

Underspecification in Optimality Theory: Vowel Harmony in Classical Manchu*

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Hong, Sung-Hoon. 2002. Underspecification in Optimality Theory: Vowel Harmony in Classical Manchu. *Studies in Phonetics, Phonology and Morphology* 8.2. 323-350. This paper addresses some important issues raised by ATR harmony in Classical Manchu, formerly treated as front/back harmony. Here, the front high vowel [i] is totally inactive with respect to the harmony: it is transparent to the harmony, and further, it does not initiate the harmony. I will show that these properties of [i] will be properly explained if we allow underspecified [i] as an option for inputs and output candidate forms. Allowing underspecified [i] in fact accords more with basic notions of Optimality Theory (OT) such as Freedom of Analysis and Richness of the Base than the analyses that do not tolerate this possibility. I will further show that once we allow underspecified [i], its selection in output candidate forms or in input forms is totally governed by OT principles such as constraint interaction and Lexicon Optimization, respectively. (Hansung University)

Keywords: underspecification, Manchu, vowel harmony, transparency, Richness of the Base, Lexicon Optimization, alignment

1. Introduction

This paper discusses some fundamental issues surrounding vowel harmony from the perspective of Optimality Theory (OT; Prince and Smolensky 1993, McCarthy and Prince 1995). Vowel harmony typically propagates a long distance and on its way, there may be a neutral segment, either being opaque or transparent. For a successful account of vowel harmony, any analyses must properly address this issue of neutrality. Further, some theories of vowel harmony have been crucially dependent upon the idea of underspecification (Archangeli 1984, Steriade 1987, Archangeli and Pulleyblank 1994), and to properly treat vowel harmony in the OT framework, we must give a due reflection on this issue of underspecification.

This paper deals with these issues, centering on vowel harmony in Classical Manchu. Classical Manchu has a quite complicated system of vowel harmony, in which two types of harmony, Advanced Tongue Root (ATR) harmony and rounding harmony, are intermingled. The notable properties of ATR harmony, which is the main focus of this paper, are associated with the front high vowel [i]: this vowel, which is supposedly [+ATR] at phonetic level, does not initiate ATR harmony even when it is placed in the root-initial syllable; and moreover, it is

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transparent to ATR harmony when it occurs in a medial position. To uniformly deal with these properties of [i], I will propose that underspecified [i] (underspecified for [+ATR]) be allowed as an option for inputs and output candidate forms. It will be noted that such inclusion of underspecified [i] is in fact more in line with basic tenets of OT such as Freedom of Analysis and Richness of the Base (Prince and Smolensky 1993, Tesar and Smolensky 1996, 2000) than the analyses that do not tolerate this option. Once we allow underspecified [i], it will be shown, its selection in output candidate forms or in input forms is totally governed by OT principles such as constraint interaction and Lexicon Optimization.

This paper is organized as follows. In section 2, we will overview the Classical Manchu vowel system and its harmonic groups. In section 3, the patterns of ATR harmony and its OT analysis will be presented. A special attention will be paid to the cases of [i]-transparency and the [i]-initial roots. In section 4, the issue of underspecification in underlying representation will be considered in relation to Lexicon Optimization. Finally, section 5 will serve as a summary and conclusion of this paper.

2. CM vowels and harmonic groups

Classical Manchu (CM), a Tungusic language, refers to the language of the Manchu court, the ruler of the Ching dynasty, which controlled China from the late 16th to the early 20th century (Norman 1978, Ard 1984). CM, by this definition, is a written language.

As for the vowels, most literature on CM distinguishes six vowel graphemes, *i, e, a, o, u, ū* (or *ô*) (Austin 1962; Vago 1973; Hayata 1980; Ard 1981, 1984). The phonetic values of these graphemes are: “the first five have the usual continental sound values” (Vago 1973:584); “the symbol typically transliterated *ô* [or *ū* -- SHH] apparently had a value approximating *u* (Ard 1981:33)”. More specifically, Hayata (1980:62) and Ard (1981:33) report that the actual phonetic values of *o* and *e* are [O] and [ə], respectively (see also Zhang 1996). Following these studies, I represent the CM vowels throughout this paper, using the symbols [i], [ə], [a], [O], [u], and [ʊ].

(1) <i>graphemes</i>	<i>phonetic values</i>
i	[i]
e	[ə]
a	[a]
o	[O]
u	[u]
ū	[ʊ]

Now let us examine the general patterns of vowel harmony. Morpheme-internally, there are fairly strict cooccurrence restrictions among these six vowels: [ə] cooccurs only with [ə], [a] only with [a], and [O] only with [O], as given in (2a-c); and [i] is neutral and freely occurs with [ə], [a] or [O], as presented in (2d-f) (cf. Vago 1973, Odden 1978, Hayata 1980, Finer 1981, Ard 1984).

- (2) a. [ə] cooccurs with [ə] d. [i] cooccurs with [ə]
 ehe 'evil, bad' sidere- 'to hobble'
 ergen 'breath, life' eri- 'to sweep'
- b. [a] cooccurs with [a] e. [i] cooccurs with [a]
 aga 'rain' ciha 'wish'
 baha- 'to get' algin 'fame'
- c. [ɔ] cooccurs with [ɔ] f. [i] cooccurs with [ɔ]¹
 boco 'color' doksin 'cruel'
 foholon 'short' golmin 'long'

Such cooccurrence restrictions force alternations on suffixes. In particular, there are two types of suffix alternation attested in CM: [ə]~[a]~[ɔ] and [u]~[ʊ] alternations. Importantly, the triggering environments for [ə] and [a] are exactly the same as those for [u] and [ʊ]. That is, a suffix with [ə] or [a] occurs after a root with [ə], and a suffix with [a] or [ʊ] appears after a root with [a].² A suffix with [ɔ], on the other hand, only follows a root with [ɔ].

- (3) [ə] ~ [a] ~ [ɔ] alternation
- a. hehe-ngge 'female'
 arga-ngga 'artificial'
 boco-nggo 'colored'
- b. meme-ken 'somewhat invalid'
 amba-kan 'somewhat large'
 foholo-kon 'somewhat short'
- (4) [u] ~ [ʊ] alternation
- a. here-ku 'ladle'
 bakta-kū 'internal organs'
- b. ene-shun 'to descend-Adjective'
 daha-shūn 'to follow-Adj.'

What draws our attention, in particular, is the transparency of [i]. As we see below, [i] in medial position does not affect suffix alternation; the trigger of the alternation is rather the vowel in the root-initial position, to the left of [i]. Thus, if the root-initial vowel is [a], the suffix vowel is [a] or [ʊ], whether or not [i] is placed in-between.

¹ In general, the neutral vowel [i], when it is in the root-initial syllable, is not followed by a rounded vowel [ɔ] (Hong 1991, Zhang 1996:44).

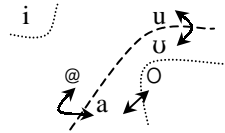
² Another piece of evidence for [ə]~[a] and [u]~[ʊ] as alternation pairs comes from a group of nouns, whose gender is differentiated according to these alternation patterns. In this group of nouns, the nouns with [ə] and [u] are feminine and those with [a] and [ʊ] are masculine: *eme* 'mother', *hehe* 'woman', *huwesen* 'Buddhist nun'; *ama* 'father', *haha* 'man', *hūwasan* 'Buddhist monk' (Norman 1978).

