An OT Account of Coalescence and Compensatory Lengthening in Dhivehi (Maldivian)*

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Dhivehi exhibits coalescence and compensatory lengthening when vowel-initial suffixes are added to stems ending in /i/. The consonant preceding the /i/ determines the type of coalescence that takes place. Only dentals get palatalized (e.g., *rodi* 'thread', *roddʒ-ek* 'a thread'), but labials and velars allow the /i/ to coalesce with the nucleus of the preceding syllable to form an off-glide (e.g., *boki, boykk-ek* 'a bulb'). In either case, the consonant must geminate if /i/ coalesces. Coalescence and gemination cannot take place if the syllable preceding /i/ is closed, or if the preceding consonant is retroflex (e.g., *bonti, bonti-y-ek* 'an unopened palm frond'; *baɖi, baɖi-y-ek* 'a gun'). I demonstrate that this data requires a feature geometry that depicts the coronals' opacity effects in relation to /i/. Given that, I show how constraints dealing with syllable structure, coalescence, and compensatory lengthening interrelate to account for the Dhivehi data within the framework of Optimality Theory.

1 Introduction

Dhivehi[1] (Maldivian) features a morphophonemic process in which /i/ preceded by certain consonants deletes before vowel initial suffixes. The /i/ does not delete, however, without causing gemination of the preceding consonant, and palatalization in relation to dentals (e.g., *roddʒek* 'a thread' from *rodi* 'thread' + *-ek* 'indefinite'), and diphthongization where the preceding consonant is non-coronal (e.g., *boki* 'bulb' and *boykkek* 'a bulb'). In either case, the consonant must geminate which I interpret as compensatory lengthening of the special type VCV → VCC.[2] In cases where both palatalization (or diphthongization) and compensatory lengthening cannot occur, the /i/ must be retained (e.g., *baɖi* 'gun', *baɖiyek* 'a gun'; *fangi* 'palm frond', *fangiyek* 'a palm frond').

[1] Dhivehi is the official language of the Republic of Maldives of which there are about 250,000 speakers. The Maldives is a nation consisting of over 1200 atoll islands in the Indian Ocean, south of India and west of Sri Lanka.

[2] Neither Hock's (1986) nor Hayes's (1989) typological studies of compensatory lengthening include one of this type.

(3) Coronals:

	anterior	distributed
t, d, l	+	
ʈ, ɖ, ɭ, r	−	−
tʃ, dʒ	−	+
n		

The nasal is not specified for [anterior] or [distributed], because there are no other coronal nasals (i.e., retroflex) with which it contrasts. Both /l/ and /ɭ/ contrast with the other coronals by being [+lateral], a feature I tentatively assume is not dominated by [coronal] (cf. McCarthy 1988, Kenstowicz 1994).

While /f/, /ʃ/, and /h/ contrast with segments /p/, /ʈ/, and /s/ respectively, this contrast is lost in geminate forms where only the latter occur:

(4) | | Contrasts | Neutralization |
|---|---|---|
| /f/ and /p/: | /faan/ 'light', /paan/ 'bread' | /gofi/ 'branch', /goyppek/ 'a branch' |
| /ʃ/ and /ʈ/: | /koʃanii/ 'cut', /koʈari/ 'room' | /koʃi/ 'cage', /koʈʈek/ 'a cage' |
| /h/ and /s/: | /aharu/ 'year', /asaru/ 'effect' | /mehi/ 'fly', /messek/ 'a fly' |

The palatals /tʃ/, /dʒ/, and /ɲ/ primarily occur in loan words (e.g., tʃooku 'chalk', dʒagu 'jug', and ɲamuɲamu[3] 'a kind of fruit'), and in geminate forms that are the result of the process described in Section 3 (e.g., fattʃek 'a seam', roddʒek 'a thread', and faɲɲek 'a worm'). Thus, /tʃ/, /dʒ/, and /ɲ/ are in complementary distribution with /t/, /d/, and /n/ in this environment.

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[3] This is the only word in which an intervocalic /ɲ/ appears. I tentatively include the /ɲ/ in the phoneme inventory as it is represented in Thaana, the Dhivehi writing system (Gair and Cain 1996).

