

Natural Derivational Phonology and Phonological Opacity

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1. Introduction

The problem of phonological opacity challenges Optimality Theory (OT), providing the main argument in favor of serialism, as McCarthy (1999) observes. He therefore seeks to solve it firstly in sympathy theory (McCarthy 1999), secondly in comparative markedness theory (McCarthy 2002) and thirdly in *OT with candidate chains* (OT-CC) (McCarthy 2007). I will discuss it by adducing data from the Yawelmani and Wikchamni dialects of Yokuts, an American Indian language of California, within the framework of Natural Derivational Phonology proposed in Lee (2009a). The Yawelmani data comprise all the Yawelmani data cited in the discussion about phonological opacity in sympathy theory (McCarthy 1999). In section 5 the Yawelmani cases dealt with in sympathy theory and OT-CC will be reviewed.

Defining phonological opacity is necessary at the start. The following definition is a restated version of that presented in Kiparsky (1971, 1973a) from the standpoint of Natural Derivational Phonology:

(1) Phonological Opacity

Regarding M

- (a) the surface structure that meets the SD of M, or
 - (b) the surface structure in which the structure derived by M or the condition that triggered M is changed by the subsequent constraint(s)
- is opaque.

Opacity (a) and opacity (b) are termed overt opacity (O-opacity) and covert opacity (C-opacity) respectively.

2. Natural Derivational Phonology¹

This section will give an outline of Natural Derivational Phonology. In Natural Derivational Phonology a constraint pair (C-pair) and an unpaired deriving markedness constraint (unpaired constraint) perform phonological derivation. A C-pair consists of a dominating markedness constraint M and the dominated faithfulness constraint F in the form of $M \gg F$. It is satisfied provided that the markedness constraint is satisfied and at the same time its paired faithfulness constraint is violated. Constraints may apply singly or multiply to any candidate (underlying or not), resulting in serial derivation.² The natural ranking of universal ranking principles (URP's) determines the ranking of constraints. Evaluation constraints (E-constraints), which may be ranked, evaluate the outputs of constraints. Only the candidates derived by the qualified constraints except the underlying candidate are presented in a tableau of Natural Derivational Phonology. Natural Derivational Phonology may be succinctly summed up as a system in which constraints apply in obedience to the natural ranking of URP's, letting E-constraints evaluate their outputs.

URP's and the counterfed constraint schema, which are the fundamentals on which Natural Derivational Phonology is structured, will be introduced. The terms to be employed need to be defined. The constraints whose SD's meet the overlapping structure in the same input candidate are said to stand in an *overlapping (O-)* relation, and the constraints whose SD's meet the non-overlapping structures in the same input candidate are said to stand in a *non-overlapping (NO-)* relation. Derivatively, constraints can be said to *be O-related* or *NO-related*, to *O-apply* or *NO-apply*, and to *O-derive* or *NO-derive a candidate*.

We are now in a position to introduce the fundamentals:

(2) Apply-M Principle (AMP)

Apply M.

- M represents a constraint. Not only does AMP allow constraints to apply singly but also it allows more than one constraint to apply simultaneously.

¹ The readers who have read Lee (2009a) may skip this section.

² 'Constraint' will be used interchangeably with 'unpaired constraint', 'markedness constraint' of a C-pair and 'C-pair'.

(3) Maximal Feeding Principle (MFP)

Apply M_α if and only if M_α M-feeds M_β .

Definition: M_α M-feeds M_β if M_α can derive the candidate with a structure S_{n+1} from the candidate with a structure S_n , where S_n and S_{n+1} are identical except the change(s) to be made by constraint(s), and both S_n and S_{n+1} meet the SD of M_β .

(4) No Reanalyzing Principle (NRP)³

Apply M_N if and only if there is no other M may apply than M_N that is NO-related with itself.

Definition: The neutralization M whose SD is met in S_I is M_N , where S_I = intramorphemic structure, i.e., the structure in the context $\mu_i[\dots_____\dots]\mu_i$, μ = morpheme.

- The constraint ranked according to NRP is said to be N-ranked.

(5) Complex Constraint Principle (CCP)

Apply M whose SD is more complex if and only if the SD's of two M's meet exactly the same structure with non-phonetic context ignored.

- It is certain that if the number of the features specified in the SD of one M is larger than that specified in the SD of the other M, the former overrides the latter according to CCP. The constraint ranked according to CCP is said to be C-ranking and C-ranked.
- In the cases of MFP and CCP alike, the constraints to be ranked by the same URP, which is checked by the natural ranking of URP's, are qualified to stand in an M-feeding relation and in a C-ranking relation. And once the M-feeding constraint and the C-ranking constraint are established, they may apply with other constraints according to the URP that ranks them previous to their establishment.

³ Neutralization M's are those which do not yield an allophonic segment.

(6) Counterfed Constraint (CFC) Schema

M must not apply to (a) S_D or (b) S_D by a specific M.

Where S_D = the structure derived phonologically.

- The instantiations of M choose (a) by default and they choose (b) on constraint-particular basis, constituting the CFC's on themselves.

The natural ranking of URP's introduced above is: NRP » MFP » CCP » AMP. And if a candidate violates an E-constraint crucially, derivation resumes from the nearest correct candidate (in such a way that the same E-constraint is not violated).

3. Yawelmani Dialect of Yokuts

In this section discussion will center around the vowel harmony of the verbal system in the Yawelmani dialect of Yokuts. This dialect furnishes adequate data for the discussion about phonological opacity (cf. McCarthy 2007: 109). The process of vowel harmony interacts with various phonological processes, from which the problem of phonological opacity will inevitably ensue. The discussion and data are mostly based on Kenstowicz & Kisseberth (1977, 1979; see also Newman 1944, Kuroda 1967, Kisseberth 1969 and Archangeli 1984, 1985, 1991).

3. 1 Vowel Harmony

In Yawelmani a vowel or a sequence of vowels becomes back and round after a back round vowel of the same height by the process of vowel harmony. The high vowel *i* is rounded to *u* after the high back round vowel *u* and the low vowel *a* is rounded to *o* after the low back round vowel *o*.

The alternations between *i* and *u*, and between *a* and *o* by the process of vowel harmony are exemplified in the following data:

(7) Vowel Harmony⁴

a.	Nonfuture	Nonfuture Passive	Precative	Dubitative	
/bokʔ/:	bokʔ-hin	bokʔ-it	bokʔ-xo	bokʔ-ol	‘find’
/kʔoʔ/:	kʔoʔ-hin	kʔoʔ-it	kʔoʔ-xo	kʔoʔ-ol	‘throw’
/dub/:	dub-hun	dub-ut	dub-xa	dub-al	‘lead by hand’
/hud/:	hud-hun	hud-ut	hud-xa	hud-al	‘recognize’
/xat/:	xat-hin	xat-it	xat-xa	xat-al	‘eat’
/xil/:	xil-hin	xil-it	xil-xa	xil-al	‘tangle’
/giyʔ/:	giyʔ-hin	giyʔ-it	giyʔ-xa	giyʔ-al	‘touch’
/max/:	max-hin	max-it	max-xa	max-al	‘procure’
b.	tul-sut-hun	‘burns for’			
	max-sit-hin	‘procures for’			
	kʔoʔ-sit-hin	‘throws to’			
	xipʔwiy-sit-hin	‘makes a rubbing motion for’			

In (a), the suffix vowels *i* and *a* harmonize to the round root vowels *u* and *o*, becoming *u* and *o* respectively. And in (b), the surface form *tul-sut-hun* derived from /tul-sit-hin/ (/sit/ ‘indirect’) demonstrates that the vowels of two suffixes harmonize to the root vowel: the process of vowel harmony is satisfied across the board within the same height domain of a word.