(5) Medial [i] is transparent:

- | | | |
|----|-----------|-----------------------|
| a. | neci-ngge | 'level-Adj.' |
| | kani-ngga | 'pair-Adj.' |
| b. | seri-ken | 'somewhat sparse' |
| | baji-kan | 'a while-Diminutive.' |
| c. | efi-ku | 'to play-Noun' |
| | ali-kū | 'to receive-N.' |

In all, then, we can establish four harmonic groups for the CM vowels as in (6): [i], which is neutral (and transparent); [ə] and [u]; [a] and [ʊ]; and finally, [ɔ]. As for suffix alternation, [ə] and [u] alternate with [a] and [ʊ], respectively: [ə]/[u] occur after another [ə]/[u], and [a]/[ʊ] after another [a]/[ʊ]. [ə] and [a] show further alternation with [ɔ].

(6) Harmonic groups and alternation patterns



The distribution of [u] and [ʊ], however, is in fact more complicated than was described above. As Hayata (1980:73) and Zhang (1996: 38-39) note, there is a peculiar phonotactic constraint in CM by which the occurrence of [u] or [ʊ] is apparently dependent upon the consonant that precedes it. Specifically, it is important whether the preceding consonant is *dorsal* or not to determine the occurrence of [u] or [ʊ]. When preceded by a dorsal consonant, *k*, *g*, or *h* (*h* is a voiceless velar fricative), [u] and [ʊ] occurs with [ə] and [a], respectively, as expected (7ab).³ When preceded by a 'non-dorsal' consonant as in (8ab), however, [u] occurs not only with [ə], but also with [a]. Apparently, then, [u] here exhibits a dual behavior: [u] after a dorsal consonant shows alternation with [ʊ] as seen in (7ab), whereas [u] after a non-dorsal consonant behaves like a neutral vowel as shown in (8ab) (since it occurs with both [ə] and [a]).

(7) Distribution of 'dorsal+[u]/[ʊ]' (alternation)

- | | | | | | |
|----|----------------|--------------|----|----------|---------------|
| a. | [ə] with | 'dorsal+[u]' | b. | [a] with | 'dorsal+[ʊ]' |
| | ce <u>ku</u> - | 'to swing' | | kūca | 'a male goat' |
| | g <u>u</u> we- | 'to forgive' | | fiyanggū | 'youngest' |
| | huren | 'an arch' | | farhūn | 'dark' |

³ Phonetically, there are two variants of dorsal consonants, velars and uvulars. As Hayata (1980:75), Ard (1984:70), and Zhang (1996:41-42) report, these two variants are in complementary distribution: velar consonants appear before [i], [ə], or [u], and uvular consonants occur before [a], [ɔ], or [ʊ]. Since their occurrence is entirely predictable, I will not deal with this issue any further.

(8) Distribution of 'non-dorsal+[u]' (apparent neutrality)

- | | |
|------------------------------|------------------------------|
| a. [ə] with 'non-dorsal+[u]' | b. [a] with 'non-dorsal+[u]' |
| het <u>u</u> 'stocky' | b <u>u</u> ktan 'pile' |
| b <u>u</u> ye- 'to desire' | da <u>cun</u> 'sharp' |
| ke <u>c</u> u 'fierce' | du <u>l</u> ba 'careless' |

These patterns of distribution are also manifested in suffix alternation. As we see below, the [u]~[ʊ] alternation is found only after a dorsal consonant, controlled by the condition described above. After a non-dorsal consonant only [u] occurs regardless of the root-initial vowel being [ə] or [a]. This latter [u], preceded by a non-dorsal consonant, appears to be transparent in medial position.

- | | |
|--|-------------------------------------|
| (9) a. [u] or [ʊ] after a dorsal cons. | b. [u] after a non-dorsal cons. |
| here- <u>ku</u> 'ladle' | neme- <u>c</u> uke 'to fear-Adj.' |
| bakta- <u>kū</u> 'internal organs' | nasa- <u>c</u> uka 'to regret-Adj.' |

The above examples all seem to suggest that first, there are two kinds of [u], one is *alternating* (the [u] that alternates with [ʊ]) and the other *transparent*, and further, these two kinds of [u] are in complementary distribution in such a way that alternating [u] occurs after a dorsal consonant and transparent [u] appears after a non-dorsal consonant.

One notable treatment of this [u]-related issue is Zhang (1996: 83). In the rule-based framework, he supposes that the two kinds of /u/ in fact come from the same underlying representation (since they are in complementary distribution), and that they are different only at the phonetic level. Specifically, he assumes that harmony applies across the board to generate the [u]~[ʊ] alternation in all instances of /u/, whether it is in alternating or transparent position, and later at the phonetic level, a merger of [u] and [ʊ] takes place after a non-dorsal consonant so that only [u] appears after a non-dorsal consonant. Below is shown how the examples in (3) are derived according to this proposal.

- | | | | | | |
|------|-----------|----------------------|---|---------------|----------------------|
| (10) | | <u>after harmony</u> | | <u>merger</u> | <u>phonetic form</u> |
| a. | here-ku | [hə@-ku] | → | no | [hə@-ku] |
| | bakta-kū | [bakta-ku] | → | no | [bakta-ku] |
| b. | neme-cuke | [nəm@cuk@] | → | vacuous | [nəm@cuk@] |
| | nasa-cuka | [nasa- <u>c</u> uka] | → | yes | [nasa- <u>c</u> uka] |

In this paper, I adopt the basic insight of Zhang, but with the provision that the exclusive occurrence of [u] after a non-dorsal consonant is directly attributed to *non-dorsal+[u], a parochial phonotactic constraint peculiar to CM which disallows the sequences of a non-dorsal consonant followed by [u]. Given this proposal, *[nasa-cuka] cannot be a final phonetic form because it violates *non-dorsal+[u].

In summary, the CM vowels fall into four harmonic categories, neutral [i], [ə]/[ʊ], [a]/[u], and [ɔ]. As for the suffix alternation, [ə] and [u] alternate with [a] and [ʊ], respectively, and medial [i] is transparent. [ə] and [a] further show alternation with [ɔ] when it is preceded by another [ɔ]. In addition, apparent transparency of [u] is due to a

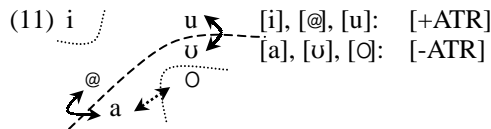
phonotactic constraint that prohibits [u] preceded by a non-dorsal consonant.

3. ATR harmony

3.1 Description

In this section, we deal with the harmony that induces [ə]~[a] and [u]~[ʊ] alternations.⁴ The first issue that we take up is to identify the harmonic feature. To this end, we need to note first that the harmony at hand is of a diagonal type in the sense of Kiparsky (1973). The harmonic changes between [ə]/[u] and [a]/[ʊ] take place along different height dimensions, between low and mid, and between lower high and higher high, respectively. Thus, it would not serve the purpose merely to use a height feature, [high] or [low], as the harmonic feature. It seems that what we need here is rather a feature that can cover shifts along different height dimensions simultaneously.

It was proposed by Hong(1991) that the feature which serves this purpose is the tongue root feature, [ATR] (see also Zhang 1996). This decision came from the consideration of the sympathetic gestures accompanying tongue root advancement/retraction. As Jacobson (1980), Hall and Hall (1980), and Archangeli and Pulleyblank (1994) note, tongue root advancement or retraction tends to be accompanied by body raising or lowering, respectively. Due to this sympathetic relation, the shifts between [ə]/[u] and [a]/[ʊ] can be ascribed to a single gesture of tongue root movement.⁵ Based on this consideration, we can characterize the CM vowels as follows.



