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Phonological Constraints, Optimality, and Phonetic Realization in Cantonese

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1. Introduction:

This paper proposes an analysis of the realization of onsets in Cantonese that develops two sets of theoretical ideas. First, it is claimed that an explanatory account of the data rests on the interaction of a set of ranked, violable, universal constraints, rendering rules unnecessary. It thus provides further support for Optimality Theory. Theory-internally, (i) the analysis further demonstrates the need for families of constraints which may be internally ranked in UG, then interspersed among other constraints of the grammar on a language-specific basis. (ii) it is argued that an avoidance of epenthesis is best characterized by **MSEG**, rather than **FILL** (iii) the analysis has implications for the treatment of optionality within OT.

Second, it is claimed that the language-specific phonetic component plays an important role in achieving sufficient closure for a well-formed onset, and that this closure is sometimes achieved in surprising ways; in particular, it is argued that [ŋ] is the phonetic realization of a non-high vowel in onset position. It is claimed that provided featural specifications are not tampered with, the phonetics has a "window" of latitude available for realization.

Finally, one can discern a conservative and minimalist tendency throughout the grammar. In the phonology, deviation from the input accrues a cost. In the phonetics, outputs are realized parsimoniously or minimally.

2. The Problem

The onsets [y, w, ŋ, ʔ] in Cantonese have a skewed distribution, with high glides not appearing before high tense vowels that differ in backness, and [ŋ, ʔ] not appearing before high vowels at all. Further, the velar nasal and the glottal stop are not contrastive:

(1) **Skewed Distribution of Certain Onsets in Cantonese**:

	i	u	[-high, +back]
y	yi	*	yaŋ
w	*	wu	waŋ
ʔ	*	*	free variation
ŋ	*	*	ʔa:m = ŋa:m

The choice between [ŋ] and [ʔ] depends on a number of sociolinguistic and historical factors, and there is variation from speaker to speaker, and lexical item to lexical item. [ŋ] seems to be dropping out; it is used less by the young, and in informal speech . The correlation with historical *ŋ, *ʔ is breaking down, with both loss of historical [ŋ], and addition of [ŋ[] where there was none historically. As a result, the earlier correlation with tone (where [ŋ] was found with low register tones, [ʔ] with high regsiter ones) is also breaking down. For details, see Bourgerie (1980).

The distribution of [ŋ] shown in (1) is in contrast to the distribution of other nasals and other velars, all of which occur rather freely before all vowels:

(2) <u>Distribution of velars and nasals</u>:

	i	u	[-high, +back]
nasals	nin	mui	ma
velars	kin	k^hu	ka

The claim of this paper is that the only onsets in (1) which are underlying are those in the shaded cells, and that all others are derived by the phonology from underlyingly onsetless syllables. Specifically:

(3)

Underlying	Surface
i	yi
u	wu
a	ŋa ~ ʔ

A morpheme structure constraint forbids *[+high][+high] sequences, accounting for the absence of underlying /yi, yu, wi, wu/. As in English, /ŋ/ is banned altogther as an underlying onset (though it exists as a phoneme, being found in codas). [ʔ] is not a phoneme at all.

The second and related task of this paper is to explain the set of onsets acquired by vowel-initial affixes in different environments. The table below includes both vowel-initial words (as discussed above) and vowel-initial affixes:

(4) <u>Surface Onsets of Vowel Initial syllables:</u>

		Wd.	Aff.
- velar nasals	[ŋ]	x	-
- glottal stops	[ʔ]	x	-
- high glides	[y,w]		x
x			
- geminates (from preceding coda):	[nn]	-	x
- "semi-geminates" (from preceding coda)	[t'd]	-	x
	[t'ʔ]	-	x

3. Introduction and Theoretical Assumptions

3.1 Optimality Theory

I will assume that the grammar is conservative in the sense that divergence from the underlying form is avoided, and when it cannot be avoided, minimal changes are made. Specifically, there are phonological constraints requiring well-formed onsets, and in order to satisfy these the grammar (i) acts conservatively, making minimal changes to underlying representations and (ii) realizes the phonological outputs phonetically in parsimonious ways. This conservatism is implicit in all generative theories. In a rule-based theory, no changes take place unless a rule mandates them. In a constraint-based theory, no changes take place unless forced by a highly ranked constraint.

This paper assumes a constraint-based grammar, with its roots in the work of such authors as Kisseberth 1970, Sommerstein 1974, Cairns and Feinstein 1982, Singh 1987, Paradis 1988a,b , McCarthy 1986, Yip 1988. and also in work on Harmonic Phonology (including Smolensky 1986, Goldsmith 1990a,b, 1991, 1992, Prince 1991, Chen 1991). Specifically, it is formulated within Optimality Theory (OT) including Prince and Smolensky 1992, 1993, McCarthy 1991, Mester 1992, Itô and Mester 1992, Itô, Kitagawa and Mester 1992, McCarthy and Prince 1993 a,b, McCarthy 1993, Itô, Mester and Padgett 1993, Paradis and La Charité 1993, and all the papers in Prince 1993). Some essential characteristics of OT are summarized here.

The input-output pairs are produced not by rules, but by an evaluation procedure that checks all possible outputs for 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.

(5) **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. Underlying /hopuk/, if not followed by a suffix, gives surface [hopu]. 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". In (6), I assess only two of the infinite number of outputs of GEN:

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

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

Legend: The pointing hand, ☞, denotes the optimal candidate. 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:

(7) 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.[1]

A typical set of outputs from **GEN** is given below for the input /i/; input material is bolded for ease of identification.

(8) **GEN** (/**i**/) = {**i**, <**i**>, y**i**, ʔ**i**, t**i**.......pk**i**, mukap**i**.....}

The conservative nature of the grammar is captured by the principles of Containment and Consistency of Exponence in (7).