The vowel harmony pattern observed above can be accounted for in a straightforward manner. Verb roots containing a long high vowel that is to be lowered, however, offer difficulty to the seemingly simple vowel harmony. This is evidenced in the following data. (The underlined vowels are epenthetic (see subsection 3. 5.))

(8) Long High Vowel and Vowel Harmony

	Nonfuture	Dubitative	
/ʃu:g/:	ʃog-hun	ʃo:g-al	‘pull out a cork’
/cʔu:m/:	cʔom-hun	cʔo:m-al	‘destroy’
/wu:ʔy/:	wo:ʔ <u>uy</u> -hun	woʔy-al	‘fall asleep’
/du:ll/:	do:l <u>l</u> -hun	doll-al	‘climb’
cf. /do:s/:	dos-hin	do:s-ol	‘report’
/wo:n/	won-hin	wo:n-ol	‘hide’

⁴ The hyphen ‘-’ represents the morpheme boundary ‘+’.

The high round vowel *u* turns up after the low back round root vowel *o* in *ʃog-hun* and the low back non-round vowel *a* is not rounded after the low back round root vowel *o*: in *ʃo:g-al*. A round vowel occurs after a round vowel of different height, whereas a round vowel does not occur after a round vowel of the same height. As a consequence, C-opacity and O-opacity are created with regard to the process of vowel harmony.

First of all, the constraint for the process of vowel harmony will be established:

(9) Vowel Harmony (VH)

Spread [+round] rightward until it meets the opaque vowel,
 where [V, -αhigh] is opaque when the trigger is [V, αhigh].

The constraint VH constitutes a C-pair with the faithfulness constraint IDENT (round₁).

Besides, the context-free markedness constraint *[V_{μμ}, +high], which forms a C-pair with the faithfulness constraint IDENT (high), lowers the abstract long high vowels *u*: and *i*: to *o*: and *e*: respectively.⁵ The C-pair *[μμμ]_σ » MAX (μ), which will be discussed in the next subsection, shortens the long vowel in the context ____ C_μσ. And in order that VH may not derive the wrong form *ʃo:g-ol* from the expected surface form *ʃo:g-al* of /ʃu:g-al/, it must not apply to the output of *[V_{μμ}, +high]: VH must be counterfed by *[V_{μμ}, +high]. It must thus be constrained by the CFC on itself. VH, an instantiation of M in the CFC schema, chooses (b) from the CFC schema with a specific M = *[V_{μμ}, +high], constituting the CFC on itself. The CFC on VH demands that VH not apply to the structure derived by *[V_{μμ}, +high].

The constraints and the CFC on VH construct the tableau for the forms in (7-8). In a tableau candidates are arranged in the order of their derivation. The underlying candidate is numbered 0, the candidate derived from it is numbered 1, and so on.

(10) Tableau for Vowel Harmony (N = N-ranked, M = M-fed)

	CFC on VH	VH » IDENT (round ₁)	*[V _{μμ} , +high] » IDENT (high)	*[μμμ] _σ » MAX (μ)
a. /bok'-hin/				
0. → bok'-hin				
b. /bok'-xa/				
1. → bok'-xo		√		
c. /dub-it/				

⁵ See Kiparsky (1968) and Lee (2009a: 6. 1) for abstract segments.

1. → dub-ut		√		
d. /ʃu:g-hin/				
1. ʃu:g-hun		√	N	N
2. ʃo:g-hun			√	M
3. → ʃog-hun				√
e. /ʃu:g-al/				
1. → ʃo:g-al			√	
2. ʃo:g-ol	*	√		
	CFC on VH	VH » IDENT (round ₁)	*[V _{μμ} , +high] » IDENT (high)	*[μμμ] _σ » MAX (μ)

In (a), no constraint applies. In (b-c), only VH participates in deriving [1]. In (d), three constraints are O-related regarding the underlying representation, but only AMP-ranked VH derives [1], overriding the two N-ranked constraints *[V_{μμ}, +high] and *[μμμ]_σ, in accordance with the natural ranking NRP » AMP. *[V_{μμ}, +high] to be N-ranked derives [2], M-feeding *[μμμ]_σ to be N-ranked, in accordance with the natural ranking NRP » MFP. *[V_{μμ}, +high] M-feeds *[μμμ]_σ, since it can derive the candidate *ʃo:g-hun* with the structure *o:g/σ* from the candidate /ʃu:g-hin/ with the structure *u:g/σ*, where the structure *u:g/σ* and the structure *o:g/σ* are identical except the change to be made by *[V_{μμ}, +high] (i.e., u: → o:), and both the structure *u:g/σ* and the structure *o:g/σ* meet the SD of *[μμμ]_σ. M-fed *[μμμ]_σ derives [3]. In (e), N-ranked *[V_{μμ}, +high] derives [1]. VH derives [2], but it violates the CFC on itself, since it applies to the structure derived by *[V_{μμ}, +high].

Firstly, the suffix vowel *u* in the surface forms in (10c-d) is in fact derived in a serial way: /i/ → ü (by VH) → [u] (by *[V, -back, +round]).⁶ Secondly, in deriving [2] in

⁶ The C-pair *[V, -back, +round] » IDENT (back) cannot be embedded in VH, since this C-pair functions as a morpheme structure condition. With this C-pair subtableau (10c) can be reconstructed as follows:

(10d), because NRP does not permit the two O-related M_N 's (i.e., $*[V_{\mu\mu}, +high]$ and $*[\mu\mu\mu]_{\sigma}$) to O-apply, they are ranked according to outranked MFP. The two constraints to be N-ranked might O-apply according to AMP but the natural ranking forestalls it. Thirdly, in (10d), C-opacity regarding VH is brought forth due to $*[V_{\mu\mu}, +high]$, since the latter changed the structure derived by the former, or changed the condition that had triggered the former. C-opacity regarding $*[V_{\mu\mu}, +high]$ is brought forth due to $*[\mu\mu\mu]_{\sigma}$, since the latter changed the structure derived by the former. And in (10e), O-opacity regarding VH is brought forth due to the CFC on itself.