The important properties of the harmony in question, characterized now as ATR harmony, are then summarized as below.

- (12) a. ATR harmony induces [ə]~[a] and [u]~[ʊ] alternations.
 b. [i] is transparent to ATR harmony.
 c. Apparent transparency of [u] is directly attributed to the phonotactic constraint, *non-dorsal+[ʊ].

Further remarks are in order regarding (12b) and (12c), in particular. First, we need to be explicit about the behavior of [i] when it occurs in root-initial positions. When it occurs in root-initial positions, we encounter

⁴ Due to space limitation, this paper will not deal with the alternation involving [ɔ], which is brought about by rounding harmony. See Hong (1991) and Zhang (1996ab), among others, for description and rule-based analyses of rounding harmony in CM.

⁵ The proposal for [ATR] as the harmonic feature for a diagonal harmony is not new. Hall/Hall (1980), for example, proposed an [ATR]-based analysis for the vowel harmony in Nez Perce, which manifests a quite similar pattern as found in CM.

two harmony patterns: root-initial [i] followed either by [+ATR] vowels as in (13a) or by [-ATR] vowels as in (13b). Of special notice is (13b), which appears to be a sort of disharmony where a [+ATR] vowel [i] is followed by [-ATR] vowels. We return to this harmony pattern in section 3.2.3.

- (13) a. ice-ken ‘somewhat firm’
 sise-ku ‘sieve’
 b. ciha-ngga ‘willing’
 nimaŝa-kū ‘two-man boat’

As for (12c), we need to elaborate which sequences involving [u]/[ʊ] are attested. Among the logically possible combinations of [ə]/[a] and [u]/[ʊ], the attested sequences are only as follows.

- (14) a. [@ - {non-dorsal + u}] hetu-ken ‘somewhat stocky’
 [a - {non-dorsal + u}] dacu-kan ‘somewhat sharp’
 b. * [ə - {non-dorsal + u}]
 * [a - {non-dorsal + u}]
 c. [@ - {dorsal + u}] gehu-ken ‘somewhat bright’
 * [a - {dorsal + u}]
 d. * [ə - {dorsal + u}]
 [a - {dorsal + u}] farhū-kan ‘somewhat dark’

The unattested cases are due to ATR harmony or the phonotactic constraint, *non-dorsal+[u]. In particular, the cases in (14b) are not possible because of *non-dorsal+[u], and the lack of *[a-{dorsal+u}] and *[ə-{dorsal+u}] in (14cd) is attributed to the application of ATR harmony. Note that [a-{non-dorsal+u}], an apparent violation of ATR harmony, is allowed, because it satisfies the more valued constraint in CM, *non-dorsal+[u].

For future reference, the notable patterns of ATR harmony in CM discussed above are summarized as follows.

- (15) a. Regular harmony
 i. [@ - ə] hehe-ngge ‘female’
 [a - a] arga-ngga ‘artificial’
 ii. [@ - {dorsal + u}] here-ku ‘ladle’
 [a - {dorsal + u}] bakta-kū ‘internal organs’
 iii. [@ {dorsal + u} - ə] gehu-ken ‘somewhat bright’
 [a {dorsal + u} - a] farhū-kan ‘somewhat dark’
 b. Genuine transparency
 [@ i - ə] seri-ken ‘somewhat sparse’
 [a i - a] baji-kan ‘a while-Dim.’
 c. Apparent transparency
 [@ {non-dorsal + u} - ə] hetu-ken ‘somewhat stocky’
 [a {non-dorsal + u} - a] dacu-kan ‘somewhat sharp’

d. [i]-initial roots

[i @ - @]
[i a - a]

ice-ken 'somewhat firm'
ciha-ngga 'willing'

3.2 Analysis

3.2.1 Regular Harmony

ATR harmony in CM manifests a typical pattern of rightward vowel harmony. In rule-based terms, ATR harmony in CM initiates from the root-initial vowel and proceeds leftward, and thereby the [ATR] value of the non-initial vowels agrees with that of the initial vowel. To put it differently from a non-processorial viewpoint, [ATR] is contrastive only in root-initial positions and the vowels in non-initial positions are neutralized with respect to [ATR].

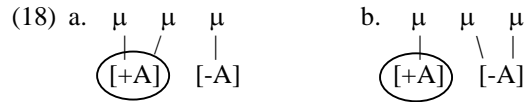
Following Kirchner (1993), Smolensky (1993), Pulleyblank (1994), Cole and Kisseberth (1994, 1995) and others, I assume an alignment-based theory of vowel harmony, corroborated with positional faithfulness proposed by Beckman (1997). In our analysis, the typical patterns of CM are due to the constraints in (10) and their interaction as in (11).

- (16) a. IDENT-IO- σ_1 (ATR): A segment in the root-initial syllable in the input and its correspondent in the output must have identical values for the feature [ATR].
 b. ALIGNRIGHT(+ATR): All instances of [+ATR] must be aligned with the right edge of its harmony domain.
 c. ALIGNRIGHT(-ATR): All instances of [-ATR] must be aligned with the right edge of its harmony domain.
 d. IDENT-IO(ATR): Correspondent segments in input and output have identical values for the feature [ATR].
- (17) IDENT-IO- σ_1 (ATR)
 ALIGNRIGHT(+ATR), ALIGNRIGHT(-ATR)
 IDENT-IO(ATR)

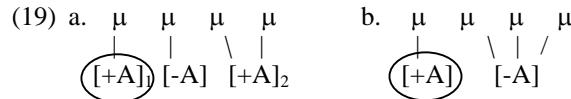
The basic effect of ATR harmony that the value of [ATR] agree in its harmony domain is brought about by the two ALIGNRIGHT constraints. The ranking of IDENT-IO- σ_1 (ATR) above the alignment constraints permits the [ATR] contrast to occur in initial syllables, and further renders these syllables insusceptible to ATR harmony. By contrast, the ranking of IDENT-IO(ATR) below the alignment constraints demands that non-initial syllables share the features of the first vowel in order to minimize violation of alignment constraints.

Before we go further, we need to be explicit about some finer details related to the evaluation of alignment constraints. First, violation of alignment constraints here is gradually assessed, in conformity with the format of Generalized Alignment (McCarthy and Prince 1993). ALIGNRIGHT(+ATR), for example, is violated once in (18a) but twice in (18b), depending on the number of moras (potential anchors of [+ATR])

located to the right of the rightmost mora associated with [+ATR] up to the right edge of the harmony domain.



Second and more crucial to this paper are the cases where there are more than one instances of a (valued) feature as in (19a). As pointed above, violations of ALIGNRIGHT(+ATR) are counted for all instances of [+ATR]. The final [+ATR] value, [+A]₂, is successfully right-aligned and incurs no violation mark. Of notice is the evaluation of initial [+A]₁. If the edges of a harmony domain are strictly calculated with reference to the word edge, the extent of the right-edge violation for initial [+A]'s in (19ab) will be identical. Under this evaluation, right-edge alignment would not be improved by the presence of [+A]₂ in (19a).