2.2 Constraints on Dhivehi Syllable Patterns

Dhivehi has the following syllable patterns:

(5) Light: (C)V   /de/   'two'   /e/   'that'

     Heavy: (C)VC   /dan/   'watch (of time)'   /us/   'high'

     Super Heavy: (C)VV   /hau/   'rooster'   /aa/   'new'

                     (C)VVC   /daan/   'to go'   /ain/   'school of fish'

Except in cases of gemination, codas are restricted to /t/, /ʃ/, /k/ (which all become [ʔ] in that environment), /s/, and /n/. The /n/ in the coda becomes homorganic with a following consonant, but [ŋ] word finally. But for /f/, /ʃ/, /h/, and /ɲ/, all consonants are found as lexical geminates. The following examples illustrate lexical (monomorphemic) geminates:

(6) Monomorphemic geminates:

/p/	/bappa/	'father'	/r/	/sirru/	'secret'
/b/	/obbun/	'pressuring'	/ʈ/	/veʈʈun/	'falling'
/m/	/mamma/	'mother'	/ɖ/	/uɖɖun/	'open side up'
/v/	/bevvun/	'placing'	/ɭ/	/seɭɭi/	'flea'
/t/	/batti/	'lamp'	/tʃ/	/kattʃi/	'small intestine'
/d/	/buddi/	'mind'	/dʒ/	/raaddʒe/	'country'
/n/	/anna/	'coming'	/y/	/iyye/	'yesterday'
/s/	/kissaru/	'boat carpentry'	/k/	/fakkaa/	'good'
/z/	/izzat/	'respected'	/g/	/diggaa/	'hibiscus (tree)'
/l/	/ellun/	'throwing'			

As Dhivehi has super-heavy syllables, lexical geminates after long vowels are permitted: *raaddʒe* 'country', *aadiitta* 'Sunday', *aammu* 'general', *kooʈʈee* 'fort'. There is thus no restriction on trimoraic syllables as such.

Dhivehi does not allow consonant clusters in the onset or the coda and thus conforms to the *Complex constraint in relation to consonants:

(7)   *Complex (*COMP)

No more than one C or V may associate to any syllable position node.

(Prince and Smolensky 1993)

Words borrowed from other languages which feature consonant clusters are adapted to Dhivehi's syllable structure by the addition of /u/: *brush* becomes *burus*. In terms of OT, the *Complex constraint for consonants is undominated (Prince and Smolensky 1993).

Since Dhivehi employs epenthetic segments in order to make words conform to its syllable structure, it must be the case that the DEP-IO constraint is violable. The DEP-IO constraint is as follows:

(8)   DEP-IO

Every segment of the output has a correspondent in the input.

(Prohibits phonological epenthesis.) (McCarthy and Prince 1996)

Dhivehi also uses epenthetic /y/ at the juncture of stems and suffixes in order to break up unpermitted hiatus between vowels. For example, *miihaa* 'person' followed by the dative *-aʃ* becomes *miihaayaʃ* 'to the person'. The epenthetic /y/ is used to give the suffix an onset which conforms to the Onset constraint:

(9)   Onset (ONS)

Syllables must have onsets. (Prince and Smolensky 1993)

Since epenthetic /y/ is used to create an onset, it must be the case that ONS outranks DEP-IO. It is more optimal to add a segment than it is to have onset-less syllables at least with suffixes. On the other hand, vowels are not deleted in order to create onsets. Dhivehi does have syllables without onsets word initially (e.g., *akuru* 'letter'). ONS must be dominated by MAX-IO:

(10) <u>MAX-IO</u>

> Every segment of the input has a correspondent in the output. (No phonological deletion.) (McCarthy and Prince 1996)

Taking these three constraints pertaining to suffixation together, the following relative ranking is obtained: MAX-IO >> ONS >> DEP-IO.[4] This constraint ranking is illustrated in the following tableau:

(11) Constraint Satisfaction in *fa ̣iyek* 'an oar':

/fa ̣i/ + /ek/ 'an oar'	MAX-IO	ONS	DEP-IO
a. ☞ fa ̣iyek			*
b. fa ̣iek		*!	
d. fa ̣ek	*!		

