]. [tãk] will never be optimal, correctly

	NAS-VOI	R-HARMONY	PARSE-NAS	SYLL-HARMONY
a. tak | nas	*!	*		*
b. tak | nas		*!		*
c. tak | nas	*!			*
d. tak \\| nas	*!			*
e. tak \\\| nas	**!			
☞f. tak <nas>			*	

(34) No nasal gives [lak]. [+nasal] gives [nak]. [lãk] will never be optimal, correctly

	NAS-VOI	R-HARMONY	PARSE-NAS	SYLL-HARMONY
a. lak | nas	*!	*		*
b. lak | nas		*!		*
☞ c. lak | nas				*
d. lak \\| nas	*!			*
e. lak \\\| nas	*!			
f. lak <nas>			*!	

6. OT vs. MSC's and rules

6.1 The Conspiracy Effect

Since OT is an output-based grammar, it by definition does not care whether the optimal candidate is optimal by virtue of its underlying form, or by virtue of "derivational" changes (in OT terms, changes made by GEN). The grammar can only distinguish these indirectly, by means of constraints of the FAITHFULNESS family, such as PARSE. Thus the conspiracy effect is not really surprising. There is still an interesting question as to *why* the structure of the lexicon should mirror the effects of the output constraints; on this point, see Prince and Smolensky 1993: 191).

6.2 The non-locality problem again:

One of the drawbacks of a rule and/or MSC approach was the non-locality problem: the influence of the final consonant in enforcing nasal harmony in [nãũ] but blocking it in [nak], *[nãk]. The reason [nak] cannot have a nasal vowel is straightforward in the OT analysis. First, the coda cannot be nasal without violating the undominated NAS-VOI. Thus the rhyme cannot possibly be wholly nasalized. Second, there is no preference in the grammar for Onset-Nucleus harmony; such harmony is simply a by-product of a preference for SYLLABLE-HARMONY, But in [nak], since the rhyme cannot be nasalized, neither can the whole syllable, and no constraint thus encourages onset-nucleus harmony. In fact , the undominated RHYME-HARMONY actively prohibits onset-nucleus harmony in such a case, because it would incur a violation of rhyme harmony! The non-locality problem thus disappears under this analysis. The particular property of OT that makes this account possible is that constraints, though real, are violable, and some are more important than others.

7. Confirmation from Reduplication

In certain types of reduplication, including onomatopoeia and some verbal reduplication, onsets are replaced by /l/ or /n/ in the third syllable, all vocalic material is replaced by /i/ in the first syllable, and codas are deleted (or neutralized to velar, as can be seen in some examples) in the first syllable. As the following data show, the only features which are retained are tone, nasality on onsets and vowels, and [c.g.] on codas. In the analysis proposed here these three features are all encoded at the level of the morpheme in underlying representation, and the features which are lost are the segment-level features. The reduplication phenomenon can thus be analyzed as a failure to parse entire segments (and not just their Place nodes, as suggested in Yip (1993).

(35) **a. Onsets: Loss of Place features:**

kʰi kʰa la kio tsi tsiau liau kio piŋ paŋ laŋ kio

b. Onsets: Loss of Laryngeal features [s..g.] and [voice]:
kʰi kʰa la kio kik kiak liak kio zue lue e siu liu kʰu

c. Onsets: Loss of Manner features
ti ta la kio tsi tsiau liau kio sik siak liak kio

d. Onsets: Retention of Nasality
ŋaŋ naŋ kio mĩ mã nã kio

e. Vowels: Loss of Place features
hi hom lom kio piŋ paŋ laŋ kio hi he le kio

f. Vowels: Retention of tone:
kʰi kʰa la kio ML ML ML ML tsi tsiau liau kio H H H ML
piŋ paŋ laŋ kio L L L ML

g. Vowels: Retention of Nasality
ĩ uãĩ nuãĩ kio tsʰĩʔ tsʰõʔ nõʔ kio

h. Codas: Loss of Place features, retention of [c.g.][12]
kiʔ kiak liak kio hiʔ hop lop kio

i. Codas: Loss of Place features, loss of 'nasal' codas (i.e. codas without [c.g.]). No residual nasality.
hi hom lom kio li lom kio

With respect to nasality, there are two further striking facts about these data. First, codas lose their `nasality', unlike onsets, as can be seen in (i) and (d) above. In the analysis offered here, this is entirely as expected, since codas have been argued to be phonologically non-nasal, whereas onsets are phonologically nasal. Second, the distribution of nasality in the outputs is in conformity with the output-based grammar presented here. For example, if an input syllable has an oral onset and a nasal vowel, like /tsʰõʔ/ in (g) above, and the onset is replaced by /l/, it will surface not as /l/ but as [n], because the derived onset is voiced and full syllable harmony is thus possible.