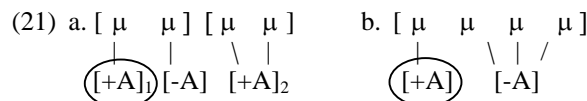


To express initial [+ATR] being better aligned to the right edge, I adopt the basic insight of Pulleyblank (1994) and Cole and Kisseberth (1994, 1995) and assume that the edges of a harmony domain are determined either phonologically or morphologically. Phonological edges here are defined by feature association, with morphological word edges serving as default delimiters.

(20) The Harmony Domain

The edge of a harmony domain of a feature [α F] is established by a link to another [α F], else by a word boundary.

According to this definition, the right edge of the harmony domain for [+A]₁ in (19a) is phonologically determined by a link to [+A]₂, while in (19b), where there are no defined phonological edges, the word edges serve as default boundaries.



As for ALIGNRIGHT(+ATR), then, [+A]₁ in (21a) has a one-mora violation whereas [+A] in (21b) accrues a three-mora violation.

Keeping in mind this interpretation of a harmony domain and feature alignment, let us now turn back to the general patterns of ATR harmony summarized in (9). First, under the constraint ranking (11), regular harmony (15a.i) is explained as follows.

(22) Regular harmony (15a.i)⁶
 a. [@ - @] (hehe-ngge ‘female’)

Input: /@ - a/ [+A][-A]	IDENT-σ ₁ (ATR)	ALRt (-ATR)	ALRt (+ATR)	IDENT (ATR)
☞ @ - @ \ / [+A]				*
@ - a [+A][-A]			*!	
a - @ [-A][+A]	*!	*		**
a - a \ / [-A]	*!			*

b. [a - a] (arga-ngga ‘artificial’)⁷

Input: /a - a/ [-A][-A]	IDENT-σ ₁ (ATR)	ALRt (-ATR)	ALRt (+ATR)	IDENT (ATR)
@ - @ \ / [+A]	*!			**
@ - a [+A][-A]	*!		*	*
a - @ [-A][+A]		*!		*
☞ a - a \ / [-A]				

For each case, the harmonized candidate, [@ - @] or [a - a], is selected because these are the forms in which the constraints are violated minimally.

This same constraint system explains the second case, [u]/[ʊ] alternation after a dorsal consonant, [@ - {dorsal+u}] and [a - {dorsal+u}] (15a.ii). The occurrence of [u] or [ʊ] in this position is subject to ATR harmony and is determined as follows. ([K] below is a cover symbol for a dorsal consonant.)

⁶ The harmonized candidates here are guaranteed regardless of the inputs for the suffix vowels being [-ATR] or [+ATR]. If the inputs for suffix vowels are [+ATR], the same harmonized output forms are selected because IDENT-IO(ATR) is ranked lowest. This conforms to Richness of the Base, a fundamental tenet of OT by which it is assumed that a correct output is selected without hinging on a particular input given a proper constraint ranking (Prince/Smolensky 1993, Smolensky 1996, Tesar/Smolensky 1996, 1998, 2000). Since inputs do not matter in the selection of an output form, I will hereafter consider only [-ATR] inputs, unless noted otherwise.

⁷ [-ATR]’s in the input are separately linked to the anchors respecting the Obligatory Contour Principle, which has been generally believed to hold within a morpheme in input or underlying level (McCarthy 1986).

(23) Regular harmony (15a.ii)

a. [$@ - \{ \text{dorsal} + \text{u} \}$] (here-ku ‘ladle’)

$/@ - \text{K} \text{u} /$	IDENT- σ_1 (ATR)	ALRT(-A)	ALRT(+A)	IDENT(ATR)
$@ - \text{K} \text{u}$				*
$@ - \text{K} \text{U}$			*!	
a - K u	*!	*		**
a - K U	*!			*

b. [$\text{a} - \{ \text{dorsal} + \text{u} \}$] (bakta-kū ‘internal organs’)

$/\text{a} - \text{K} \text{u} /$	IDENT- σ_1 (ATR)	ALRT(-A)	ALRT(+A)	IDENT(ATR)
$@ - \text{K} \text{u}$	*!			**
$@ - \text{K} \text{U}$	*!		*	*
a - K u		*!		*
$\text{a} - \text{K} \text{U}$				

The harmonized candidates, [$@ - \{ \text{dorsal} + \text{u} \}$] and [$\text{a} - \{ \text{dorsal} + \text{u} \}$], minimally violate the constraints and are thus selected as optimal outputs.

Next, the cases in (15a.iii), [$@ \{ \text{dorsal} + \text{u} \} - \text{a}$] and [$\text{a} \{ \text{dorsal} + \text{u} \} - \text{a}$], obtains a similar account by the ranking established above with no additional constraints introduced. Here, the [ATR] value of the root-initial vowel is propagated to the non-initial vowels by ATR harmony.

(24) Regular harmony (15a.iii)

a. [$@ \{ \text{dorsal} + \text{u} \} - \text{a}$] (gehu-ken ‘somewhat bright’)

$/@ \text{K} \text{u} - \text{a} /$	IDENT- σ_1 (ATR)	ALRT(-A)	ALRT(+A)	IDENT(ATR)
$@ \text{K} \text{u} - \text{a}$			*!	*
$@ \text{K} \text{u} - @$				**
$@ \text{K} \text{U} - \text{a}$			*!*	
$@ \text{K} \text{U} - @$		*!	*	*

b. [$\text{a} \{ \text{dorsal} + \text{u} \} - \text{a}$] (farhū-kan ‘somewhat’)

$/\text{a} \text{K} \text{u} - \text{a} /$	IDENT- σ_1 (ATR)	ALRT(-A)	ALRT(+A)	IDENT(ATR)
a K u - a		*!	*	*
a K u - @		*!*		**
$\text{a} \text{K} \text{U} - \text{a}$				
a K U - @		*!		*

We have so far discussed the regular cases of ATR harmony in (15a). ATR harmony is initiated by the root-initial syllable, because faithfulness to underlying contrasts in this position is the most important. Subsequent vowels must share the features of the first vowel in order to minimize violation of feature alignment constraints. Both these properties of harmony have been explained in terms of the constraint ranking in which IDENT-IO- σ_1 (ATR) dominates ALIGNRIGHT(+ATR) and ALIGNRIGHT(-ATR), which in turn outrank IDENT-IO(ATR).

3.2.2 Transparency

In this section, we deal with the cases where transparency is involved: genuine transparency of [i] in (15b) and apparent transparency of [u] in (15c), reproduced below.

- (25) a. Genuine transparency
 [əi - ə] seri-ken 'somewhat sparse'
 [a i - a] baji-kan 'a while-Dim.'
- b. Apparent transparency
 [ə {non-dorsal + u} - ə] hetu-ken 'somewhat stocky'
 [a {non-dorsal + u} - a] dacu-kan 'somewhat sharp'

First of all, [i] not being a target of [-ATR] harmony is due to a feature cooccurrence restriction, *[-ATR, -back], which disfavors the combination of [-ATR] and [-back].⁸ (Note that [i] is the only [-back] vowel in CM.) This constraint is motivated from the fact that tongue root retraction tends to be accompanied by tongue body backing, as well as tongue body lowering (Jacobson 1980, Hall and Hall 1980, Archangeli and Pulleyblank 1994). Since there are no known cases of [ɨ] in CM, where [-ATR] combines with [-back], *[-ATR, -back] is presumed to be inviolable in this language.