The tableau in (11) shows the ranking of the constraints for retroflex segments followed by /i/. When the /i/ must remain, an epenthetic /y/ is added to prevent hiatus as seen in *fa ̣iyek* 'an oar' (see (17) below for additional examples). To account for the palatalization and gemination patterns, however, several other constraints must be taken into consideration. These are detailed in the later sections.

3   Palatalization and Gemination Facts: The Data

Dhivehi has a number of vowel initial suffixes, and all of them affect consonant plus –*i* stems in the same way. The following illustrates *loobi* 'love' with both vowel initial and consonant initial suffixes. Note that only vowel initial suffixes induce the palatalization (or diphthongization):[5]

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[4] The constraint ranking as stated here only applies to suffixation. Ultimately, additional constraints are needed to account for syllable structure as it pertains to stems versus suffixes. If it were always more optimal to add a segment than to go without an onset, then forms such *akuru* 'letters' would not occur. For this present study, I deal with suffixation only.

[5] Hereafter I use the term "palatalization" to include the diphthongization of the preceding syllable nucleus as well as a convenient way to refer to /i/'s impact on either preceding consonants or vowels.

(12)   With vowel initial suffixes: With consonant initial suffixes:

       looybb*ek* 'love-Indefinite'   loobi*n* 'love- Instrumental'

       looybb*akii* 'love -Equative marker'   loobii*ge* 'love-Genitive'[6]

       looybb*aʃ* 'love-Dative'   loobii*gai* 'love-Locative'

       looybb*aku* 'love-Unspecified marker'

While all vowel initial suffixes induce the palatalization, only examples with the suffix *–ek* 'indefinite' are given below for simplicity of presentation. The indefinite is especially useful for this purpose as it can adjoin any noun or adjective, and must do so, in fact, in cases of negation (Cain 2000: 127-128).

The data in this section reveal that /i/ deletes only when it can leave a trace of itself behind in terms of both its features and moraic weight. Both are essential. In (13), the dental (coronal, +anterior) consonant preceding the *–i* palatalizes and lengthens, and the *–i* as a segment is lost.

(13)   Palatalization and Gemination with Dentals [coronal, +anterior]:

eti	'thing'	ettʃek	'a thing'
rodi	'thread'	roddʒek	'a thread'
fani	'worm'	faɲɲek	'a worm'
duni	'bow'	duɲɲek	'a bow'
fali	'oar'	fayyek	'an oar'

When the preceding consonant is either labial or velar, the *–i* trace is manifested as an off-glide on the vowel of the preceding syllable, but the consonant preceding the /i/ still lengthens:

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[6] Stem final /i/ lengthens before suffixes *-ge* 'Genitive' and *-gai* 'Locative' (cf. *aharen* 'I', *aharenge* 'mine').

(14) [y] off-glide (diphthongization) and gemination for non-coronals:

Labials:	abi	'wedge'	aybbek	'a wedge'
	niyami	'navigator'	niyaymmek	'a navigator'
	kurafi	'roach'	kurayppek	'a roach'
	avi·	'sunlight'	ayvvek	'some sunlight'
Velars:	boki	'bulb'	boykkek	'a bulb'
	buraki	'perch (fish)'	buraykkek	'a perch'

Note that the prenasalized stops pattern with their non-nasalized counterparts except that in their case the segment changes to a full nasal plus stop rather than a geminate:

(15)
Prenasalized coronal:	ka^{n}di	'porridge'	kandʒek	'porridge'
Prenasalized labial:	a^{m}bi	'wife'	aymbek	'a wife'
Prenasalized velar:	fu ̹a^{n}gi	'flying fish'	fu ̹ayngek	'a flying fish'

These palatalization patterns also hold when the preceding syllable is CVV, creating a super-heavy syllable as a result:

(16)
Dentals:	doodi	'ray'	dooddʒek	'a ray'
	duuni	'bird'	duuɲɲek	'a bird'
Labials:	loobi	'love'	looybbek	'a love'
Velars:	vaagi	'strength'	vaayggek	'strength'

There are some i-ending words which retain the final *–i* before vowel-initial suffixes, and an epenthetic /y/ breaks up the hiatus of the vowels. The palatalization process appears to be blocked. There are two types. The first type consists of words which end in /i/ preceded by a retroflex consonant [coronal, –anterior, –distributed]:

(17)   No Palatalization and No Gemination with Retroflex Segments:

buri   'tier'   buriyek   'a tier'

faḷi   'slice (n.)'   faḷiyek   'a slice'

baḍi   'gun'   baḍiyek   'a gun'

The second type features a closed penultimate syllable. The mora-bearing consonant in the coda position of the preceding syllable appears to block the palatalization process. The /i/ is retained, and an epenthetic /y/ is inserted between the /i/ and the ending:

(18)   No Palatalization and No Gemination with CVC Penultimate Syllables:

Labials:	nappi	'bad food'	nappiyek	'bad food'
	bimbi	'millet'	bimbiyek	'millet'
Dentals:	batti	'light'	battiyek	'a light'
	buddi	'mind'	buddiyek	'a mind'
	bonti	'unopened frond'	bontiyek	'an unopened frond'
	kulli	'emergency'	kulliyek	'an emergency'
	dʒinni	'jinni'	dʒinniyek	'a jinni'
Velars:	fangi	'frond'	fangiyek	'a frond'

The data in (18) reveal that /i/'s features cannot merge across non-coronal consonant clusters to form an off-glide, nor can they palatalize preceding dental (coronal, +anterior) segments that are second members of a consonant cluster. Thus, it is the mora-bearing quality of the preceding syllable's coda that prevents any type of feature spreading from /i/, rather than the place features of the preceding consonants.

The data in this section suggests the following generalizations that need to be accounted for in the phonology:

- There should be a principled way to determine which types of C–i words feature palatalization cum gemination, and which ones do not.
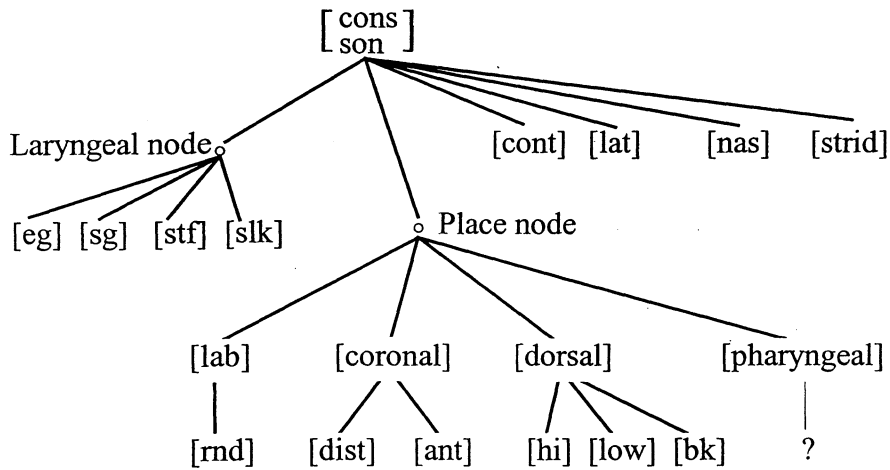
- Of those which feature palatalization cum gemination, there needs to be a principled way to determine which words feature palatalization of the preceding consonant, and which ones feature *y* off-glide in the preceding syllable.

- The palatalization of preceding consonants and syllable nuclei, the deletion of the −*i* as a segment, and the lengthening of the previous consonant must be related in a principled way for all three are intricately related.

In a constraint-based framework like Optimality Theory, we can incorporate the insights of Feature Geometry (McCarthy 1988) and Moraic Theory (Hayes 1989), and find principled reasons for the Dhivehi surface forms. OT accounts for language through a number of constraints on well-formedness. These constraints are violable, but only minimally so. Candidates from a single lexical form are evaluated according to the ranking of these constraints, and the most optimal candidate wins as the surface form (McCarthy and Prince 1993b). Most of this paper is given to identifying the constraints needed to account for Dhivehi palatalization facts, and establishing their ranking.