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. This is necessary because the status of an output is not always absolute. For example, the onset /t/ is a better onset (lower in sonority) than the onset /y/. However, for the input /i/ [yi] may be a better output than [ti], because it deviates less from the input. The conservatism is also a result of constraints such as **PARSE** (which blocks deletion) and **FILL** or **MSEG** (which block epenthesis). Only when some other constraint outranks one of these constraints will changes from the input be preferred. **PARSE** was discussed above. **FILL** requires that all nodes in structure be filled; epenthesis (or node insertion) is thus avoided. **MSEG** (McCarthy, 1993c:14) is an alternative way of assessing a cost for epenthesis, and replaces **FILL**. It requires that all segments be part of a morpheme, and it will thus be violated by epenthetic segments. We will see below that the Cantonese data require **MSEG**, not **FILL**.

(9) **PARSE**: Melody must be parsed

MSEG: Every segment belongs to a morpheme

replaces:**FILL**: Structural positions must be filled

In previous work the group of constraints that together induce conservatism have been referred to as **FAITHFULNESS** (Prince and Smolensky 1993, Itô Mester and Padgett 1993).

Previewing the analysis, I give below the set of constraints needed for the Cantonese data. Their rankings will be discussed below. Note especially that each constraint has been independently argued in the cited sources to be one of the set of constraints provided by UG; their interaction gives rise to particular grammars, including that of Cantonese.

(10) **Constraint Set for Cantonese**

a. **ONS**: Avoid Onsetless Syllables:(Itô 1989)
$*_{\sigma}[V$

b. **MSEG**:
Every segment belongs to a morpheme

c. **PARSE**:
Melody must be parsed

d. **Margin Hierarchy**:
***Mar/a** >>... >> ***Mar/i,u** >>... >> ***Mar/[nasal]** >>... >> ***Mar/[stop]**

The Margin Hierarchy (Prince & Smolensky 1993) sets up a preference for the onset (or coda) with the lowest possible sonority. It depends on the sonority hierarchy of Selkirk 1984, Clements 1988, given in (11); here > denotes "more sonorous than".

(11) Sonority Hierarchy

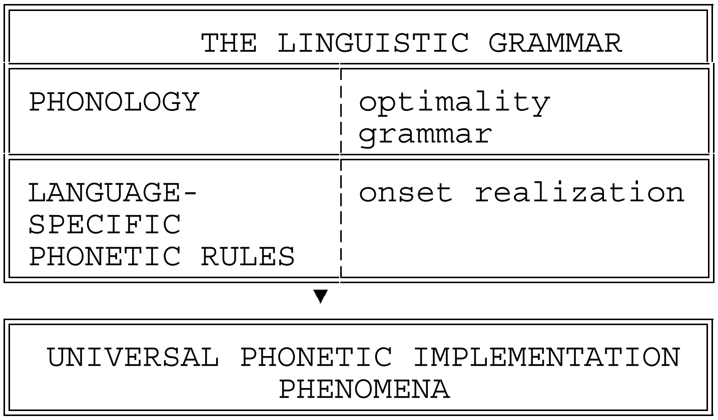
non-high vowels > high vowels, glides > nasals > obstruents

The Margin Hierarchy is an exploded family of constraints, ranked by UG. This UG ranking may not be reversed, but it may be interrupted by other constraints; we will see that such is the case in Cantonese. [2]

3.2 Phonetic Implementation:

A full explanation of the Cantonese data will require an understanding of how onsets are realized phonetically, as well as their phonological origins. I assume a model like that of Cohn (1990:4), shown below:

(12)



The phonetic component that will concern us here is presumably language-specific, part of the grammar of Cantonese.

A second assumption I will make is that the phonetic realization of phonological outputs is quite flexible. Targets do not necessarily have absolute values attached, but rather 'windows', or ranges, within which they must be realized (roughly as in Keating (1988), Cohn 1990). The size of this window may vary cross-linguistically. For example, Cohn (1990) shows that the window for velum position allows less freedom for French vowels than for English vowels.

The final assumption is that prosodic structure (not just featural specification) may require implementation. Although not obvious, this seems to be necessary. The most obvious example is vowel length: if length is characterized prosodically, with moras, then phonetic length must be partly a matter of realizing the prosodic structure phonetically (Hubbard 1993). Or consider geminate consonants, which are typically heterosyllabic, occupying a coda and an onset. Their phonetic length is the result of realizing a single feature matrix in two syllabic positions. Still at the syllable level, consider the difference between English [ai] and heterosyllabic [a.i]. These are acoustically different in that only the latter has two pulses, and this difference I take to be acoustic consequence of the phonetic implementation of syllabic information. As a final example, consider the phonetic realization of stress. This may vary from language to language, surfacing with a particular pitch, greater duration or amplitude, or some mixture of these (see Hayes 1991:4 for a recent summary).

For Cantonese, what will concern us is the phonetic implementation of onsets.[3] The central ideas are summarized below:

(13) **<u>Language Specific Phonetic Implementation of Onsets</u>**: [4]
a. Onsets require a degree of closure equal to or greater than that of a glide [5]
b. Feature specifications cannot be altered; otherwise, targets may be achieved in various ways, within their windows

In (14) I show the phonological specifications of various Cantonese onsets, and their phonetic realization:

(14) a.	/t/	[t]
b.	/i/	[y]
	/u/	[w]
c.	/-high, +back/	[ŋ]

Consider first a simple /t/ onset. It has its closure already specified, both as to Place (Coronal) and manner ([-cont]). The phonetic component has little to do. Next consider the high vowels /i,u/. I take the view here that (at least some) high glides are featurally identical to the homorganic vowels.[6] The phonetic difference is a result of the need to achieve some degree of closure: a simple intensification of the existing gesture, [+high, α back], will achieve the right result. Here [+ high] is realized at the extreme of its window, given the need to remain [-cons] and retain its backness.[7]

The most controversial case is an onset consisting of /a/ and the other [-hi, +back] vowels. The features [-hi, +back] block raising or fronting of the tongue body. One way to achieve closure is by further backing , which gives contact as the pharyngeal or velar glide [ ]. However, since contact is with the soft palate, which is itself mobile, "rapprochement" can also be achieved by lowering the velum, giving a nasalized back continuant sound, a nasal glide or anusvara, often transcribed as [ŋ] (see Trigo 1988). Crucially, this segment is never phonologically specified as [+nasal]. The nasality is simply a chance by-product of the attempt to achieve closure in the phonetics. This is the strategy used in Cantonese. The choice of realization strategy depends on the language-specific 'window'; interestingly, different dialects of Mandarin are reported to show both [ŋ] and [ ] before initial /a/.