Second, given the newly defined notion of harmony domain, transparency is directly attributed to the interaction of feature alignment constraints, ALIGNRIGHT(-ATR) and ALIGNRIGHT(+ATR). If we compare the transparent case in (26a) with the opaque case in (26b), we observe that the transparent case has a one-mora violation of ALIGNRIGHT(-ATR) but a two-mora violation of ALIGNRIGHT(+ATR) (violated by [-A]₁ within a phonologically defined harmony domain), whereas the opaque case records a three-mora violation of ALIGNRIGHT(-ATR) but no violation of ALIGNRIGHT(+ATR). Given this interpretation of feature alignment, the transparency of [i] can now be explained by ALIGNRIGHT(-ATR) dominating ALIGNRIGHT(+ATR).⁹

- | | | ALIGNRT(-ATR) | ALIGNRT(+ATR) |
|---------|--|---------------|---------------|
| (26) a. | $\begin{array}{c} \mu \quad \textcircled{\mu_i} \quad \mu \quad \mu \\ \quad \quad \backslash \quad \\ [-A]_1 [+A] \quad [-A]_2 \end{array}$ | * | ** |
| b. | $\begin{array}{c} \mu \quad \textcircled{\mu_i} \quad \mu \quad \mu \\ \quad \backslash \quad \quad / \\ [-A] \quad [+A] \end{array}$ | *** | ✓ |

⁸ Note that the transparency of [i] takes place due to the antagonistic relation between [-back] and [-ATR]. I will refer to this type of transparency as 'antagonistic transparency,' following Archangeli/Pulleyblank (1994).

⁹ Other analyses of antagonistic transparency include Walker (1998, 1999) and Baković (2000). See Baković (2000: 266-280) for comparison between different analyses of antagonistic transparency.

Third, by being transparent, the transparent structures will observe *[-ATR, -back] and improve the alignment of [-ATR], but at the same time, they will violate *EMBED(ATR), which prohibits [α ATR] embedded within multiple instances of [- α ATR] (Smolensky 1993). *EMBED(ATR) is readily violable by the transparent structures, and hence is ranked fairly low, lower than feature alignment constraints.

(27) *EMBED(ATR)

A root node is parsed into a non-embedded ATR domain.

(28) *[-ATR, -back]

IDENT-IO- σ_1 (ATR)

ALIGNRIGHT(-ATR)

ALIGNRIGHT(+ATR)

*EMBED(ATR), IDENT-IO(ATR)

Based on the constraints and the constraint ranking above, let us now consider the constraint tableaux for the relevant examples. First, the genuine case of antagonistic transparency, [a i - a], is explained as follows.

(29) Antagonistic transparent [i]: [a i - a] (baji-kan ‘a while-Dim.’)

/a i - a/ [-A][+A][-A]	*[-A, -bk]	ALRT (-ATR)	ALRT (+ATR)	*EMBED (ATR)	IDENT (ATR)
a i - @ \ / [-A] [+A]		**!			*
☞ a i - a [-A][+A][-A]		*	*	*	
a I - @ \ / [-A] [+A]	*!	*			**
a I - a \ / [-A]	*!				*

High ranked *[-ATR, -back] disallows [ɿ], and hence [a I- @] and [a I- a] are excluded; ALIGNRIGHT(-ATR) outranks ALIGNRIGHT(+ATR), and thus transparent [a i - a] is preferred over opaque [a i - @].

Second, the case of [@i - @] (as in *seri-ken* ‘somewhat sparse’), where the input for the initial vowel is [+ATR], is explained by this same constraint ranking. What differs from the previous transparent pattern is that [i] is not antagonistic to the harmony of [+ATR] in this case.

(30) [a i - @] (seri-ken ‘somewhat sparse’)

/a i - a/	*[-A, -bk]	ALRT (-ATR)	ALRT (+ATR)	*EMBED (ATR)	IDENT (ATR)
☞ a i - @					*
a i - a			*!		
@ I - @	*!	*	*	*	**
@ I - a	*!		**		*

Finally, the apparent transparency of [u], [a{non-dorsal+u}-a], which we observed in (15c) when it comes after a non-dorsal consonant (e.g. *dacu-kan* ‘somewhat sharp’) is also easily ascribed to this constraint system. The competing candidate here is *[a{non-dorsal+u}-a], but it cannot surface as the optimal output form because it violates *non-dorsal+[u], which was introduced in section 2. Note that *non-dorsal+[u] is presumably very high ranked in CM (possibly the highest) since its violation is extremely rare (Zhang 1996:43). As seen below, the optimal output form here, [a{non-dorsal+u}-a], is selected because it best satisfies both *non-dorsal+[u] and the feature alignment constraints. ([T] is a cover symbol for a non-dorsal consonant.)

(31) Apparent transparency of [u] (*dacu-kan* ‘somewhat sharp’)

/a T u - a/	*non-dor+[u]	ALRT (-ATR)	ALRT (+ATR)	*EMBED (ATR)	IDENT (ATR)
a T u - @		**!			**
☞ a T u - a		*	*	*	*
a T ũ - @	*!	*			*
a T ũ - a	*!				

In summary, the neutral vowel [i] is not subject to the harmony of [-ATR] because it is specified for [-back], which opposes the combination with [-ATR]. For this reason, the transparency of [i] as in the harmony pattern [a i - a] was characterized as antagonistic transparency. As for the treatment of the antagonistic transparency of [i], we have seen that it is directly attributed to the interaction of feature alignment constraints, specifically ALIGNRIGHT(-ATR) outranking ALIGNRIGHT(+ATR). We have also found that the apparent transparency of [u] is accommodated in this analysis without any additional complications.

3.2.3 [i]-initial Roots

We now turn to the examples where the root-initial vowel is [i]. Of notice here is the fact that the suffix forms in these examples are not determined by root-initial [i], but rather by the vowel of the second syllable in the root. This pattern of harmony is clearly shown in the following examples, reproduced from (15d).

(32) [i]-initial roots

- a. *ciha-ngga* ‘willing’
- b. *ice-ken* ‘somewhat firm’

These [i]-initial examples pose a problem to any analyses of CM which assume that the harmony propagates from the root-initial vowel. The OT analysis proposed above is no exception, and it predicts [+ATR] vowels to occur following root-initial [i], which is [+ATR]. Thus, instead of *ciha-ngga*, **cihe-ngge* is expected to appear.

The problem is more revealing in the so-called “neutral vowel roots” or [i]-only roots, which are composed solely of the neutral vowel [i]. After the roots of this sort, only the suffixes with a [-ATR] vowel occur, as Zhang (1996) and Dresher and Zhang (2000) explicitly show.

- (33) [i]-only roots: only a [-ATR] suffix appears (Zhang 1996, Dresher and Zhang 2000)
- ici-ngga (*ngge) ‘direction-Adj.’
 - fili-kan (*ken) ‘solid-Dim.’
 - sifi-kū (*ku) ‘to stick in the hair-Noun’
 - iji-shūn (*shun) ‘to put in order-Adj.’

Here too, the present OT analysis (and any other analyses hinging on the idea that the [ATR] value of an initial vowel determines those of subsequent vowels) predict a [+ATR] suffix vowel to appear after such a root because the root consists only of [i], which is [+ATR].

- (34) [i i - a] (ici-ngga ‘direction-Adj.’)