4   A Feature Geometry for Coronals and the No-Crossing Constraint (NCC)

From the data above, it is clear that the vowel −*i*, and some of the coronals that precede it interact in a significant way. Namely, if the preceding consonant is [coronal] and [+anterior], it becomes palatalized (and affricated) when a vowel initial suffix is added to the stem ending in −*i*. If the coronal is [−anterior] however, as the retroflex consonants indeed are, the −*i* cannot delete. This suggests a formal relationship between the −*i* and the coronal place node. Clearly the features involved are related, and Feature Geometry, which formalizes a feature hierarchy into classes which interact would best capture this intuition. In some models of Feature Geometry, however, it is not entirely clear how the interaction of vocoid features and consonant features is accounted for. The feature hierarchy given in (19) is primarily based on McCarthy (1988) and Kenstowicz (1994) and is illustrative of this difficulty.

(19) Feature Geometry

$$\begin{bmatrix} \text{cons} \\ \text{son} \end{bmatrix}$$

Laryngeal node

[eg] [sg] [stf] [slk]   Place node

[cont] [lat]   [nas]   [strid]

[lab]   [coronal]   [dorsal]   [pharyngeal]

[rnd]   [dist] [ant]   [hi] [low] [bk]   ?

The focus of our attention is the [coronal] place feature. In (19), and accounts like it, the vocalic features relating to tongue height are found as dependents of [dorsal]. There is no direct relationship between the [dorsal] and [coronal]. As a result, phonological processes in which typical vocalic features and consonantal features interact are not taken into account. Coronal consonants and vowels, especially front ones, interact in many phonological processes cross-linguistically (e.g., Latin $s \rightarrow \int$ before $-i$). Given such representations as (19), front vowels would be [−back] under [dorsal], and coronals would not have access to it (Lahiri and Evers 1991). In response to this problematic result, various modifications of the feature geometry have been proposed. Clements (1991) has proposed that the same articulator features can be used for both consonants and vowels. Back vowels, for example, are [dorsal], but front vowels are [coronal]. Since front vowels are [coronal], their interaction with coronal consonants is accounted for by sharing the same feature. The same feature, however, is under two different place nodes: a consonant one and a vocoidal one. This approach has undergone various modifications, but this distinction between a C-place (consonant) and a V-place (vocalic) remains central (Hume 1992, Clements and Hume 1995). (20) shows those features that pertain to the interaction of /i/ with coronals.

(20) Feature Geometry of Clements and Hume (1995):
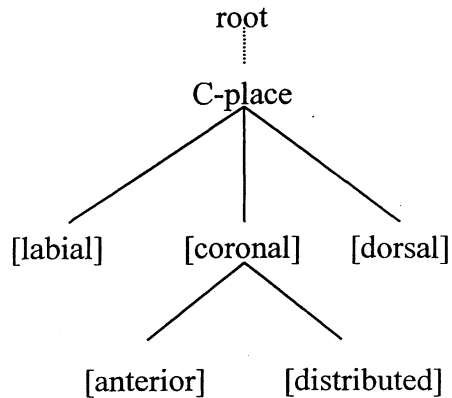
(a) Consonants: (b) Vocoids:
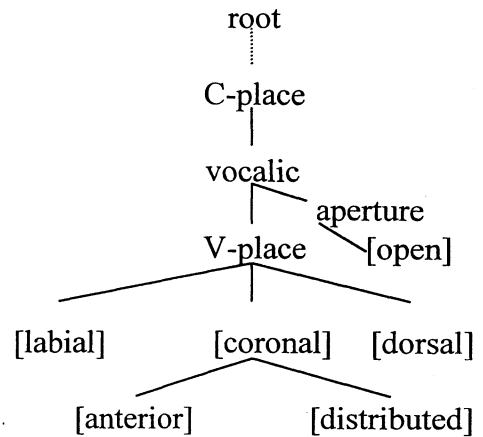
A modification of Clements's approach has been offered by Lahiri and Evers (1991) who build on Clements's model, but reject the notion that the same features are under different nodes. They argue that this complication draws an unnecessary and redundant distinction between vowels and consonants, fails to motivate what Clements calls "tier promotion" by which a consonant's secondary articulation becomes primary, and predicts wrong results and suspect processes (e.g., all types of vowel induced palatalization are claimed to be preceded by consonants having secondary articulations). They offer a more straightforward approach. The place node is divided into articulator node and tongue position node. The tongue position node dominates the traditional tongue height positions, and the articulator node dominates the features [labial], [coronal], [dorsal], and [radical]. The relevant features discussed in this paper are given below in terms of the geometry proposed by Lahiri and Evers in (21):