3. 2 Vowel Shortening

In this subsection the vowel-length alternation will be discussed. A long vowel is shortened in the context $____ C\{C, \#\}$. The following examples illustrate how the process of vowel shortening works:

(11) Long Vowel Shortening

	Nonfuture	Nonfuture Passive	Precative	Dubitative		
a.	/ʃa:p/:	ʃap-hin	ʃa:p-it	ʃap-xa	ʃa:p-al	‘burn’
	/mi:k’/:	mek’-hin	me:k’-it	mek’-xa	me:k’-al	‘swallow’
	/do:s/:	dos-hin	do:s-it	dos-xo	do:s-ol	‘report’
	/c’u:m/:	c’om-hun	c’o:m-ut	c’om-xa	c’o:m-al	‘destroy’
b.	/pana:/:	pana:-hin			pana-ϕl	‘arrive’
	/taxa:/:	taxa:-hin			taxa-ϕl	‘bring’
	/hoyo:/:	hoyo:-hin			hoyo-ϕl	‘name’
	/nini:/:	nine:-hin			nine-ϕl	‘get quiet’
	/ʔili:/:	ʔile:-hin			ʔile-ϕl	‘fan’
	/c’uyu:/:	c’uyo:-hun			c’uyo-ϕl	‘urinate’

(i) Reconstructed tableau of Subtableau (10c)

	VH » IDENT (round ₁)	*[V, -back, +round] » IDENT (back)
c. /dub-it/		
1. dub-üt	√	
2. → dub-ut		√

VH derives [1] and $*[V, -back, +round]$ derives [2].

The evidence for the process of shortening is provided by the root-final vowels of nonfuture and precative forms in (a) and those of dubitative forms in (b).

The C-pair $*[\mu\mu\mu]_{\sigma} \gg \text{MAX}(\mu)$ introduced in the preceding subsection takes care of the process of vowel shortening (cf. McCarthy 1999). This C-pair is formulated on the ground that coda consonant is assigned a mora. In addition, we need the C-pair $*\text{HIATUS} \gg \text{MAX}$, which truncates the suffix vowel in the context $V____$, for the dubitative forms in (11b).⁷ In deriving the short low vowel from the underlying root-final long high vowel in the last three dubitative forms in (11b) the interaction of the constraints $*[\mu\mu\mu]_{\sigma}$ and $[V_{\mu\mu}, +\text{high}]$ creates C-opacity regarding the latter.

The problem we encounter is that AMP-ranked $*[\mu\mu\mu]_{\sigma}$ must be overridden by N-ranked $*[V_{\mu\mu}, +\text{high}]$ that is O-related with itself for the last three dubitative forms in (11b). For instance, the intermediate form $\text{?ile}:-\phi l$ must be derived from the intermediate form $\text{?ili}:-\phi l$ derived from $/\text{?ili}:-\text{al}/$. Namely, N-ranked $*[V_{\mu\mu}, +\text{high}]$ must apply before AMP-ranked $*[\mu\mu\mu]_{\sigma}$ despite the natural ranking $\text{NRP} \gg \text{AMP}$. The natural ranking would derive the wrong surface form:

(12) Long Vowel Lowering and Shortening

$/\text{?ili}:-\text{al}/$	Underlying Representation
$\text{?ili}:-\phi l$	AMP-ranked $*\text{HIATUS}$ (with $*[V_{\mu\mu}, +\text{high}]$ N-ranked)
$\text{?ili}-\phi l$	AMP-ranked $*[\mu\mu\mu]_{\sigma}$ (with $*[V_{\mu\mu}, +\text{high}]$ N-ranked)
$*[\text{?ili}-\phi l]$	Surface Representation

The natural ranking $\text{NRP} \gg \text{AMP}$, which enjoins AMP-ranked $*[\mu\mu\mu]_{\sigma}$ to apply before N-ranked $*[V_{\mu\mu}, +\text{high}]$, derives the wrong surface form. But we notice that the last three forms in (11b) that include the form in (12) are dubitative forms. Accordingly, we may take advantage of the morphological information: $*[V_{\mu\mu}, +\text{high}]$ to be N-ranked can be revised as in the following:

(13) $*[V_{\mu\mu}, +\text{high}]$ Revised

$*[V_{\mu\mu}, +\text{high}] < \dots \rangle_{\text{DUBITATIVE}}$

In case $*[V_{\mu\mu}, +\text{high}]$ applies to dubitative forms, it chooses the morphological context

⁷ We may employ the meta-constraint $\text{Root-Faith} \gg \text{Affix-Faith}$ (McCarthy & Prince 1995) for the deletion of the suffix vowel in preference to the root vowel. The dominating ROOT-FAITH and the dominated AFFIX-FAITH may function as two E-constraints on $*\text{HIATUS}$.

<DUBITATIVE>. Hence, $*[V_{\mu\mu}, +high] \dots]_{DUBITATIVE}$ can be ranked according to AMP.

With the revised constraint we can construct the tableau for the forms in (11):

(14) Tableau for Long Vowel Shortening

	VH	$*[V_{\mu\mu}, +high] \dots]_{DUB}$	$*[\mu\mu\mu]_{\sigma}$	*HIATUS
a. /mi:k'-hin/				
1. me:k'-hin		√	M	
2. → mek'-hin			√	
b. /c'u:m-hin/				
1. c'u:m-hun	√	N	N	
2. c'o:m-hun		√	M	
3. → c'om-hun			√	
c. /hoyo-al/				
1. hoyo-ol	√			M
2. → hoyo-φl				√
d. /ʔili:-al] _{DUB} /				
1. ʔili:-φl] _{DUB}		M		√
2. ʔile:-φl] _{DUB}		√	M	
3. → ʔile-φl] _{DUB}			√	
e. /c'uyu:-al] _{DUB} /				
1. c'uyu:-φl] _{DUB}		M		√
2. c'uyo:-φl] _{DUB}		√	M	
3. → c'uyo-φl] _{DUB}			√	
f. /c'uyu:-hin/				
1. c'uyu:-hun	√	N		
2. → c'uyo:-hun		√		

In (a), N-ranked $*[V_{\mu\mu}, +high]$ derives [1], M-feeding N-ranked $*[\mu\mu\mu]_{\sigma}$, in accordance with the natural ranking NRP » MFP. M-fed $*[\mu\mu\mu]_{\sigma}$ derives the surface form. What is true of subtableau (10d) is true of subtableau (b). In (c), VH derives [1], M-feeding *HIATUS, in accordance with the natural ranking MFP » AMP. M-fed *HIATUS derives the surface form. In (d-e), AMP-ranked *HIATUS derives [1], M-feeding AMP-ranked $*[V_{\mu\mu}, +high] \dots]_{DUB}$, in accordance with the natural ranking MFP » AMP. AMP-ranked $*[V_{\mu\mu}, +high] \dots]_{DUB}$ derives [2], M-feeding AMP-ranked $*[\mu\mu\mu]_{\sigma}$. M-fed $*[\mu\mu\mu]_{\sigma}$ derives the surface form. For instance, in deriving [1] in (d) *HIATUS M-feeds $*[V_{\mu\mu},$

+high]...]_{DUB}, since it can derive the candidate *ʔili:-φl*_{DUB} with the structure *i:-φl*_{DUB} from the candidate */ʔili:-al*_{DUB}/ with the structure *i:-al*_{DUB}, where the structure *i:-al*_{DUB} and the structure *i:-φl*_{DUB} are identical except the change to be made by *HIATUS (i.e., a → φ), and both the structure *i:-al*_{DUB} and the structure *i:-φl*_{DUB} meet the SD of *[V_{μμ}, +high]...]_{DUB}. In (f), AMP-ranked VH derives [1], overriding N-ranked *[V_{μμ}, +high] in accordance with the natural ranking NRP » AMP. N-ranked *[V_{μμ}, +high] derives the surface form.