$\begin{array}{c} \hat{A} \text{ i - a/} \\ \text{ / } \\ [+A] [-A] \end{array}$	*[-A, -bk]	IDENT- σ_1 (ATR)	ALIGNRT (-ATR)	ALIGNRT (+ATR)	*EMBED (ATR)	IDENT (ATR)
☛ i i - @						*
☞ i i - a						
i I - @	*!		*	*	*	**
i I - a	*!			**		*

To deal with the problem posed by initial [i], I propose the following. All the [i]-initial examples examined above show, among other things, that [+ATR] for [i] does not initiate ATR harmony, which suggest that [+ATR] is not ‘active’ for [i]. In a variety of pre-OT theories (beginning with Kiparsky 1982; see Archangeli and Pulleyblank 1994 and Steriade 1995 for comprehensive references), such phonological inactivity has been formally expressed as feature underspecification.¹⁰ In the case at hand, too, we must consider the possibility that [+ATR] could be underspecified for [i].¹¹

Note that including underspecified structures in fact conforms to the basic tenets of OT, Freedom of Analysis and Richness of the Base. According to Freedom of Analysis, the essential function in OT that

¹⁰ Underspecification has come under severe pressure from researchers like Mohanan (1991), McCarthy/Taub (1992), Smolensky (1993), and Steriade (1995). Smolensky, for example, argues that underspecification is not necessary since its effect is equally attained by constraint interaction. Note that the present analysis is in the same vein: underspecification is not forced, but it rather follows from the basic principles of OT.

¹¹ See Dresher/Zhang (2000) for an argument for [i] lacking [+ATR] based on the contrasts among vowels.

maps an input to outputs, i.e. *Gen*, is free to generate any conceivable output candidates for some input (Prince and Smolensky 1993). Richness of the Base states that the input cannot in principle be constrained at all and all inputs are possible (Prince and Smolensky 1993, Smolensky 1996, Tesar and Smolensky 1998). These two properties of OT theoretically support the idea that underspecified options, when relevant, must be considered in both output candidate and input forms (cf. Itô, Mester and Padgett 1995 (IMP), Inkelas 1995).

The next step is to make explicit how underspecified [i] can be selected among competing candidate forms. Following the central concept of OT, I take the position that underspecification is possible only if it is selected by constraint interaction (cf. Smolensky 1993). In particular, I propose an analysis *à la* IMP, in which an underspecified structure is allowed by a constraint for lexical minimality (or underspecification) dominating a constraint for full specification. In the present case, [i] in CM is the only front [+ATR] vowel, and constraints are set up based on the feature correlation between [-back] and [+ATR]. One constraint is LICENSE, by which redundant [+ATR] is not permitted (or not 'licensed,' following the terminology of IMP) if [-back] is already present. The other constraint is FRONTATR, which ensures the full specification of [-back] and [+ATR]. The front vowel [i] is underspecified for [+ATR] when LICENSE dominates FRONTATR (and also IDENT-IO(ATR)). (Note that this ranking gives rise to the same underspecified [i] regardless of the input being specified or underspecified for [+ATR].)

- (35) a. LICENSE: F licenses G if and only if the presence of G is *not* implied by the presence of F. (Lexical minimality is preferred.)
 b. FRONTATR: If [-back] is present then [+ATR] must also be present. (Redundant features are specified.)

(36) LICENSE FRONTATR, IDENT-IO(ATR)

- a. Input: /i/ specified for [+ATR]^{1 2}

/ i / [+A]	LICENSE	FRONTATR	IDENT(ATR)
i [+A]	*!		
☞ i		*	*

- b. Input: /i/ not specified for [+ATR]


/ i /	LICENSE	FRONTATR	IDENT(ATR)
i [+A]	*!		*
☞ i		*	

^{1 2} The evaluation of IDENT(F), when underspecification is involved, is based on Archangeli and Pulleyblank's (1994: 105-106) notion of "distinctness", by which [αF] is treated as distinct from [øF].

Combining LICENSE and FRONTATR with the constraints already established in the previous section, we are now able to handle the problematic cases of [i]-initial roots (32a), [i a - a]. Note that in the constraint tableau below, LICENSE must outrank IDENT-IO- σ_1 (ATR); otherwise, unwanted [i @ - @] (in which [i] is specified for [+ATR]) results from the input /i a - a/.



(37) LICENSE IDENT-IO- σ_1 (ATR)

(38) [i a - a] (ciha-ngga ‘willing’)

/i a - a/ [+A][-A][-A]	*[-A, -bk]	LIC	ID- σ_1 (A)	FR ATR	ALRT (-A)	ALRT (+A)	*EMB (A)	ID (A)
i @ - @ \ / [+A]			*	*				***
i @ - a [+A][-A]			*	*		*!		**
i a - @ [-A][+A]			*	*	*!			**
 i a - a \ / [-A]			*	*				*
i @ - @ \ / [+A]		*!						**
i a - a \ / [+A][-A]		*!				**		

This constraint system, however, does not explain the other harmony pattern of [i]-initial roots, [i @ - @] (*ice-ken* (32b)). As we saw above, the choice of the optimal form is made by the lowest ranked faithfulness constraint, IDENT-IO(ATR). Given that the input form for [i @ - @] is /i @ - a/ (to be consistent with the rest of the analysis in which [-ATR] suffix forms are posited in inputs), IDENT-IO(ATR) here does not distinguish optimal [i @ - @] from suboptimal [i @ - a]: they would equally accrue two violation marks.

(39) [i @ - @] (*ice-ken* ‘somewhat firm’)

	/i @ - a/ [+A] [-A]	LIC	ID- σ_1 (A)	FR ATR	ALRT (-A)	ALRT (+A)	*EMB (A)	ID (A)
 a.	i @ - @ \ / [+A]		*	*				(**)
 b.	i a - a \ / [-A]		*	*				(**)

Note that (39a) and (39b) above both violate faithfulness in the root-initial position. What differs is that the suboptimal form [i a - a] violates root faithfulness, whereas optimal [i @ - @] contravenes suffix faithfulness. This suggests that root faithfulness is more valued than suffix faithfulness, and hence violation of the former is more critical than violation of the latter. This difference is characterized by constraint ranking in which root faithfulness dominates affix faithfulness (cf. McCarthy and Prince 1995).

(40) IDENT_{root}-IO(ATR) IDENT_{affix}-IO(ATR)

(41) [i @ - @] (ice-ken ‘somewhat firm’) ^{1 3}

/i @ - a/ \ [+A] [-A]	*[-A, -bk]	LIC	Id-σ ₁ (A)	FR ATR	ALRT (-A)	ALRT (+A)	Id _{rt} (A)	*EMB (A)	Id _{af} (A)
☞ i @ - @ \ [+A]			*	*			*		*
i @ - a [+A] [-A]			*	*		*!	*		
i a - @ [-A] [+A]			*	*	*!		**		*
i a - a \ [-A]			*	*			**!		
i @ - @ \ [+A]		*!							*
i a - a \ [+A] [-A]		*!				**	*		

The [i]-only roots, which are always followed by a [-ATR] suffix (27), receive an account as follows. LICENSE excludes [i] specified with [+ATR], and hence (42cd) are ruled out; and [i i - @] (42a) and [i i - a] (42b) with underspecified [i] record a tie on IDENT_{root}-IO(ATR), but the latter is selected because it observes IDENT_{affix}-IO(ATR) whereas the former does not.