The phonetics claims in this paper make potentially testable predictions. Among the more interesting is the possibility of differentiating phonetically between the phonologically specified [+nasal] of the true nasals, and the nasality that is merely a by-product of the phonologically non-nasal realization of /a/ onsets. I leave this and other questions for future research.

4. Cantonese Onsets

4.1 Word-initial Onset Satisfaction

Cantonese has the following vowel phonemes:/i, u, ü, e, o, ö, a, e:, o:, a:/. The length contrast in the mid vowels is marginal. For alternative analyses, see Hashimoto (1972). Vowels are given here in rough phonemic transciption, ignoring late allophonic variations. Below I give some examples of each of the onsets schematized in (1). Tones, which play no role in this discussion, have been omitted.

(15) a. <u>High Tense Vowels</u>

i	->	yi	*ʔi	'two'
im	->	yim	*ʔim	'salt'
iw	->	yiw	*ʔiw	'want'
un	->	wun	*ʔun	'bowl'
uy	->	wuy	*ʔuy	'meeting'
u	->	wu	*ʔu	'lake'
ü	->	ÿü	*ʔü	'fish'
ün	->	ÿün	ʔün	'far'
üt	->	ÿüt	ʔüt	'month'

b. <u>Other [+back]</u>

ɔ	-> ŋɔ	~	ʔɔ	'I, me'
ɔy	-> ŋɔy	~	ʔɔy	'to love'
ak saw	-> ŋak saw	~	ʔak saw	'shake hands'
a:m	-> ŋa:m	~	ʔa:m	'correct'
ow	-> ŋow	~	ʔow	'shake'
ʊk	-> ŋʊk	~	ʔʊk	'house'
ʊŋ	-> ŋʊŋ	~	ʔʊŋ	'push'

c. <u>Other [-back], ie /e/, /ö/</u>: virtually non-existent word-initially. When found, [ʔ] is used. ŋe/ö is clearly out.
ʔɛ hesitating particle

True surface non-high vowels can also occur with high glide onsets with the same value of backness, except for /a, a:/, which occur freely with both glides.

(16)	ye	'thing'	wɔ	'rice plant'
	ÿöŋ	'style'	wɔŋ	'yellow'
	yaw	'have'	wa:n	'return (something'

It is might thus be tempting to suppose that the glide onset is derived before vowels other than /a/, so that [yɛ] is underlying /ɛ/. However, the [y] in words like yɛ'thing' cannot be viewed as parallel to the [y] in words like yi 'two', for two reasons. First, English vowel-initial words borrowed into Cantonese behave differently depending on whether the vowel is high or not. Initial high vowels may spread to fill their onsets, but initial mid-vowels never do. Contrast:

(17)a.	yin tsi	'inch'
	yin sɔ	'insurance'
b.	ey si	'ace'
	ɛn tsin	'engine'

Second, vowel-initial affixes use a preceding /i/ as an onset, but not a preceding /e/ (see below):

(18)	tsi^{53} a^{33}	-> tsi ya	'know'
vs.	$ts^{h}e^{35}$ a^{33}	-> tshe a	'go away'

These two pieces of evidence converge to show that mid-vowels cannot be used to fill an onset position and give a phonetic high glide. I conclude that all glides before non-high vowels are underlying. In confirmation of this view, there is the occasional morpheme with a glide before a non-high vowel of differing backness, as in we 'out of shape, distorted'.[8]

There are some complications with the lax high vowels [ɪ] and [ʊ], which are found only before velar codas [ŋ] and [k]. It would appear that these vowels can have underlying glide onsets, since we find words like those in (19)b, where the glides differ in backness from the following vowel, as well as the expected cases in (19)a where the glides agree in frontness. The absence of [wʊ..] must be an accidental gap.

(19)	a.	yɪŋ	'eagle'		
		yɪk	'100 million'		
	b.	yʊŋ	'use'	wɪŋ ÿü	'honor'
		yʊk	'jade'	wɪŋ ÿün	'eternally'

In this respect, they group with the non-high back vowels. [ʊ] behaves like a non-high vowel in another respect: it can take the velar nasal or glottal stop onset. Indeed, some researchers have analyzed these vowels as /e/ and /o/, and I will adopt this view here. See Hashimoto (1972) for details. [9]

4.1.1 High Glides [y] and [w]: Evidence for Three Constraints

Inputs with initial high vowels show evidence for three constraints. First, the fact that these vowels surface with an onset and not as simple .i. provides evidence for the **ONS** constraint, restated here for convenience:

(20) **ONS**: Avoid Onsetless Syllables: (Itô 1989)
$*_{\sigma}[V$

Secondly, this constraint is not satisfied by deleting (i.e. failing to parse) the offending syllable to give <i>, showing that parsing melody is enforced, and motivating the next constraint:

(21) **<u>PARSE</u>**: Melody must be parsed

Thirdly, the onset is not filled by epenthesis of a new segment to give <u>ti</u> or <u>ʔi</u>; this motivates the next constraint:

(22) **<u>MSEG</u>**: Every segment belongs to a morpheme

On the other hand, using the existing melody, /i/, to fill the onset, satisfies all three constraints, as shown in the tableau below. This surfaces after phonetic implementation as [yi], and is shown as such below.