I will next examine the verb roots of the structure /CVCV:/ that take the future suffix /ʔ/. Here N-ranked *[V_{μμ}, +high] must be overridden by AMP-ranked *[μμμ]_σ in accordance with the natural ranking NRP » AMP. This contrasts with the M-feeding ranking of AMP-ranked *[V_{μμ}, +high]...]_{DUB} and AMP-ranked *[μμμ]_σ in (14d-e). The following examples illustrate the point:

(15) Verb Roots of the Structure /CVCV:/

	Nonfuture	Dubitative	Future	
/pana:/:	pana:-hin	pana-φl	pana-ʔ	‘arrive’
/hoyo:/:	hoyo:-hin	hoyo-φl	hoyo-ʔ	‘name’
/ʔili:/:	ʔile:-hin	ʔile-φl	ʔili-ʔ	‘fan’
/c’uyu:/:	c’uyo:-hun	c’uyo-φl	c’uyu-ʔ	‘urinate’

The underlying root-final long high vowel of the future forms *ʔili-ʔ* and *c’uyu-ʔ* is shortened without being lowered: N-ranked *[V_{μμ}, +high] is overridden by AMP-ranked *[μμμ]_σ in accordance with the natural ranking NRP » AMP.

The following noun forms that are also suffixed with /ʔ/ are added to the examples above:

(16) Noun Forms Suffixed with ʔ

Sub. case:	p’islu-ʔ	ʔohyo-ʔ	ʔutu-ʔ
Ind. obj. case:	p’islo:-nu	ʔohyo:-ni	ʔutu-nu
	‘mouse’	‘seeing’	‘tree’

The underlying root-final long high vowel of the subjective case form */p’islu:-ʔ/* is shortened without being lowered in deriving the surface form *p’islu-ʔ*.

The following tableau shows how the (15-16) forms are derived:

(17) Tableau for the (15-16) Forms

	VH	*[V _{μμ} , +high]	*[μμμ] _σ
a. /ʔili:-ʔ/			
1. → ʔili-ʔ		N	√
b. /c'uyu:-ʔ/			
1. → c'uyu-ʔ		N	√
c. /p'islu:-ʔ/			
1. → p'islu-ʔ		N	√
d. /p'islu:-ni/			
1. p'islu:-nu	√	N	
2. → p'islo:-nu		√	

In (a-c), AMP-ranked *[μμμ]_σ derives [1], overriding N-ranked *[V_{μμ}, +high], in agreement with the natural ranking NRP » AMP. In (d), AMP-ranked VH derives [1], overriding N-ranked *[V_{μμ}, +high], in agreement with the natural ranking NRP » AMP. N-ranked *[V_{μμ}, +high] derives [2].

First, in (14c), *HIATUS does not directly derive the expected surface form: it is derived by way of VH in compliance with the natural ranking MFP » AMP. Second, tableaux (14, 17) illustrate how the natural rankings of URP's direct the same constraints to operate differently. In subtableaux (14a-b) *[V_{μμ}, +high] and *[μμμ]_σ that are to be N-ranked are ranked in accordance with the natural ranking NRP » MFP, while in subtableaux (17a-c) N-ranked *[V_{μμ}, +high] is overridden by AMP-ranked *[μμμ]_σ in accordance with the natural ranking NRP » AMP. Third, C-opacity with respect to *[V_{μμ}, +high] in (14a-b, d-e) is occasioned due to *[μμμ]_σ, since the latter changed the structure derived by the former. C-opacity with respect to VH in (14b, 17d) is occasioned due to *[V_{μμ}, +high], since the latter changed the structure derived by the former, or changed the condition that had triggered the former. And C-opacity with respect to VH in (14e-f) is occasioned due to *[V_{μμ}, +high], since the latter changed the structure derived by the former.

3. 3 Forms with the Future Suffix /i:n/

In this subsection I will examine the forms with the future suffix /i:n/. This suffix is abstract in the sense that it includes the abstract vowel /i:/ and it never surfaces unchanged. The interaction of the three constraints employed in (17) along with the CFC on VH may justify the postulation of the underlying abstract suffix /i:n/, from

whose /i:/ the surface low vowels *e* and *o* are derived.

Consider the following examples to see how the vowel /i:/ of the future suffix is realized in surface forms:

(18) Forms with the Future Suffix /i:n/

	Nonfuture	Dubitative	Imperative	Future	
a. /xat/:	xat-hin	xat-al	xat-k'a	xat-en	'eat'
/giy':	giy'-hin	giy'-al	giy'-k'a	giy'en	'touch'
b. /do:s/:	dos-hin	do:s-ol	dos-k'o	do:s-en	'report'
c. /c'u:m/:	c'om-hun	c'o:m-al	c'om-k'a	c'o:m-on	'destroy'
/dub/:	dub-hun	dub-al	dub-k'a	dub-on	'lead by hand'

In (b-c) the vowel /i:/ of the future suffix is realized as *e* and *o* after the same surface root vowel *o*:. In deriving these shortened low vowels $*[\mu\mu\mu]_{\sigma}$ and $*[V_{\mu\mu}, +high]$ interact C-opaquely.

The C-pairs and the CFC on VH established so far are sufficient to account for the forms with the future suffix /i:n/. This is demonstrated in the following tableau:

(19) Tableau for the Forms with the Future Suffix /i:n/

	CFC	VH	$*[V_{\mu\mu}, +high]$	$*[\mu\mu\mu]_{\sigma}$
a. /xat-i:n/				
1. xat-e:n			√	M
2. → xat-en				√
b. /giy'-i:n/				
1. giy'-e:n			√	M
2. → giy'-en				√
c. /do:s-i:n/				
1. do:s-e:n			√	M
2. do:s-o:n	*	√		N
3. → do:s-en				√
d. /c'u:m-i:n/				
1. c'u:m-u:n		√	NN	N
2. c'o:m-o:n			√√	M
3. → c'o:m-on				√
e. /dub-i:n/				

1. dub-u:n		√	N	N
2. dub-o:n			√	M
3. → dub-on				√
	CFC	VH	*[V _{μμ} , +high]	*[μμμ] _σ

In (a-b), *[V_{μμ}, +high] to be N-ranked derives [1], M-feeding *[μμμ]_σ to be N-ranked, in accordance with the natural ranking NRP » MFP.⁸ M-fed N-ranked *[μμμ]_σ derives [2]. In (c), *[V_{μμ}, +high] to be N-ranked derives [1], M-feeding *[μμμ]_σ to be N-ranked, in accordance with the natural ranking NRP » MFP. VH derives [2], overriding N-ranked *[μμμ]_σ, but it violates CFC, since it applies to the structure derived by *[V_{μμ}, +high]. N-ranked *[μμμ]_σ derives [3] from [1]. In (d-e), AMP-ranked VH derives [1], overriding the N-ranked constraints *[V_{μμ}, +high] and *[μμμ]_σ, in accordance with the natural ranking NRP » AMP. Furthermore, in (d), VH overrides two instantiations of *[V_{μμ}, +high]. In (d), two instantiations of *[V_{μμ}, +high] NO-derive [2] according to NRP, one instantiation M-feeding *[μμμ]_σ to be N-ranked. M-fed *[μμμ]_σ derives [3]. In (e), *[V_{μμ}, +high] to be N-ranked derives [2], M-feeding *[μμμ]_σ to be N-ranked, in accordance with the natural ranking NRP » MFP. M-fed *[μμμ]_σ derives [3].