^{1 3} IDENT_{root}-IO(ATR) is outranked by ALIGNRIGHT(+ATR) because the harmonized root [@@-] is preferred over disharmonized *[@a-], given the input form /@a-/. Here, optimal [i @ -] violates IDENT_{root}-IO(ATR), while suboptimal *[i @ a -] does not observe ALIGNRIGHT(+ATR).

(42) [i i - a] (ici-ngga ‘direction-Adj.’): input /i i - a/

	/i i - a/ \ / [+A] [-A]	LIC	ID- σ_i (A)	FR ATR	ALRT (-A)	ALRT (+A)	ID _{rt} (A)	*EMB (A)	ID _{af} (A)
a.	i i - @ [+A]		*	**			**		*!
b.	i i - a [-A]		*	**			**		
c.	i i - @ \ / [+A]	*!*							*
d.	i i - a \ / [+A] [-A]	*!*				*			

There still remains a problem, however. Unlike other [i]-initial examples, where both [+ATR] and [-ATR] suffixes may occur depending on the ATR value of the vowel that immediately precedes, the [i]-only roots in (27) are always followed by a [-ATR] suffix. This implies that the suffix vowel after an [i]-only root must neutralize into [-ATR], whatever its input may be. That is, even when the input for the suffix vowel is [+ATR], its output form must somehow become [-ATR]. In the current constraint system, however, the optimal form is chosen by IDENT_{affix}-IO(ATR). Hence, the output suffix vowel is always identical to its input form, and if the input for the suffix vowel is [+ATR], its output would also be incorrectly predicted to [+ATR].

I propose that such neutralization be attributed to a context-free markedness constraint *[+ATR], disfavoring the occurrence of [+ATR]. This constraint is ranked below IDENT_{root}-IO(ATR) as seen in (38), but ranked over IDENT_{affix}-IO(ATR) to explain the effect of suffix neutralization after [i]-only roots as presented in (40).

(43) IDENT_{root}-IO(ATR) *[+ATR]

(44) [i @ - @] (ice-ken ‘somewhat firm’) (from (33))

	/i @ - a/ \ / [+A] [-A]	IDENT _{root} -IO (ATR)	*[+ATR]
a.	i @ - @ \ / [+A]	*	*
b.	i a - a \ / [-A]	**!	

(45) *[+ATR] IDENT_{affix}-IO(ATR)

(46) [i i - a] (ici-ngga ‘direction-Adj.’): input /i i - a/

	/i i - @/ [+A][+A]	LIC	ID-σ ₁ (A)	FR ATR	ALRT (-A)	ALRT (+A)	ID _{rt} (A)	*EMB (A)	*[+A]	ID _{af} (A)
	a. i i - @ [+A]		*	**			**		*!	
☞	b. i i - a [-A]		*	**			**			*
	c. i i - @ [+A]	*!*							*	
	d. i i - a [+A][-A]	*!*				*			*	*

To confirm the constraints and the ranking established so far, I turn back now to the case of antagonistic transparency and see if the proposed constraints and the ranking provide a proper explanation. The result is successful: as we see below, [a i - a] with its medial [i] being underspecified for [+ATR] is selected over opaque [a i - @] and [a i - a] with specified [i].

(47) Back to antagonistic transparency of [i]

	/a i - a/ [-A][+A][-A]	*[-A, -bk]	LIC	IDσ ₁ (A)	FR ATR	ALR (-A)	ALR (+A)	ID _{rt} (A)	*EMB (A)	*[+A]	ID _{af} (A)
	a. a i - @ [-A][+A]				*	**!		*		*	*
	b. a i - @ [-A][+A]		*!			**				*	*
	c. a i - a [-A][+A][-A]		*!			*	*		*	*	
☞	d. a i - a [-A][-A]				*	*		*	*		
	e. a I - a [-A]	*!						*			

We can observe here two important aspects regarding the analysis of antagonistic transparency. First, specified [i]’s (specified for [+ATR]) are excluded due to LICENSE (see (47bc)); and second more significantly, ALIGNRIGHT(-ATR), which holds on the phonologically defined harmony domain, ultimately determines the optimal output form (see (47ad)).

Thus far we have examined the harmony patterns of [i]-initial roots. The constraint ranking compiled up to now is given below.

- (48) *[-ATR, -back], *non-dor+[u]
 LICENSE
 IDENT-IO- σ_1 (ATR), FRONTATR
 ALIGNRIGHT(-ATR)
 ALIGNRIGHT(+ATR)
 IDENT-IO_{root}(ATR)
 *EMBED(ATR), *[+ATR]
 IDENT-IO_{affix}(ATR)

The important points of the discussion can be summarized as follows. It was shown that [+ATR] in [i] is ‘inactive’ in two respects: although it is [+ATR], [i] does not initiate [ATR] harmony, and further, only a [-ATR] suffix vowel appears after the [i]-only roots. I proposed that such inactivity be due to the underspecification of [i] for [+ATR]. We noted that inclusion of underspecified structure conforms to two important OT concepts, Freedom of Analysis and Richness of the Base. These two OT concepts ensure that there are no restrictions on output candidates and input forms, respectively. We have seen how underspecified structures in output candidates are selected via constraint interaction, between LICENSE (which ensures lexical minimality) and FRONTATR (which guarantees specification of redundant features). We have yet to see how underspecified structures in input forms determined by another OT principle of Lexicon Optimization, to which we will turn in the next section.

4. Multiple inputs but unique UR

One of the fundamental assumption of OT is that the input component is not constrained and all inputs are possible for deducing the possible outputs of a grammar (Prince and Smolensky 1993: 191). Such an assumption is formulated as the now well-known Richness of the Base.

- (49) Richness of the Base (ROB):
 “The set of possible inputs to the grammar of all languages is the same. The grammatical inventories of languages are defined as the forms appearing in the structural descriptions that emerge from the grammar when it is fed the universal set of all possible inputs.”
 (Tesar and Smolensky 1998: 252)

The major goal of ROB is to attribute all systematic cross-linguistic variation entirely to constraint ranking (Prince and Smolensky 1993, Smolensky 1996, Tesar and Smolensky 1996, 1998, 2000). When cast into an actual analysis, this means that a correct output is guaranteed without hinging on any particular input, if provided with proper constraint ranking.

It was noted, however, that ROB may pose a serious computation problem on learnability. Since any input can be posited for a given

output, learning a grammar, whose basic function is to map an input to an output, may become a burden on the part of a learner. The basic stance of OT on this issue is to “distinguish possible inputs, which are drawn from the universal pool of possible linguistic structures, from the URs of the morphemes of a particular language (Benua 1997: 14),” and to posit that the input space is infinite (thus unrestricted) but the lexicon is finite.

The important claim in this regard is that a learner's construction of lexical representation or UR is guided by Lexicon Optimization (LO). The basic function of LO is to track down the “optimal inputs” among the potential inputs, given proper constraint ranking (Prince and Smolensky 1993, Inkelas 1995, IMP 1995, Tesar and Smolensky 2000).

(50) Lexicon Optimization

Suppose we are given an overt structure φ and a grammar.
Consider all structural descriptions (of all inputs) with overt part equal to φ ; let the one with maximal Harmony be p , a parse of some input I . Then I is assigned as the underlying form of φ .
(Tesar and Smolensky 2000: 77)

In plain terms, this means that of several potential inputs whose outputs all converge on the same phonetic form, the particular UR is chosen whose mapping to phonetic form incurs the fewest violations of highly ranked grammatical constraints.