(23) /i/

	PARSE	**ONS**	**MSEG**
i		*	
ʔi			*
ti			*
☞ yi			
<i>	*		

Here and throughout I will consider only the set of plausible candidates { V, ʔV, tV, VV, <V> }; more baroque possibilities, such as <u>mukapi</u>, will never be optimal because the excessive epenthesis produces multiple **MSEG** violations, and does not serve to satisfy any other constraint.

<u>4.1.2 Velar Nasal [ŋ]: The Role of Phonetic Implementation</u>

Now consider the comparable tableau for the input /a/. Just as the constraints identified [yi] as the optimal output for /i/, they will identify [a̤a] as the optimal output for /a/, where [a̤a] shows a syllable where the vowel /a/ fills the onset as well as the nucleus.

(24) /a/

	PARSE	**ONS**	**MSEG**
a		*	
ʔa			*
ta			*
☞ a̪a			
<a>	*		

Here the implementation component plays a more dramatic role, as outlined earlier. To realize the onset of [a̪a], the tongue must stay non-high and back. Closure can be achieved by further backing, to give a uvular fricative like that transcribed as [ɤa] (Mandarin:Chao 1968, Pulleyblank 1992, Salish : Bessell 1992), or by lowering the velum to meet the tongue, giving a uvular nasal that is commonly transcribed with the velar nasal symbol [ŋa] (Cantonese, Mandarin: Chao 1968). These are two extremes of the window, but they are not as far apart as one might think. It is well known that low back vowels tend to be somewhat nasal (Ohala 1975, Whalen and Beddor 1989, Henderson 1984). If low vowels already have a lowered velum, full nasalization is a relatively small change, and indeed [ŋ] and [a] are also acoustically close. Lastly, according to Cheung (1986:198) some Cantonese speakers may use a pharyngeal, [ʕ], instead of [ŋ], lending support to the phonological identity of these two onsets in Cantonese.

<u>2.1.3 Initial non-high front vowels</u>:

The optimal output for the input /e/ will of course be [ee], as shown in the tableau below.

(25) /e/

	PARSE	**ONS**	**MSEG**
e		*	
√ ʔe			*
te			*
☞ e̯e			
<e>	*		

However, [e̯e] is, I would argue, phonetically unrealizable; no closure is possible while keeping the tongue [-high, -back]. We thus arrive at an understanding for the almost total absence of syllables with inital non-high vowels: there is no way to realize the optimal output, and thus no possible surface form. In the case of the "hesitation particle", [ʔe], notice that a different resolution of this impasse is chosen: the next best output is used, indicated by a check-mark in the tableau. This output violates one constraint, **MSEG**, so evidently this is the lowest ranked constraint, and may be violated on the surface in deference to the need to satisfy the higher ranked **ONS** and **PARSE**.

(26) <u>Preliminary Ranking</u>:
PARSE, **ONS** >> **MSEG**

This analysis lends support to the findings of Hayes (1993) on the status of non-optimal forms, and the possibility of using them under certain circumstances. Finally, the choice of [ʔe] over [te] can be accounted for by a constraint against specifying Place features, ***PL**, following McCarthy (1993).

4.1.4 Glottal Stop [ʔ]: Preliminary Evidence for a Fourth Constraint

So far I have accounted for the use of a velar nasal onset with non-high back vowels, but recall that some speakers prefer to use a glottal stop instead. It seems then that the high sonority non-high vowels are not acceptable onsets for some speakers. This is not surprising, since cross-linguistically it is clear that such onsets, often transcribed as [ɣ], are not only rare but unstable (as in Axininca Campa (Payne 1981, Yip 1983, Black 1991) and Maxacalí (Gudschinsky, Popovich and Popovich 1970)). Those Cantonese speakers who reject or avoid this take the final resort of introducing glottal stop, to give [ʔa].

Formally, we need to introduce a constraint that distinguishes between onsets of varying sonority. Such a constraint has been proposed by Prince and Smolensky (1993), and is given below:

(27) **Margin Hierarchy**:
Prefer onset with lowest possible sonority:
***Mar/a** >>... >> ***Mar/i**,u >>... >> *Mar/[nasal] >>... >> *Mar/[stop]

This hierarchy consists of an exploded family of constraints, ranked by Universal Grammar. Although the ranking may not be inverted in any way, other constraints may be interspersed among the members of the hierarchy. This is exactly what we need for the

Cantonese data. The avoidance of non-high onsets can be attributed to a more highly ranked ***Mar/a** constraint, and the choice of glottal stop epenthesis as the alternative strategy can be attributed to a lower ranked **MSEG**. Crucially, since epenthesis is not used for any speakers before a high vowel it is clear that **MSEG** is more highly ranked than the rest of the margin hierarchy, represented here by ***Mar/i....** We may thus establish the ranking

(28) **PARSE**, **ONS**, ***Mar/a** >> **MSEG** >> ***Mar/i**....

The results are shown in the tableau below.

(29) Idiolects that dislike [ŋ] onsets: /a/ -> [ʔa]

	PARSE	**ONS**	***Mar/a**	**MSEG**	***Mar/i..**
a		*			
☞ ʔa				*	*ʔ
☞ ta				*	*t
a̤a = ŋa			*		
<a>	*				

On the choice of [ʔ] over [t], see discussion of /e/ in section 4.1.3.