In Lee (2009a: subsection 17. 1) the E-constraint Identical Candidate Violation (ICV) is established. ICV says that the candidate derived by constraint_i is discarded if and only if it violates the same E-constraint(s) that a preceding candidate derived by constraint_i violates, violating no other E-constraint. But the candidate that violates ICV will not be presented in a tableau for the sake of simplicity. In (19c), the candidate *do:s-on* that can be derived from [3] by VH violates the CFC on VH. Moreover, it violates the same E-constraint CFC on VH that [2] violates. Hence, it violates ICV. And in (19d), *[V_{μμ}, +high] and *[μμμ]_σ that are to be N-ranked are O-related regarding the structure *u:n* of [1], but the former M-feeds the latter. Since the M-feeding constraint *[V_{μμ}, +high] is established, it NO-applies with N-ranked *[V_{μμ}, +high] that applies to the root vowel *u*: according to NRP that ranks it previous to its establishment.

O-opacity with respect to VH in (19c) is brought out due to CFC. C-opacity with respect to VH in (19e) is brought out due to *[V_{μμ}, +high], which changed the structure derived by the former. And C-opacity of the suffix vowel with respect to *[V_{μμ}, +high] in (19a-e) is brought out due to *[μμμ]_σ, which changed the structure derived by the former.

⁸ The constraint *[μμμ]_σ here is M_N, since the root-final consonant which serves as an onset has nothing to do with constituting a mora.

3. 4 Epenthetic Forms

The forms with the epenthetic high vowel *i* will be discussed. The roots of the structure CVCC have the alternant CVC{i, u}C in the preconsonantal or word-final position as a consequence of the application of the constraint responsible for epenthesis and VH.

The effects of the two constraints can be seen in the following examples. (The epenthetic vowel is underlined.)

(20) Epenthesis and Vowel Harmony

	Nonfuture	Dubitative	Imperative	
/ʔilk/:	ʔil <u>i</u> k-hin	ʔilk-al	ʔil <u>i</u> k-k'a	'sing'
/paʔt/:	paʔ <u>i</u> t-hin	paʔt-al	paʔ <u>i</u> t-k'a	'fight'
/ʔayy/:	ʔay <u>i</u> y-hin	ʔayy-al	ʔay <u>i</u> y-k'a	'pole a boat'
/lihm/:	lih <u>i</u> m-hin	lihm-al	lih <u>i</u> m-k'a	'run'
/logw/:	log <u>i</u> w-hin	logw-ol	log <u>i</u> w-k'a	'pulverize'
/t'oyx/:	t'oy <u>i</u> x-hin	t'oyx-ol	t'oy <u>i</u> x-k'a	'give medicine'
/ʔuty/:	ʔut <u>u</u> y-hun	ʔuty-al	ʔut <u>u</u> y-k'a	'fall'
/luk'l/:	luk' <u>u</u> l-hun	luk'l-al	luk' <u>u</u> l-k'a	'bury'

The surface form *ʔuty-hun* exemplifies that the epenthetic high vowel is subject to VH. The C-pair *COMPLEX » DEP (i) that epenthesizes the high vowel *i* in the context C _____ C{C,]_{PW}} is responsible for the epenthesis.⁹ Besides, the E-constraint DISHARMONY is required that says that the non-round vowel must not be flanked on both sides by round vowels.

*COMPLEX authorizes the tableau for the forms in (20) to be constructed:

(21) Tableau for Epenthetic Forms

	DISH	VH	*COMPLEX
a. /ʔilk-hin/			
1. → ʔil <u>i</u> k-hin			√
b. /logw-al/			
1. → logw-ol		√	
c. /logw-k'a/			

⁹ See the cf. forms in (24) for those which have the high vowel *i* epenthesized in the context C _____ C]_{PW}.

1. logiw-k'o	*	√	√
2. → logiw-k'a			√
d. /ʔuty-al/			
0. → ʔuty-al			
e. /ʔuty-hin/			
1. ʔutiy-hun	*	√	√
2. ʔutiy-hin			√
3. → ʔutuy-hun		√	
	DISH	VH	*COMPLEX

In (a), *COMPLEX derives [1]. In (b), VH derives [1]. In (c, e), VH and *COMPLEX NO-derive [1]. (The two constraints NO-apply, since the consonant clusters *gw-k'* and *ty-h* have nothing to do with the SD of VH.) But it violates DISHARMONY. *COMPLEX derives [2] from the underlying representation. In (d), no constraint applies. In (e), VH derives [3].

I will next consider the Yokuts data cited from Clements & Halle (1983):¹⁰

(22) Epenthesis and Vowel Harmony

Dubitative	Gerund	Imperative	/wu:wɫ/ 'stand up'
/wu:wɫ-al/	/wu:wɫ-taw/	/wu:wɫ-k'a/	
→ [wowl-al]	→ [wo:w <u>u</u> l-taw]	→ [wo:w <u>u</u> l-k'a]	

The vowel *a* of *wowl-al* is O-opaque with regard to VH. And the epenthetic high vowel *i* undergoes VH after the triggering underlying long high round vowel, which is lowered eventually. As a result, the vowel *o:* in *wo:wul-taw* and *wo:wul-k'a* is C-opaque with regard to VH.

The constraints established so far are sufficient to deal with the (22) forms, which is exemplified in the following tableau:

¹⁰ Argument will proceed on the assumption that the following forms are found in the Yawelmani dialect of Yokuts.

(23) Tableau for Epenthetic Forms

	CFC	VH	*[V _{μμ} , +high]	*[μμμ] _σ	*COMPLEX
a. /wu:wɪ-al/					
1. wɔ:wɪ-al			√	M	
2. wɔ:wɪ-ol	*	√		N	
3. → wɔwɪ-al				√	
b. /wu:wɪ-taw/					
1. wu:wɪ-taw			N	N	√
2. → wɔ:wɪ-taw		√	√		

In (a), *[V_{μμ}, +high] to be N-ranked derives [1], M-feeding *[μμμ]_σ to be N-ranked, in accordance with the natural ranking NRP » MFP. VH derives [2], overriding N-ranked *[μμμ]_σ, but it violates CFC, since it applies to the structure derived by *[V_{μμ}, +high]. N-ranked *[μμμ]_σ derives [3] from [1]. The candidate *wɔwɪ-ol* that VH will derive from [3] will violate ICV (see (19c)). In (b), *COMPLEX derives [1], overriding the N-ranked constraints *[V_{μμ}, +high] and *[μμμ]_σ, in accordance with the natural ranking NRP » AMP. VH and *[V_{μμ}, +high] that are to be N-ranked O-derive [2] according to AMP.

The surface form *logiw-k'a* in (21c) may be said to be quasi-O-opaque with regard to VH, since its underlying representation /logw-k'a/ meets the SD of VH. In (23a), O-opacity with regard to VH arises due to CFC, and C-opacity with regard to *[V_{μμ}, +high] arises due to *[μμμ]_σ, which changed the structure derived by the former. And in (23b), C-opacity with regard to VH arises due to *[V_{μμ}, +high], which changed the structure derived by the former, or changed the condition that had triggered the former.