8. Conclusions

This paper argues that certain features in Chaoyang, in particular [c.g.] and [nasal], are specified at the level of the morpheme, and distributed in the surface syllable as the result of a set of licensing conditions and constraints. [c.g.] is restricted to syllable-final position by the licensing conditions, whereas [nasal] has great freedom of occurrence, preferring in fact to occupy the entire syllable if possible. Both conditions could be reformulated as alignment constraints. [c.g.] would align with the right edge of the syllable in conformity with a constraint ALIGN ([c.g.] R, σ, R) (see Itô and Mester 1994 for a similar approach). SYLLABLE HARMONY would be formulated as alignment of [nasal] with both edges by a simple extension of the Generalized Alignment (McCarthy and Prince 1993b) schema ALIGN ([nasal], σ, R,L). The difference reduces to the lop-sided alignment of [c.g.] with the right edge of the syllable, and the symmetrical alignment of [nasal] with both edges of the syllable. This paper offers an OT analysis of these data which avoids two problems associated with a rule or MSC approach, the "conspiracy" problem, and the non-locality problem.

This analysis raises a number of questions. What does the Chaoyang lexicon look like under this approach, and how learnable would it be? If associating features to segments is a cost, then lexical minimality would encourage, in fact require, the approach taken here. On the other hand the associations are then inserted by GEN, and presumably violate some constraint of the FAITHFULNESS family. Thus the language learner might reasonably be expected to reject these more abstract U.R's in favor of ones that mimic the surface forms. For discussion of these issues, I refer the reader to Prince and Smolensky (1993:192).

Second, how does this analysis help with our understanding of more familiar nasal harmony systems, in which nasality spreads out over polysyllabic and polymorphemic domains? Very little, it seems. Extending this analysis would predict that voiceless segments might block nasal harmony, but it would not predict that all obstruents, voiced or not, could block harmony as they do in Sundanese. (Piggott 1992). Further, nasal spreading does not necessarily improve rhyme or syllable harmony: Capanahua spreading produces disharmonic syllables like [pã], Malay has disharmonic rhymes like [ãp]. Finally, nasal spreading does not necessarily act to satisfy PARSE-nasal, since [nasal] is usually associated underlyingly and thus already parsed.

Notes

* This paper has benefited greatly from the comments of audiences at Cornell University, U. of Toronto, UC Berkeley, and UC Santa Cruz, and especially Abigail Cohn,, Sharon Inkelas, Junko Itô, Armin Mester, Jaye Padgett, Keren Rice, Benard Tranel, Draga Zec, and Cheryl Zoll. This paper could not have been written without the contributions of Li Xiaoguang.. This research was supported in part by an Irvine Faculty Research Grant, # 92/93-13. All errors and omissions are of course my own.

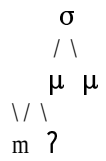
1. Chaoyang is a Southern Min dialect, spoken in south-east Guangdong province, near Chaozhou. It is part of the Chaoshan sub-family, related to Shantou (Swatow) and Chaozhou.

2. Given that the Minimum Word in Chinese is the monosyllable, and noting McCarthy and Prince's (1986) claim that the Minimum Word is always binary, composed of either two moras or two syllables, a bi-moraic minimal syllable is the expected consequence.

3.Further evidence that laryngeal features may associate to [-cons] moras is that there are four rhymes composed entirely of syllabic nasal consonants, and these may bear tone and [c.g.].

(i) a:33 m53 'aunt, mother'
pŋ33 pʰi:53 'rice crust'
hmʔ11 'hit someone with fist'
tŋʔ11 tio:ʔ11 'fall back'

These syllables will have the following structure:



Since the nasals remain nasal - that is, we do not get [mpʔ] or [ppʔ] - it appears that doubly linked [c.g.] nasals resist becoming stops.

4. This requirement that all moras bear a Laryngeal feature seems to fill somewhat the same role in the phonology as exhaustive footing fills in stress languages.

5. In a theory without sub-syllabic constituents, the harmony domain could be stated with reference to moraic segments. I will use rhyme as a convenient term of reference, without any commitment to its theoretical status.