Having established a ranking for all constraints for what I will call the [a̤a] idiolect, let us return to the [ŋa] idiolect and add the Margin Hierarchy to the previously established ranking, **PARSE**, OBNS >> **MSEG**. Since epenthesis fails even when ***Mar/a** is violated, clearly the complete Margin Hierarchy is ranked below **MSEG** in this idiolect, giving the ranking:

(30) **<u>Normal Rankings in [ŋ] idiolects</u>:**

PARSE, **ONS** >> **MSEG** >> ***Mar/a** >> ***Mar/i**... t

The results are shown in the tableau below:

(31) /a/ > [ŋa]

	PARSE	ONS	MSEG	***Mar/a**..i..
a		*		
ʔa			*	*ʔ
ta			*	*t
☞ a̯a = ŋa				*a
<a>	*			

Combining these rankings gives the picture below, where the idiolectal variation comes from a re-ranking of **MSEG** and ***Mar/a** with respect to each other, and all other rankings are held constant.[10]

(32) **<u>Full Ranking for both idiolects</u>**

PARSE, **ONS** >> { **MSEG** >> ***Mar/a** (ŋa idiolect) / ***Mar/a** >> **MSEG** (ʔa idiolect) } >> ***Mar/i**....t

Before discussing resyllabification before affixes, I wish to briefly discuss the choice of **MSEG** over **FILL** as a way of avoiding epenthesis. In most earlier work in OT, epenthesis is blocked by a constraint on empty structure, called **FILL**. The eventual featural specification of epenthetic segments is abstracted away from, and constraints assess the form before insertion of features. However, such a formulation fails here, since all candidates, [yi], [ti],

[ʔi] have an inserted onset node and would thus violate **FILL** equally. What distinguishes these candidates is how the empty node is filled, and there is thus a need for a melodic constraint, such as **MSEG** (McCarthy 1993), which will penalize insertion of featural material, but countenance the recruitment of material from the original morpheme for a additional syllabic role.[11]

4.2 Word-Medial Onset Satisfaction

In the environment V(C)#V Cantonese exhibits gemination into the onset of the second syllable. This environment is found with the sentence-final particles, including a33, a13, a11, a, ɛ and ak33 (see Law 1990). Data shows the sentence-final particle a^{33}, used after reduplicated interrogative verbs with infixed m^{21} 'not': hay^{22} 'be', hay m hay ya 'is it'? [12]

(33)	a.	hay^{22} a^{33}	-> hay ya	'to be'
		how^{35} a^{33}	-> how wa	'good'
		tsi^{53} a^{33}	-> tsi ya	'know'
		fu^{35} a^{33}	-> fu wa	'bitter'
	b.	$tsan^{53}$ a^{33}	-> tsan na	'true'
		$leŋ^{33}$ a^{33}	-> leŋ ŋa	'beautiful'
		$ŋa{:}m^{55}$ a^{33}	-> ŋa:m ma	'correct'
		tim^{35} a^{33}	-> tim ma	'how?'
	c.	yit^{3} a^{33}	-> yit' ʔa/ yit' da	'hot'
		lek^{5} a^{33}	-> lek' ʔa/ lek' ga	'smart'
		$ta{:}p^{3}$ a^{33}	-> ta:p' ʔa/ ta:p' ba	'answer'
	d.	ta^{35} a^{33}	-> ta a	'hit'
		$t^hɔ^{24}$ a^{33}	-> $t^hɔ$ a	'fine'
		ts^he^{35} a^{33}	-> tshe a	'go away'

In (33)c the first variant is found in slow to normal speech, the second in fast speech. Note that there is no resyllabification between two roots, even when the second root begins with /a/:

(34)

tsa:m^{35} ʔa:n^{24}	/ tsa:m ŋa:n	'blink one's eyes'	*ma:n
hoy^{35} ʔɔn^{22}	/ hoy ŋɔn	'seacoast'	*yɔn
t^{h}ow^{24} ʔɔ^{22}	/ t^{h}ow ŋɔ	'hungry'	*wɔ

The data in (33) seem rather straightforward, but in fact they raise three questions, discussed in the following sections.

4.2.1 Directionality of Onset Filling: More Evidence for Margin Hierarchy

The first question is why the onset should be filled by the previous segment, not the following one: /tsi a/ > [tsi ya], and not *[tsi ŋa]? A rule-based account might posit a left-to-right directional spreading rule, but a deeper explanation is available that relies on the sonority-based Margin Hierarchy.

Notice that the affixes begin with non-high vowels, which are maximally sonorous and thus poor onsets. On the other hand the material that spreads is either a high vowel/glide or a consonant, all of which are less sonorous and thus better onsets. The choice of onset segment, then, is not based on a left-over-right preference, but on a search for the least sonorous onset, formalized as the Margin Hierarchy. To test this hypothesis, one could examine sequences of [-high] followed by [+high] vowels, such as /ta i/; a directional account will predict spreading from the left, ignoring sonority considerations, while a sonority-based account will predict a change in directionality, with spreading from the more sonorous right-hand vowel. Unfortunately, the language possesses no high vowel affixes, but two native speakers who were asked to pronounce hypothetical /ta i/ inputs agreed that [tayi] was the only possible output, with *[taŋi] and *[taʔi] both unacceptable. This is as predicted by the sonority-based account, not by the directional account.[13] The two tableaux below make this clear; only the Margin Hierarchy constraints are shown since clearly these candidates tie on all other constraints. [14]

(35) Tableaux showing asymmetries in onset filling.

a. /i a/

	***Mar/a**	***Mar/i**
☞ iya		*
ia̯a	*	

b. /a i/ (hypothetical)

	***Mar/a**	***Mar/i**
☞ ayi		*
aa̯i	*	

4.2.2 Resyllabification of Stops: Minimal Phonetic Implementation

The second question posed by the data in (33) is why stops appear not to spread at all in normal speech, and instead undergo glottal stop epenthesis, as in (33)c [tak' ʔa]? Since stops are excellent onsets, this apparent failure to spread is particularly mysterious. Here I suggest that the answer lies in the requirements for the phonetic realization of onsets. Specifically, note that onsets require closure, but that one closure is sufficient for onsethood (provided all features are realized). Final stops like