3. 5 Forms with a Surface Long High Vowel

Although the data are limited, there are surface long high vowels that survive despite the constraint responsible for lowering long high vowels (i.e., *[V_{μμ}, +high]). They are thus O-opaque with respect to it.

The vowel *i:* is produced by the process of contraction that shifts the sequence *iw*]_σ to *i:* before a consonant (i.e., *s*), and VH may change it to *u:*. The contraction process is restricted to the reflexive/reciprocal suffix /iws/, because the surface sequence *iw* occurs before a consonant elsewhere.

The following examples illustrate that the long high vowel derived from the sequence /iw/ persists:

(24) Forms with a Surface Long High Vowel (/a/ = objective case suffix)

/wagç-iws-a/ → [wagç-i:s-a] ‘act of dividing’

cf. /wagç-iws/ → [wagç-iw $\bar{ı}$ s]

/huwt-iws-a/ → [huwt-u:s-a] ‘a shell game’

cf. /huwt-iws/ → [huwt-uw \bar{u} s]

The sequence iw/σ changes to $i:$ before s . And i is inserted in the context $C ______ C]_{PW}$ by the C-pair *COMPLEX » DEP (i) employed in (21, 23), as is observed in the cf. forms.

Prior to formulating the constraint for the process of contraction it is in order to introduce the following schema (Lee 2009e; see also Lee 2009a: subsection 17. 6):

(25) Compensatory Lengthening (CL) Schema

Add μ to α_1 , where $\alpha_1 = V$, or geminate α_1 , where $\alpha_1 = C$, if and only if α_2 or α_3 is deleted in the sequence $\alpha_1\alpha_2(\alpha_3)$.

The constraint that feeds an instantiation of the CL schema and the fed instantiation must be construed as a single constraint. Thus, the latter must override the constraint that is O-related with itself. In effect this reflects the purport of transformational rules in rule-based phonology (Chomsky & Halle 1968: 360-363, Kenstowicz & Kisseberth 1979: 369-377).

We are now in a position to formulate the C-pair * $iw]_{\sigma\dots}]_{REFLEX/RECI}$ (CONTR) » MAX for the process of contraction.¹¹ The lengthening of the vowel i after the deletion of w is taken care of by the CL for CONTR, an instantiation of the CL schema. In the CL for CONTR, $\alpha_1 = i$ and $\alpha_2 = w$; hence, it says: Add μ to i if and only if w is deleted in the sequence iw .

The respective long high vowels $i:$ and $u:$ of $wagç-i:s-a$ and $huwt-u:s-a$ are O-opaque regarding * $[V_{\mu\mu}, +high]$. To leave the surface long high vowels $i:$ and $u:$ untouched by * $[V_{\mu\mu}, +high]$, it must be constrained by the CFC on itself. * $[V_{\mu\mu}, +high]$, an instantiation of M in the CFC schema, chooses (a) from the CFC schema by default, constituting the CFC on itself. The CFC on * $[V_{\mu\mu}, +high]$ demands that * $[V_{\mu\mu}, +high]$ not apply to derived structure.

With CONTR, the CL for CONTR and the CFC on * $[V_{\mu\mu}, +high]$ established the tableau for the (24) forms can be constructed:

¹¹ The target in the SD of the markedness constraint in a C-pair is bold-faced in order to indicate definitely to which element in the input the dominated faithfulness constraint must be faithful.

(26) Tableau for the Surface Forms with a Long High Vowel

	CFC	VH	*[V _{μμ} , +high]	*COMPLEX	CONTR	CL
a. /wagç-iws-a/						
1. wagç-iφs-a					√	
2. → wagç-i:s-a						√
3. wagç-e:s-a	*		√			
b. /wagç-iws/						
1. → wagç-iwis				√		
c. /huwç-iws-a/						
1. huwç-iφs-a		M			√	
2. huwç-i:s-a		M				√
3. → huwç-u:s-a		√	N			
4. huwç-o:s-a	*		√			
d. /huwç-iws/						
1. huwç-uwis		√		√		
2. → huwç-uwus		√				

In (a), CONTR derives [1], and CL derives [2], fed by CONTR. *[V_{μμ}, +high] derives [3], but it violates CFC, since it applies to the derived structure. In (b), *COMPLEX derives [1]. In (c), CONTR derives [1] and CL derives [2], both M-feeding VH, in accordance with the natural ranking MFP » AMP. VH derives [3], overriding N-ranked *[V_{μμ}, +high]. N-ranked *[V_{μμ}, +high] derives [4], but it violates CFC, since it applies to the derived structure. In (d), VH and *COMPLEX NO-derive [1], and VH derives [2], rounding the inserted *i*.

In (26c), if CONTR and the CL for CONTR were not treated as a single constraint, CONTR could not M-feed VH, since it does not derive the structure that meets the SD of the latter. And in (26a, c), O-opacity with respect to *[V_{μμ}, +high] arises by virtue of the CFC on itself.

3. 6 Triply Opaque Forms

In this last subsection I will discuss the forms with the verb roots of the structure /CuCu:C/. The interaction of the three constraints VH, *[V_{μμ}, +high] and *[μμμ]_σ gives birth to triply opaque surface forms. This is exemplified by the following examples:

(27) Triply Opaque Forms

	Nonfuture	Dubitative	
/şudu:k'/:	şudok'-hun	şudo:k'-al	'remove'
cf. /ʔopo:t/:	ʔopot-hin	ʔopo:t-ol	'arise from bed'
/t'unu:y/:	t'unoy-hun	t'uno:y-al	'scorch'
cf. /yolo:w/:	yolow-hin	yolo:w-ol	'assemble'

The surface form *şudok'-hun* is triply opaque and the surface form *şudo:k'-al* is doubly opaque. The cause of triple opacity is attributable to the interplay of the three constraints mentioned above strictly under the control of the natural ranking of URP's.

The three constraints and the CFC on VH construct the tableau for the (27) forms:

(28) Tableau for the Forms in (27)

	CFC	VH	*[V _{μμ} , +high]	*[μμμ] _σ
a. /şudu:k'-hin/				
1. şudu:k'-hun		√	N	N
2. şudo:k'-hun			√	M
3. → şudok'-hun				√
b. /şudu:k'-al/				
1. → şudo:k'-al			√	
2. şudo:k'-ol	*	√		
c. /ʔopo:t-hin/				
1. → ʔopot-hin				√
d. /ʔopo:t-al/				
1. → ʔopo:t-ol		√		

In (a), AMP-ranked VH derives [1], overriding the N-ranked constraints *[V_{μμ}, +high] and *[μμμ]_σ, in accordance with the natural ranking NRP » AMP. *[V_{μμ}, +high] to be N-ranked derives [2], M-feeding *[μμμ]_σ to be N-ranked, in accordance with the natural ranking NRP » MFP. M-fed *[μμμ]_σ derives [3]. In (b), *[V_{μμ}, +high] derives [1]. VH

derives [2], but it violates CFC, since it applies to the structure derived by $*[V_{\mu\mu}, +high]$. In (c), N-ranked $*[\mu\mu\mu]_{\sigma}$ derives [1]. In (d), VH derives [1].