With this much background, let us now consider how LO determines the UR for [i]. The focus of the discussion is to verify whether multiple inputs converge on a single output form, and to find out whether fully or underspecified UR is chosen for [i]. Let us first examine the harmony patterns of [i]-initial roots (e.g. ciha-ngga ‘willing’). We saw in (32) how [i a - a] with [i] being underspecified for [+ATR] is determined as the optimal output form from the fully specified input. What we have to verify now is whether the same output form can also be chosen from other input forms. This is significant because OT assumes no constraints on inputs (ROB), and LO applies only when multiple inputs converge on a single output forms. Below we present some plausible inputs for [i a - a], of which the first (51a) is already considered in (32).

(51) Some plausible *inputs* for [i a - a] (ciha-ngga ‘willing’)

- | | |
|---------------------|---------------------|
| a. i a - a | b. i a - a |
| | |
| [+A][-A] [-A] | [-A] [-A] |
| c. i a - @ | d. i a - @ |
| | |
| [+A][-A] [+A] | [-A] [+A] |

As the following tableaux demonstrate, these inputs all converge on the same output form. It does not matter whether the input for initial [i] is specified for [+ATR] (52a), nor does it matter whether the suffix vowel is [+ATR] or [-ATR] (52bc).

(52) [i a - a] (ciha-ngga ‘willing’)

a. /i a - a/ [-A][-A]	LIC	ID- σ_1 (A)	FR ATR	ALRT (-A)	ALRT (+A)	ID _{rt} (A)	*EMB (A)	*[+A]	ID _{af} (A)
i @ - @ [+A]			*			*!		*	*
i @ - a [+A][-A]			*		*!	*		*	
☞ i a - a [-A]			*						
i @ - @ / [+A]	*!	*				**		*	*

b. /i a - @/ [+A][-A][+A]	LIC	ID- σ_1 (A)	FR ATR	ALRT (-A)	ALRT (+A)	ID _{rt} (A)	*EMB (A)	*[+A]	ID _{af} (A)
i @ - @ [+A]		*	*			**!		*	
i a - @ [-A][+A]		*	*	*!		*		*	
☞ i a - a [-A]		*	*			*			*
i @ - @ / [+A]	*!					*		*	

c. /i a - @/ [-A][+A]	LIC	ID- σ_1 (A)	FR ATR	ALRT (-A)	ALRT (+A)	ID _{rt} (A)	*EMB (A)	*[+A]	ID _{af} (A)
i @ - @ [+A]			*			*!		*	
i a - @ [-A][+A]			*	*!				*	
☞ i a - a [-A]			*						*
i @ - @ / [+A]	*!	*				**		*	

Since all the inputs we considered converge on the same output, LO comes into play to determine the UR. The harmonic evaluation of LO can be seen by the following “tableau des tableaux” (*à la* IMP), in which the best parses from each input, (51a-d), are compared. It is shown that the optimal parse is from the input /i a - a/ (53a), where /i/ is underspecified for [+ATR]. This form is chosen as the UR by LO.¹⁴

(53) Lexicon Optimization: [i]-initial roots

	<i>Inputs</i>	<i>Output</i>	Id _σ (A)	Fr ATR	AlR (-A)	AlR (+A)	Id _{rt} (A)	*EMB (A)	*[+A]	Id _{af} (A)
☞	a. /i a - a/ [-A] [-A]	i a - a \ / [-A]		*						
	b. /i a - @/ [-A] [+A]	i a - a \ / [-A]		*						*!
	c. /i a - a/ [+A] [-A] [-A]	i a - a \ / [-A]	*!	*			*			
	d. /i a - @/ [+A] [-A] [+A]	i a - a \ / [-A]	*!	*			*			*

LO applies to other [i]-related cases in a similar fashion. After considering the parses from some plausible inputs for [i]-only roots, we find that /i i - a/, where both /i/'s are underspecified for [+ATR], is selected as the UR. Likewise, in the cases of antagonistic transparency, /a i - a/ with underspecified medial /i/ is chosen as the UR.

(54) Lexicon Optimization: [i]-only roots

	<i>Inputs</i>	<i>Output</i>	Id _σ (A)	Fr ATR	AlR (-A)	AlR (+A)	Id _{rt} (A)	*EMB (A)	*[+A]	Id _{af} (A)
☞	/i i - a/ [-A] [-A]	i i - a [-A]		**						
	/i i - @/ [+A] [-A]	i i - a [-A]		**						*!
	/i i - a/ \ / [+A] [-A]	i i - a [-A]	*!	**			**			
	/i i - @/ \ / [+A] [+A]	i i - a [-A]	*!	**			**			*

¹⁴ An obvious consequence of LO is that the chosen UR is always maximally similar to its output form. Thus, “the chosen UR will, *ceteris paribus*, be the one with the fewest Faithfulness violations (Yip 1996: 758-759).” In this respect, LO shares its view of UR with earlier approaches such as Kiparsky (1968), Stampe (1972), Vennemann (1973), and Hooper (1976). For a view against LO, see Idsardi (1997).

(55) Lexicon Optimization: antagonistic transparency of [i]

	<i>Inputs</i>	<i>Output</i>	ID-σ (A)	FR ATR	ALR (-A)	ALR (+A)	ID _π (A)	*EMB (A)	*[+A]	ID _{af} (A)
☞	/a i - a/ [-A] [-A]	ai-a [-A][-A]		*	*			*		
	/a i - @/ [-A] [+A]	ai-a [-A][-A]		*	*			*		*!
	/a i - a/ [-A][+A][-A]	ai-a [-A][-A]		*	*		*!	*		
	/a i - @/ [-A][+A][+A]	ai-a [-A][-A]		*	*		*!	*		*

To summarize, we have discussed the issue of the UR for [i] based on the [i]-initial roots and the cases of antagonistic transparency. We have pointed out that the target outputs are obtained regardless of input forms, as demanded by ROB. Since multiple inputs converge on a single output, LO is invoked to determine the genuine UR. In all the [i]-related examples, the UR for [i] was selected as /i/ unspecified for [+ATR].

5. Conclusion

This paper has investigated some fundamental issues of vowel harmony -- underspecification and transparency, focusing on ATR harmony in CM. Most of the discussion centered on [i] in particular. Although this vowel is phonetically [+ATR], it does not initiate ATR harmony even when it is root-initial. Further, medial [i] exhibits antagonistic transparency to allow [-ATR]-[i]-[-ATR] sequences.

Adopting the basic insight of underspecification theory that phonological inactivity is expressed as feature underspecification, I proposed that [i] be underspecified for [+ATR]. It was noted that underspecified [i] being considered as an option for inputs and output candidate forms is in fact more in line with the basic concept of OT than the analyses that do not allow this possibility. That is, Freedom of Analysis imposes no limit on the candidate forms that *Gen* could generate, and ROB allows any form of inputs in the analysis. Once underspecified structures are ruled in, its selection in output candidate forms or in input forms is totally governed by OT principles such as constraint interaction and LO, respectively.

We have seen that the exact nature of [i] in CM can be determined precisely in this way. Following IMP, I adopted the view that full specification and underspecification can be decided by the interaction between a constraint that ensures lexical minimality (proposed as LICENSE by IMP) and a constraint that prefers full specification. We have observed that we obtain underspecified outputs when the former dominates the latter. After applying LO, we have also seen that this same ranking selects underspecified /i/ as the UR for [i].

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