/t'/ are unreleased and glottalized, with two simultaneous closures, one oral, and one glottal. The normal and fast speech pronunciations each make use of a different one of these two closures for the onset portion. In slow speech, we find [t'ʔ], with the glottal closure used for the onset, and in fast speech we find [t'd], with the oral closure used for the onset. The claim is then that both [tʔ] and [t'd] are phonologically the result of spreading of /t'/ and that there are two possible phonetic implementations of this spreading, each a minimal response to the requirement for closure. Here we see the parsimonious nature of the phonetic component in action.[15]

4.2.3 Phonetically Onsetless Syllables and the Affixal Phonology

The third and most vexing question is why no onset at all is provided in the data in (33)d, such as /ta a/ > [ta a]? Before offering an explanation, it is necessary to digress briefly into Chinese morphology.

As is well known, a lexical root in Chinese must be a single well-formed syllable, and complete syllabification must therefore take place at the level of the root. As we have seen in (34), there is no resyllabification across the boundary between two roots, and in fact no further evidence for syllabification in the compounding phonology (where compounding includes derivation). These 3 observations combine to suggest the existence of an **ALIGN** constraint (McCarthy and Prince 1993 a,b)

(36) **ALIGN (Root, σ; L,R)**
"**ALIGN** root morpheme boundaries with syllable boundaries, at both edges"

This constraint will disallow resyllabification in root-root sequences, such as [t^how wɔ] from /t^how#ɔ/.

The limited number of affixes found in Cantonese will not have root boundaries, since they are not roots; they are added later, (probably in the syntax) and will not be syllabified until a later level, the affixal phonology. At this level, as we have seen, resyllabification to fill onsets is possible. Note that this level includes root-suffix, and also root#prefix- (see later in this section).

Let us assume a model of lexical phonology along the lines of (Kiparsky 1982, McCarthy and Prince 1993a). [16] We must posit two levels in Cantonese phonology, here called Level A and Level B, because they do not necessarily coincide precisely with the more familiar lexical and post-lexical levels. The inputs to Level B are the optimal outputs of the Level A phonology. At Level A, **ALIGN** (Rt, σ) is more highly ranked than **ONS**, because onsets cannot be filled by **ALIGN** violations. At Level B, **ONS** is more highly ranked than **ALIGN** (Rt, σ), because syllables that have no onsets when they enter Level B (i.e. affixes) acquire onsets even at the price of de-aligning the end of the preceding root syllable.

(37) <u>Level-Ordered Phonology</u>

root-root **Level A**, compounding, derivation
ALIGN (Rt, σ) >> **ONS**
no resyllabification

root-suffix **Level B**, affixation
root#prefix- post-lexical
ONS >> **ALIGN (Rt, σ)**
resyllabification

Having established the need for two levels, we may return to the question of why affixes after non-high vowels surface as onsetless.[17] The answer lies in a change in the constraint rankings between the two levels. The existence of surface **ONS** violations makes it clear that **ONS** is demoted in Level B. Since these violations are found in preference to using a [-high] vowel as an onset, we may conclude that ***Mar/a** >> **ONS**. Since these violations are found in preference to epenthesis, we may conclude that **MSEG** >> **ONS**. The complete Level B Ranking is given below:

(38) <u>Level B Ranking</u>
PARSE, **MSEG**, ***Mar/a** >> **ONS** >> ***Mar/i**...t

(39) Level B Phonology: /i a/

	PARSE	**MSEG**	***Mar/a**	**ONS**	***Mar/i..**
i a				*	
☞ iya					*i
ia̯a = iŋa			*		
iʔa		*			*ʔ
ita		*			*t

(40) Level B Phonology: /a a/

	PARSE	**MSEG**	***Mar/a**	**ONS**	***Mar/i**
☞ a a				*	
aa̪a (= aŋa)			*		
aa̪a (= aŋa)			*		
aʔa		*			*ʔ
ata		*			*t

To conclude the analysis, consider the only indubitable prefix in the language, the familiar name prefix /a^{33}/, which absolutely cannot take [ŋ] and is usually decribed as also lacking [ʔ]. As expected, this prefix behaves exactly like the suffixes: since it is not a root, it will not acquire an onset at Level A. Unlike the suffixes, there is no preceding morpheme within the phonological word from which to steal an onset in the Level B phonology. Spreading of its own nucleus /a/ is not a possible strategy in the Level B phonology because ***Mar/a** is highly ranked.[18] The surface form is thus onsetless [a]. The following tableau makes the point clear:

(41) Level B Phonology: / a tseŋ/

	PARSE	**MSEG**	***Mar/a**	**ONS**	***Mar/i.**
☞ a.tseŋ				*	
<a>.tseŋ	*				
a̪a.tseŋ			*		
ʔa.tseŋ		*			*ʔ
ta.tseŋ		*			*t

Now consider what we would expect if a word with this prefix were preceded by another word in the phrase. Resyllabification should occur in precisely the same way as it does with a vowel-initial suffix, and this is indeed the case:

(42) wan^{35} a^{33}-tseŋ^{25} -> wan na-tseŋ 'look for A-Cheng'
sa:t^{33} a^{33}-tseŋ^{25} -> sa:t' da-tseŋ 'kill A-Cheng'
ta:y^{33} a^{33}-tseŋ^{25} -> ta:y ya-tseŋ 'bring A-Cheng'

This is directly analagous to a sequence like /tsi a/ > [tsi ya], and the relevant tableau here would be tableau (39). [19]

4.2.4 The overall picture:

If we combine the rankings from the two levels, the following picture emerges. **PARSE** is always the most highly ranked constraint, and ***Mar/i**.. the lowest. **ONS** is highly ranked at Level A, low ranked at Level B., changing its ranking with respect to the two constraints **MSEG** and ***Mar/a**. These two constraints have a ranking with respect to each other that varies with idiolect. The complete picture is given below:

(43) Complete Rankings, both levels:

Level A:

PARSE, **ONS** >> { **MSEG** >> ***Mar/a** (ŋa) / ***Mar/a** >> **MSEG** (ʔa) } >> ***Mar/i**....t

Level B:

PARSE >> { **MSEG** >> ***Mar/a** (ŋa) / ***Mar/a** >> **MSEG** (ʔa) } >> **ONS** >> ***Mar/i**....t

The idiolectal variation could alternatively be handled by assuming that ***Mar/a** and **MSEG** are unranked with respect to each other, thus giving two equally optimal outputs for a non-high vowel input. Speakers may then select either output freely, and no speaker-internal consistency is necessarily expected. Since individual speakers do indeed usually use both [ŋa] and [ʔa], this approach is very attractive. The claim would then be that some kinds of optionality may be a consequence of EVAL underdetermining the optimal output. I leave this issue for future research.

The rankings I have argued for here clearly show that the Margin Hierarchy consists of a set of separate constraints , and that another constraint, here **MSEG**, may intrude itself between two members of the Margin Hierarchy family, here either between ***Mar/a** and the others (assuming the variation is due to re-ranking) or alongside ***Mar/a** but still above the others (if the variation is due to an unranked ***Mar/a** and **MSEG** pair).

5 Constraint-Based vs. Rule-Based Accounts of Cantonese Onset-Filling

The account offered here in Optimality Theory uses four ranked constraints, and no rules. In this section I will briefly contrast it with a rule-based approach. First consider an entirely rule-based account in which the grammar contains no constraints, no role for the sonority hierarchy and no role for phonetic implementation. Such a grammar would need several spreading rules: a right-to-left one to explain root-internal onset-filling, and several left-to-right ones for the medial resyllabification cases. The reason several rules would be needed is because it would be necessary to distinguish between which segments spread fully (such as nasals and high vowels), which spread partially (such as stops) and which do not spread at all, (such as [-high] vowels). Finally, we would need a rule of glottal stop insertion and a rule of velar nasal insertion. Below I give a very rough rule-based analysis, for concreteness only.

```
(44) R>L Spreading:(Lexicon)

       σ                   [yi]
      \|
       V

(45) L>R Spreading (1):
     σ       σ                 [tsan na]
     |     / |
     [+nasal] V

(46) L>R Spreading (2):
     σ       σ                 [fu wa]
     |     / |
     [+high] V

(47) L>R Spreading (3):
     σ        σ           [yit' ʔa]
     |      / |
   [-son] /   |
     |  /     |
     Laryn.   V

(48) Velar Nasal Insertion:

     σ    ->    σ         [ŋa]
     |         /|
     [-high]    ŋ V
     [+back]

(49) Glottal Stop Insertion:

     σ    ->    σ         [ʔa]
     |         /|
     V        ʔ V
```

This pure rules-only account offers no explanation for why left-to-right spreading is preferred to right-to-left spreading in a VC+V environment; it is simply stipulated. It also offers no explanation for why [+nasal] spreads, [+high] spreads, but not [-nasal], or [-high], or for why stops spread only their Laryngeal features. Structure Preservation may explain the failure of [-high] to spread, but it has nothing to say about the behavior of the final stops. In any case, I will argue below that the details of a rule-based account are largely irrelevant: it is inferior on principled grounds.

Of course, this account could be greatly improved if we added in a role for the preference for low-sonority onsets, and also a phonetic component. Such a mixed rule-and-constraint account would now have some explanatory power, and would leave only three rules: a bi-directional spreading rule (Levels A, B), and two insertion rules (Level A only). The problem now becomes understanding the interaction between the rules and the sonority hierarchy. It would appear that the grammar would need to freely order a rule (spreading) with respect to a constraint (high-sonority onsets are bad), making no principled distinction. This is because spreading ignores sonority at Level A in ŋa-idiolects, and observes it in Level A in ʔa-idiolects and all Level B idiolects.

There is a more telling reason to reject a mixed account that includes both rules and constraints. The fact is that the rules (no matter how simple) are superfluous; the constraints are needed anyway in any reasonable grammar, and the data can be explained by the constraints alone. Consider the constraints that have been invoked here. **ONS** is a UG statement about σ well-formedness, needed in any theory to explain the well-known generalization that intervocalic consonants syllabify rightwards into the following onset position. **MSEG** and **PARSE** are UG statements of inertness, or conservatism: inputs are not gratuitously altered by insertion or deletion of material. Again, all theories make such an assumption; in rule-based theories, nothing happens unless a rule mandates action. Lastly, the Margin Hierarchy is the Sonority Hierarchy in another guise, intertwined with a theory of syllable structure. All these are components of every explanatory phonological theory, and what I have tried to show is that they alone suffice, provided we can situate them within a theory which views them as violable constraints which may be ranked with respect to each other.

6 Summary

I have argued that the realization of vowel-initial syllables in Cantonese is the result of the interaction of a set of constraints that together act conservatively, making minimal changes to underlying representations. This conservative tendency is instantiated in the grammar by (i.e. is a result of) two constraints, **MSEG** and **PARSE**, and also by two principles which restrict the range of candidates produced by GEN, Containment and Consistency of Exponence. The optimal output of the grammar is then interpreted by the phonetic realization component in ways compatible with Keating 1988, Cohn 1990, where realization of featural and prosodic specifications is achieved within a certain language-specific window, allowing some freedom of interpretation.