The surface form *šudok'-hun* in (28a) is triply C-opaque: the root vowel *o* and the suffix vowel *u* are respectively C-opaque regarding VH, and the former is C-opaque regarding $*[V_{\mu\mu}, +high]$ in addition. And the surface form *šudo:k'-al* in (28b) is doubly opaque: the root vowel *o:* is C-opaque regarding VH and the suffix vowel *a* is O-opaque regarding VH.

4. Wikchamni Dialect of Yokuts

In this section I will discuss the process of vowel harmony and the process of *o*-raising in the Wikchamni dialect of Yokuts on the basis of Archangeli & Suzuki (1997). The two processes interact with each other, which inevitably presents the problem of phonological opacity. The process of Wikchamni vowel harmony can be compared with that of Yawelmani.

Wikchamni has the two front round vowels *ü* and *ö*, which Yawelmani lacks. The constraint in charge of Wikchamni vowel harmony, which differs from the Yawelmani vowel harmony in that it yields the two front vowels, is stated as in the following:

(29) Vowel Harmony (VH) in Wikchamni Dialect of Yokuts

Spread [$\langle +back \rangle +round$] rightward until it meets the opaque vowel,
where $[V, -\alpha high]$ is opaque when the trigger is $[V, \alpha high]$.

The constraint VH constitutes a C-pair with the faithfulness constraint IDENT ($\langle back_1 \rangle round_1$). VH expands to VH_1 that chooses $\langle +back \rangle$ and $\langle back_1 \rangle$, and VH_2 that does not choose them. Although VH_1 brings about the same result as VH in Yawelmani does, their formulations are different. This is due to the fact that Wikchamni does not own the featural markedness constraint $*[V, -back, +round]$ that pairs with the faithfulness constraint IDENT (back). The formulation of VH_2 is the same as that of VH in Yawelmani, but it brings about different result, because Wikchamni does not own the above-mentioned featural markedness constraint. $VH_{1/2}$ ensure the different surface occurrences of *u* and *ü* of the respective suffix vowels of *hut-šü* of /hut-šü/ ‘knew’ and *tü?üs-šü* of /tü?üs-šü/ ‘made’, namely, the different surface realizations of the same underlying suffix vowel /i/.

In Wikchamni, in addition, *o* is raised to *u* when it is followed by *i* (long or short) with a consonant intervening. The raised vowel *u*, however, must not feed VH_1 , which is

similar to the way the lowered *o*(:) must not feed VH in Yawelmani. This is exemplified in (a) of the following data:

(30) *o*-Raising and Vowel Harmony in Wikchamni

- | | |
|--|----------------|
| a. /t'oyx-ši/ → [t'uyix-ši] (→ *[t'uyux-šu]) | ‘doctored’ |
| cf. /t'oyx-at/ → [t'oyx-ot] | ‘might doctor’ |
| /poṭk'-ši/ → [puṭik'-ši] (→ *[puṭuk'-šu]) | ‘sourred’ |
| cf. /poṭk'-at/ → [poṭk'-ot] | ‘might sour’ |
| /ʔoṭ'w-hat/ → [ʔuṭ'iw-hat] (→ *[ʔuṭ'uw-hat]) | ‘hairs’ |
| /toʔt'-hat/ → [tuʔi't'-hat] (→ *[tuʔu't'-hat]) | ‘heads’ |
| b. /pok'-i:na/ → [puk'-e:na] | ‘will find’ |

The surface forms in (a) are O-opaque regarding VH₁ and the vowel *u* of *puk'-e:na* in (b) is C-opaque regarding the process of *o*-raising.

We are in need of the C-pair *oCi (RAISING) » IDENT (high) for the raising phenomenon. Because the raised high round vowel of the root must not feed VH₁, as is evidenced by the wrong forms presented in the parentheses in (30a), RAISING must counterfeed VH₁. VH₁ is thus constrained by the CFC on itself. VH₁, an instantiation of M in the CFC schema, chooses (b) from the CFC schema with a specific M = RAISING, constituting the CFC on itself. The CFC on VH₁ requires that VH₁ not apply to the structure derived by RAISING. The CFC on VH₁ rejects the wrong forms mentioned above. The C-pairs *[V_{μμ}, +high] » IDENT (high) and *COMPLEX » DEP (i) in Yawelmani remain unchanged in Wikchamni. And Wikchamni has the same E-constraint DISHARMONY as that in Yawelmani.

The following tableau sums up what has been discussed:

(31) Tableau for Vowel Harmony in Wikchamni (C = C-ranked)

	DISH	CFC	VH ₁	VH ₂	*[V _{μμ} , +high]	*COMP	RAIS
a. /hut-ši/							
1. → hut-šu			√	C			
b. /tüʔüs-ši/							
1. → tüʔüs-šü				√			
c. /t'oyx-ši/							
1. t'oyix-ši						√	
2. → t'uyix-ši							√
3. t'uyux-šu		*	√	C			

d. /ʔotʰw-hat/							
1. ʔotʰiw-hot	*		√	C		√	
2. ʔotʰiw-hat						√	
3. → ʔutʰiw-hat							√
4. ʔutʰuw-hat		*	√	C			
e. /pokʰ-i:na/							
1. pukʰ-i:na					N		√
2. pukʰ-u:na		*	√	C	N		
3. → pukʰ-e:na					√		
	DISH	CFC	VH ₁	VH ₂	*[V _{μμ} , +high]	*COMP	RAIS

In (a) and (b), the surface forms are derived by the different constraints responsible for vowel harmony, namely, by VH₁ and by VH₂ respectively. In (a), VH₁ and VH₂ are O-related regarding the underlying representation, but the former is C-ranking, since exactly the same structure is met by the SD's of the two constraints and the SD of the former is more complex. The same can be said of the application of VH₁ in (c-e). In (b), the underlying representation meets only the SD of VH₂. In (c), *COMPLEX derives [1] and N-ranked RAISING derives [2]. VH₁ derives [3], but it violates CFC, since it applies to the structure derived by RAISING. In (d), VH₁ and *COMPLEX NO-derive [1] but it violates DISHARMONY. AMP-ranked *COMPLEX derives [2] from the underlying representation. RAISING derives [3], and VH₁ derives [4] but it violates CFC. In (e), AMP-ranked RAISING derives [1], overriding N-ranked *[V_{μμ}, +high], in accordance with the natural ranking NRP » AMP. VH₁ derives [2], overriding N-ranked *[V_{μμ}, +high], but it violates CFC. N-ranked *[V_{μμ}, +high] derives [3] from [1].

In (31c-d), O-opacity with respect to VH₁ originates from CFC. And in (31e), C-opacity with respect to RAISING originates from *[V_{μμ}, +high], which changed the condition that had triggered the former.

5. Sympathy Theory and OT-CC

In this section I will review the Yawelmani cases dealt with in sympathy theory (McCarthy 1999) and OT-CC (McCarthy 2007).