6. Zhang (1981) is quite explicit on the absence of nasal vowels before consonantal codas. However, I have found two counter-examples to this generalization in other sources. One is in another paper by Zhang (1979:113), where we find [hõp], and the other is in Zhu (1982:176) where we find [niãp]. I have no explanation for these cases.

7. There is a further oddity about a rule-based analysis. Notice that for every output with nasal onset followed by nasalized vowel, such as [muẽ] 'porridge', there are two possible UR's, /muẽ/ or /buẽ/. For the former, spreading is vacuous; for the latter, it produces a nasal onset. But the language learner would surely never be led to postulate the more abstract /buẽ/. The effect would thus be that U.R.'s would obey the (rejected) M.S.C. by accident, so to speak.

8. Consistency of Exponence may subsume Containment, but this issue is beyond the scope of this paper.

9.Armin Mester (p.c.) has suggested that nasalization may not be associated to individual segments even on the surface, but rather to syllable, rhyme, and onset. Nasalization of segments is then done at the level of phonetic implementation. A problem for this approach is syllables like /tak/, which cannot have any surface nasalization. It is not clear why nasalization on the rhyme or the syllable could not be implemented on the nucleus of such syllables.

10. Keren Rice (p.c.) has pointed out to me that this constraint might be derivable from the placement of [nasal] under a Sonorant Voicing (or Spontaneous Voicing) node , as suggested in Rice and Avery(1989).

11. Itô Mester and Padgett 1993 show that in Japanese nasals are not specified for [voice] except when they are linked to a following stop. In Chaoyang, nasal onsets are crucially specified underlyingly for voice, but not for nasal, suggesting the possibility of cross-linguistic variation in this regard. What is more, all vowels must be specified for [voice] under this analysis, even though their voicing is predictable.

12. For final codas, oral or nasal, there are also usually variants with velar codas. These I take to be default Place assignment, following Trigo (1988).

References

Chang, M. L. 1992 *A Prosodic Account of Tone, Stress, and Tone Sandhi in Chinese Languages*. U od Hawaii Ph D Dissertation.

Chen, M. and W. S-Y Wang 1975 Sound change: actuation and implementation . *Language*: 51: 255-281.

Chiang, W-Y 1991 *Prosodic Phonology and Morphology of Affixation in Chinese Languages* PhD Dissertation, U. of Delaware.

Duanmu, S. 1990 *A Formal Study of Syllable, Tone, Stress and Domain in Chinese Languages* MIT Dissertation.

Goldsmith, J. 1990 *Autosegmental Phonology* Basil Blackwell, Oxford.

Hale, K. 1973 Deep-surface canoncial disparities in relation to analysis and change: an Australian example. *Current Trends in Linguistics* 11: 401-458

Hyman, L. 1993 "Register Tones and Tonal Geometry". in K. Snider and H. van der Hulst, eds, *The Representation of Tonal Register*. Mouton de Gruyter.

Itô, J. 1989 "A Prosodic Theory of Epenthesis". *NLLT* 7.1:217-259

Itô , J. and R.A. Mester 1989 Feature Predictability and Underspecification: Palatal Prosody in Japanese Mimetics. *Language* 65.2:258-291

Itô , J. and R. A. Mester 1993 "Licensed Segments and Safe Paths". Ms, UC Santa Cruz. In C. Paradis and D. LaCharite, ed.s, Constraint-Based Theories in Multilinear Phonology Special Issue of *Canadian Journal of Linguistics*: 197-214

Itô, J. and R. A. Mester 1994 Reflections on CodaCond and Alignment. Ms., UC Santa Cruz.

Itô, J., R.A. Mester and J. Padgett 1993 Licensing and Redundancy: Underspecification in Optimality Theory. Ms., UC Santa Cruz.

Kirchner, R. 1993 "Turkish Vowel Disharmony in Optimality theory". Paper presented at ROW-1. Handout to appear in Prince (1993).

Kisseberth, C. 1970 On the functional unity of phonological rules. *Linguistic Inquiry* 1: 291-306

Kisseberth, C. 1972 On derivative properties of phonological rules. In Brame, M. ed *Contributions to Generative Phonology* 201-228. U. of Texas press, Austin.

Lombardi, L. 1991 *Laryngeal Features and Laryngeal Neutralization* Ph D Dissertation, U. Mass, Amherst

McCarthy, J. and A. Prince 1986 *Prosodic Morphology* Ms, UMass Amherst and Brandeis University.

McCarthy, J. and A. Prince 1993a *Prosodic Morphology I: Constraint Interaction and Satisfaction* Ms., U Mass, Amherst and Rutgers University.