(21)   Feature Geometry of Lahiri and Evers (1991)

root

Place node

Articulator node

Tongue Position node

[hi] [low]

[lab]   [coronal]   [dorsal]   [radical]

[rnd]   [dist]   [ant]
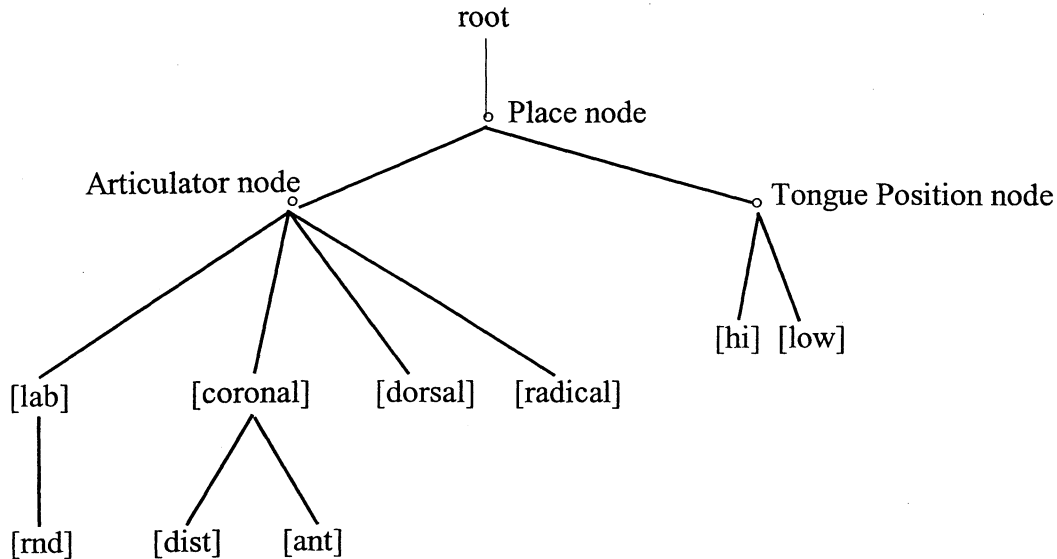
As will be demonstrated in the following discussion, the feature geometry which best accounts for the Dhivehi palatalization facts is the one proposed by Lahiri and Evers as opposed to that of Clements and Hume, and it is the former that I adopt in this analysis.

With the configuration of (21), we have a way to account for the interaction of −*i* with various consonants in Dhivehi that is not available in (20). First, I illustrate how the model in (21) accounts for the palatalization of *rodd͡ʒek* 'a thread'. Then, I show how off-glide formation is accounted for in words like *aymbek* 'a wife'. And finally, I examine how retroflex consonants fail to palatalize in words like *baḍiyek* 'a gun'. Below are sample feature configurations depicting the ability or inability of −*i*'s [coronal [−anterior]] features to spread. For simplicity of presentation I only give the features from the place node down (A= Articulator node, TP= Tongue position node):

(22)   rodd͡ʒek 'a thread'

ro d   i   + ek

Place

A   A   TP

[cor]   [cor]   [+hi]