Fundamental to Optimality Theory is the notion that constraints are violable in deference to a higher-ranked constraint, and in confirmation of this hypothesis surface violations of all dominated constraints are indeed found:

(50) Surface Violations of Constraints:

***ONS**:	a tseŋ, ta a
***MSEG**	ʔa:m
***Mar/a**	ŋa:m
***Mar/i**	yi

Finally, the Cantonese data require that epenthesis be considered a violation of **MSEG**, not **FILL**, in support of McCarthy 1993b.

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Endnotes

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

2.The notion "Margin" will play no role here; an Onset Hierarchy would serve equally well for the Cantonese data.

3. The status of "onset" in phonological theory is controversial. In some versions of moraic theory, such as McCarthy and Prince 1986, or other flat notions of syllable structure, such as Clements and Keyser 1983, it does not exist as an entity, although it can be referred to by circuitous means such as "any segments preceding the syllable nucleus". Resolution of this issue does not affect the central claims of this paper.

4. It seems reasonable to suppose that the statements in (13) may be part of UG, and that the language-specific portion may be the characterization of the window. However, such a claim must wait for future research.

5. Juliette Blevins, p.c., suggests that the rise in sonority from onset to nucleus follows automatically from sonority theory, and that the requirement for closure is unnecessary, and even problematic. However, there is an articulatory difference between [yi] and [i], with the former having a tenser, more extreme

tongue position at the start of syllable, and this is what I wish to account for. It is also not clear how an account without closure can incorporate the velar nasal facts into the analysis.

6. In some languages this is less clear. For example, in many Semitic languages glides pattern with [+cons] elements in appearing in the consonantism of verb roots. See ?Hayes 1989 for discussion.

7. The common cross-linguistic tendencey for /w/ onsets to be realized as a bi-labial fricative can be viewed as another way of achieving closure. Some Mandarin speakers show this phenomenon. Even in Cantonese, Hashimoto reports that some speakers produce the glides with considerable friction, suggesting they become almost consonantal. As pointed out to me by a reviewer, this is of course reminiscent of German /j/.

8. Thanks to Lily Chan and Matthew Chen for this information.

9. A reviewer rightly points out that [ɪ] and [ʊ] need parallel treatment because both occur only before velar codas. Responding to this comment, I here treat both as mid vowels; this explains the occurrence of the velar nasal before [ʊ], and the occurrence of both underlying [y] and [w] before [ɪ], and underlying [y] before [ʊ]. It does not explain the absence of [w] before [ʊ], which must be treated here as an accidental gap. The same reviewer also points out that historically the high glides before high vowels grouped with other comparable onsets (i.e. [y] with palatals, and [w] with labio-velars) in stopping dipthongization of the following vowel. It seems likely that both underlying and "derived" onsets may have shared features with the following vowel in these cases, and that this may have inhibited diphthongization; if this is right, the historical development does not provide a strong argument for taking the glides to be underlyingly present.

10. McCarthy, quoted in Ní Chiosáin and Padgett (1993), suggests that /a/ may be an impossible margin, not just a disfavored one. This amounts to saying that *Mar/a is highly ranked, as I have assumed for the idiolects that prefer [ ]. What is unclear in McCarthy's proposal is how the velar nasal pronunciation is to be derived if it is not the surface reflex of /a/ in the onset.

11. Sylvain Bromberger (p.c.) has pointed out that the additional structure implied by using /i/ as both onset and nucleus, instead of just nucleus, must itself incur a cost. Calling the constraint that is violated by the addition of structure ***INSERT STRUCTURE**, we must assume that **MSEG** >> ***INSERT STRUCTURE**. For English, where epenthetic glottal stop is the norm, the rankings would be reversed, with ***INSERT STRUCTURE** >> **MSEG**.

12. The digits show tones, where 5 is high pitch, descending to 1, low pitch. A sequence of two digits show the beginning and ending pitches of the syllable, so that [35] denotes a tone rising from mid to high.

13. Informants who were asked about hypothetical inputs with a nasal before a high-vowel affix, such as /tan i/, rather surprisingly felt that the preferred output would be [tanyi]. This is unexpected under both directional and sonority-based accounts, and raises questions about the relative acceptability of /i/, /n/ in margins that are beyond the scope of this paper. Thanks to John Moore for raising this question.

14. Note that a velar nasal onset **is** acceptable if it is spread from a true velar nasal coda, as in /le a/ > [le   a], showing that an onset is judged on its phonological properties, not on its phonetic manifestation.

15. I have no explanation for why glottal closure is used in slow speech and an oral closure is used in fast speech, rather than vice versa.

16. It seems to me that level-ordered phonology is not in the spirit of Optimality Theory, in that it introduces a derivational flavor with accessible intermediate representations into a theory committed to the evaluation of outputs. However, following McCarthy and Prince 1993a, I see no alternative at present to allowing for different levels in the grammar of Cantonese.

17. An anonymous reviewer makes the interesting suggestion that in /ta a/ the low vowel may indeed spread into the empty onset, but may be too sonorous to be recognized as a consonant by phoneticians. This would account for the audible difference between bi-syllabic [ta a], and fast speech mono-syllabic [ta:] . I find this suggestion very appealing, but see no way to reconcile it with the account offered here for the usual realization of /a/ in an onset as [ ]. As for the difference between [ta a] and [ta:], in the view taken here this would presumably be audible as a result of the phonetic realization of syllable peaks as pulses.

18. Blevins (p.c.) questions whether languages care about the sonority of their onsets. The view taken in this paper is that only an avoidance of the high sonority non-high vowels in onset position can explain three facts: the option of glottal stop before such vowels (but not before high vowels), the "directionality" of onset filling when vowels of different sonority are available, and the inability of /a/ to fill onset position at all in the Level B phonology. The general rarity of /a/ in onsets cross-linguistically can also be attributed to its high sonority.

19. There are no other clear prefixes in the language so prefix-root resyllabification cannot be investigated. Since all roots will acquire an onset before prefixation, we would expect that prefixes would never be enlisted to fill root onsets.

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