McCarthy, J. and A. Prince 1993b Generalized Alignment Ms., U Mass, Amherst and Rutgers University.

Norman, J. 1988 *Chinese* Cambridge University Press.

Piggott, G. 1992 Variability in feature dependency: the case of nasality. *NLLT* 10.1:33-78

Prince, Alan and Paul Smolensky (1991) "Connectionism and Harmony Theory in Linguistics". Tech report, CU-CS-533-91, Dept of Computer Science, U. of Colorado, Boulder

Prince, Alan and Paul Smolensky (1991) "Connectionism and Harmony Theory in Linguistics". Course taught at the 1991 LSA Linguistics Institute, U. C. Santa Cruz.

Prince, Alan and Paul Smolensky (1992) "Optimality. Constraint Interaction in Generative Grammar". WCCFL handout.

Prince, A. and P. Smolensky 1993 *Optimality Theory: Constraint Interaction in Generative Grammar* Ms., Rutgers University and U. of Colorado, Boulder

Prince, A. 1993 (ed) Handouts from Rutgers Optimality Workshop 1.

Pulleyblank, D. 1986 *Tone in Lexical Phonology*. Reidel, Dordrecht.

Pulleyblank, D. n.d. Patterns of feature co-occurrence: the case of nasality. Ms, U. of Ottawa.

Rice, K. and P. Avery 1989 On the interaction between sonoroancy and voicing. *Toronto Working Papers in Linguistics*, vol. 10.

Shaw, P. 1992 "Templatic Evidence for the Syllable Nucleus" *NELS* 1992

Shaw, P. 1993 "The Prosodic Constituency of Minor Syllables" *WCCFL* 1993

Smolensky, Paul (1986) "Information Processing in Dynamical Systems: Foundations of Harmony Theory" in D. Rumelhart, J. McClelland and P.D.P.R. Group, ed.s,

Parallel Distributed Processing: Explorations in the Microstructure of Cognition I: Foundations MIT Press: 104-281

Steriade, D. 1990 "Moras and Other Slots" *Proceedings of the 1st Conference of the Formal Linguistics Society of Mid America.*

Steriade, D. 1994 Underspecification and Markedness. To appear in Goldsmith, J. ed. *Handbook of Theoretical Phonology* Basil Blackwell, New York

Trigo, L. 1988 *On the Phonological Derivation and Behavior of Nasal Glides* MIT PhD Dissertation.

Yip, M.(1980) *The Tonal Phonology of Chinese*. MIT PhD Dissertation. Published 1990 Garland, New York.

Yip, M.(1989) "Cantonese Morpheme Structure and Linear Ordering." *Proceedings of West Coast Conference on Formal Linguistics* VIII. University of British Columbia, Vancouver. pp. 445-456.

Yip, M. 1993 The Interaction of Align, Parse-Place, and Echo in Reduplication. Paper given at ROW-1. Handout to appear in Prince 1993.

Zec, D, 1988 *Sonority Constraints on Prosodic Structure* Stanford University PhD Dissertation.

Zhang, Sheng Yu. 1979. Chaoyang fangyan de wenbai yidu. [Colloquial and literary strata in the Chaoyang dialect]. *Fangyan* 1979, 4.241-267.

Zhang, Sheng Yu. 1979. Chaoyang fangyan de chongdieshi. [Reduplication in the Chaoyang dialect]. *Zhongguo Yuwen* 1979, 2.106-114.

Zhang, Sheng Yu. 1979. Chaoyang fangyan de liandu biandiao. [Tone sandhi in the Chaoyang dialect]. *Fangyan* 1979, 2.93-121.

Zhang, Sheng Yu. 1980. Chaoyang fangyan de liandu biandiao. [Tone Sandhi in the Chaoyang dialect (II)]. *Fangyan* 1980, 2.123-136.

Zhang, Sheng Yu. 1981. Chaoyang fangyan de yuyin xitong. [An outline of Chaoyang phonology]. *Fangyan* 1981, 1.27-39.

Zhang, Sheng Yu. 1982. Chaoyang fangyan de xiangshengzi chongdie shi. [The reduplicated onomatopoeic particles in the Chaoyang dialect]. *Fangyan* 1982, 3.181-182.

Zhu, De Xi. 1982. Chaoyang hua he Beijing hua chongdie shi xiangshengci de gouzhao. [A comparison between onomatopoeic words in reduplicated forms in the Chaoyang and Beijing dialects]. *Fangyan* 1982, 3.174-180.