In the first place, in order to review the case dealt with in sympathy theory I can very profitably quote from what is discussed in Lee (2009a: section 14). McCarthy (1999) deals with doubly C-opaque forms in sympathy theory, citing the doubly C-opaque

forms from Yokuts:¹²

(32) Doubly C-Opaque Forms in Yokuts

- /ʔu:t-hin/ → [ʔot-hun] (Nonfut.) ‘steal’
 /c’u:m-hin/ → [c’om-hun] (Nonfut.) ‘destroy’
 /ʃu:g-hin/ → [ʃog-hun] (Nonfut.) ‘pull out a cork’

The surface form *ʔot-hun* derived from /ʔu:t-hin/ is doubly C-opaque owing to its *o* and *u*. The vowel *o* is C-opaque with regard to the process of vowel lowering and *u* is C-opaque with regard to the process of vowel harmony.

To account for the doubly C-opaque forms in sympathy theory the rankings ALIGN-COL(OR) » ID (col), LG/-HI » ID (hi) and * $[\mu\mu\mu]_{\sigma}$ » MAX- μ are respectively required for the processes of vowel harmony, vowel lowering and vowel shortening. And ROUND/ α HIGH demands that every path including [round_i] include [α high] (i.e., every token of [round] be linked to vowels of the same height) (see also Archangeli & Suzuki 1997). In addition, two sympathy constraints and two selector constraints for the doubly C-opaque forms are necessary. And the two sympathy constraints are indexed with subscripts to their respective selector constraints. Eventually, the extrinsic ranking of the established constraints is shown by a diagram in (42) in McCarthy (1999). The diagram can be interpreted as in the following:

(33) Extrinsic Ranking of the Constraints in Yokuts in Sympathy Theory

- a. * $[\mu\mu\mu]_{\sigma}$, *ID(hi)_{MAX- μ} , LG/-HI, *ID(col)_{ID(hi)}
- b. * $[\mu\mu\mu]_{\sigma}$ » *MAX- μ » *ID (hi)
- c. *ID(hi)_{MAX- μ} , LG/-HI » *ID (hi)
- d. LG/-HI, *ID(col)_{ID(hi)} » RD/ α HI
- e. *ID (hi), RD/ α HI » ALIGN-COL » ID (col)

With the extrinsic ranking presented above a complex sympathy tableau for a doubly C-opaque form (i.e., /ʔu:t-hin/ → [ʔot-hun]) is constructed in (43) in McCarthy (1999).

Instead of arguing for and against the sympathy tableau I will reconstruct it in Natural Derivational Phonology. The C-pairs employed in Yawelmani, namely, VH » IDENT (round_i), * $[V_{\mu\mu}, +high]$ » IDENT (high) and * $[\mu\mu\mu]_{\sigma}$ » MAX (μ) respectively replace the rankings ALIGN-COL » ID (col) and LG/-HI » ID (hi) and * $[\mu\mu\mu]_{\sigma}$ » MAX- μ .

¹² Actually, the following forms are found in the Yawelmani dialect of Yokuts (cf. (8)).

(34) Tableau for a Doubly C-Opaque Form in Yokuts in Natural Derivational Phonology

/ʔu:t-hin/	VH » IDENT (round ₁)	*[V _{μμ} , +high] » IDENT (high)	*[μμμ] _σ » MAX (μ)
1. ʔu:t-hun	√	N	N
2. ʔo:t-hun		√	M
3. → ʔot-hun			√

AMP-ranked VH derives [1], overriding the two N-ranked constraints *[V_{μμ}, +high] and *[μμμ]_σ, in accordance with the natural ranking NRP » AMP. *[V_{μμ}, +high] to be N-ranked derives [2], M-feeding *[μμμ]_σ to be N-ranked, in accordance with the natural ranking NRP » MFP. M-fed *[μμμ]_σ derives the surface form.

In the second place, I will review the Yawelmani case analyzed in OT-CC (McCarthy 2007:109-118). To cut a long story short, after going through a highly complicated process the derivation of *c'om-hun* from /c'u:m-hin/ is completed with the ranking given in (35) below and the OT-CC tableau constructed in (3-55) in McCarthy (2007: 118).

(35) Ranking Summary for a Doubly Opaque Form in Yawelmani in OT-CC

{*[μμμ] » IDENT(long) » PREC (ID (hi), ID(long))}, LONG/-HI » IDENT (high) » PREC (ID(Col), ID(hi)) » RD/αHI » ALIGN(Col) » IDENT(Col)

Confronted with the above-mentioned complicated OT-CC tableau, even one who is schooled in OT-CC is sure to be at a loss how to decipher it. At any rate, the expected surface form *c'om.hun* is selected. It would be wise to give up trying to understand the OT-CC tableau readily.

I will now reconstruct the OT-CC tableau in question in Natural Derivational Phonology:

(36) Reconstructed Tableau of the OT-CC tableau in Natural Derivational Phonology

/c'u:m-hin/	VH » IDENT (round ₁)	*[V _{μμ} , +high] » IDENT (high)	*[μμμ] _σ » MAX (μ)
1. c'u:m-hun	√	N	N
2. c'o:m-hun		√	M
3. → c'om-hun			√

This tableau is exactly the same as that in (34) except that /c'u:m-hin/ takes the place of /ʔu:t-hin/.

Both in (34) and (36), C-opacity regarding VH is created owing to $*[V_{\mu\mu}, +high]$, which changed the structure derived by the former, or changed the condition that had triggered the former. And C-opacity regarding $*[V_{\mu\mu}, +high]$ is created owing to $*[\mu\mu\mu]_{\sigma}$, which changed the structure derived by the former.

In the tableau constructed in sympathy theory complex extrinsic ranking of the constraints is taken advantage of, not to mention the complexity presented by the selector constraints and the sympathy constraints. In the corresponding tableau (34) constructed in Natural Derivational Phonology the constraints apply in accordance with the natural ranking of URP's without further ado. Moreover, McCarthy (2002) himself observes that classic OT (sympathy theory) cannot accommodate counterfeeding opacity (CFO) in a fully general way. And the comparison between the OT-CC tableau and the corresponding tableau (36) constructed in Natural Derivational Phonology is sufficient to make us choose the latter before the former.

6. Conclusion

The problem of phonological opacity encountered in the data adduced from the two dialects of Yokuts has been shown to be settled definitely within the framework of Natural Derivational Phonology. In Natural Derivational Phonology constraints have only to apply under the direction of the natural ranking of URP's, letting E-constraints including the instantiations of the CFC schema evaluate their outputs, regardless of whether the problem of opacity is involved or not.

In Natural Derivational Phonology O-opacity is created due to the instantiations of the CFC schema (and those of the DC schema (see 2009a: (35))). And C-opacity is created if the structure derived by a constraint or the condition that triggered it is changed by the subsequent constraint(s). Nevertheless, it ought to be stressed that the purpose of this paper is not to illustrate the properties of phonological opacity but to demonstrate that it offers no difficulty to Natural Derivational Phonology.

It can be easily imagined that if we let sympathy theory and OT-CC analyze the Yawelmani data on the same scale on which it is analyzed in this paper, a surprising degree of complexity will result.

Additionally, in Lee (2009a: sections 15-16) it is proven that comparative markedness theory (McCarthy 2002) cannot grapple with the problem of phonological opacity.

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