[+ant]   [−ant]
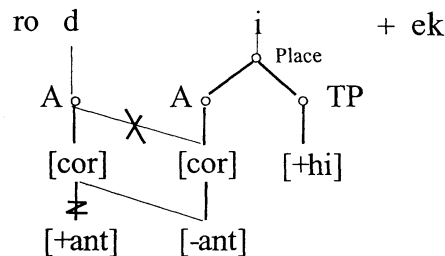
In (22), I show that [+anterior] under the [coronal] of the /d/ is delinked, and the [−anterior] of /i/ also under [coronal] spreads to the preceding /d/.[7] The presence of [−anterior] produces /dʒ/. The /d/ also obtains the feature [+continuant] in addition to its already existing [−continuant] to render it as an affricate /dʒ/. I assume the [+continuant] to be predictable for palato-alveolar affricates (Lahiri and Evers 1991). Thus, the [−anterior] is all that is needed to signal the trace of /i/. Note, too, that the [coronal] feature of /i/ cannot spread past /d/, with which it shares place, to form an off-glide on the preceding vowel. The geometry of (21) accounts for the data in (13) above. For laterals that become /y/ (i.e., *fali* 'oar', *fayyek* 'an oar'), I assume that after the spread of −*i*'s [−anterior] feature, the [lateral] feature is lost. Dhivehi does not have a palatalized lateral.
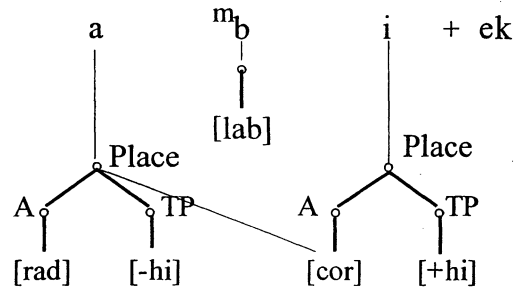
For the interaction of /i/ with preceding non-coronals, a different result obtains. The [coronal] feature of /i/ bypasses the preceding non-coronal consonant, and attaches to the vowel of the preceding syllable. (23) and (24) illustrate this process with a preceding velar and labial respectively:

(23)   boykkek 'a bulb'
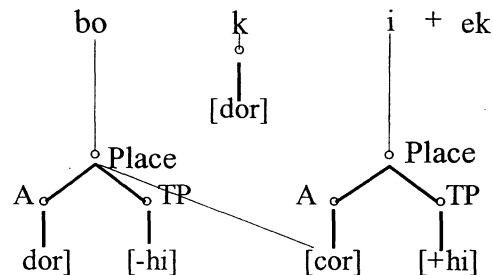
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(24)   aymbek 'a wife'

With both velars and labials, the [coronal] of /i/ fails to form complex segments with either (i.e., */kʸ/ and */bʸ/). As Dhivehi has no complex consonants featuring multi-linked place, the formation of /y/ following /k/ or /b/ together with gemination would create a complex onset (e.g. */bokkyek/ and */ambyek/). The *ComplexOnset constraint, however, is undominated, and such formations are prohibited (see Section 2.2). For the /i/ to leave a trace, it must do so on the preceding vowel. I assume for the examples above that when the [coronal] of /i/ retracts to the nucleus of the preceding syllable, a new articulator node is interpolated under the place node as required to preserve well-formedness (Clements and Hume 1995). Thus, the representation of /oy/ and /ay/ diphthongs in Dhivehi is as follows:

(25)   Diphthong Representation:
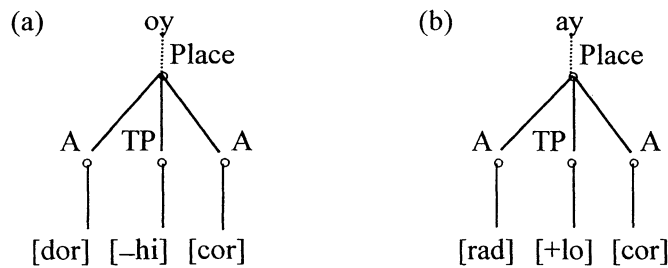
This depiction of Dhivehi diphthong facts is independently corroborated by /t/'s behavior word finally with a preceding vowel. When /t/ occurs word finally, it is realized as a glottal stop [ʔ] preceded by a *y* off-glide: *fot* [foyʔ] 'book', *fotek* 'a book'; *at* [ayʔ] 'hand', *atek* 'a hand'. Thus, the /t/ loses its place node word finally, but not without

leaving a trace of itself behind as a coronal feature on the preceding vowel. Note that for diphthongs, only [coronal] attaches to the vowel, and the [anterior] specification is irrelevant.

The reason the coronal feature can retract to a preceding vowel in (23) and (24) is because the intervening consonants are [dorsal] and [labial] respectively. When the preceding consonant is [coronal], however, such retraction is not possible. The [coronal] of the /i/ cannot cross the [coronal] of the consonant. This would cause a violation of the line crossing prohibition (Goldsmith 1976, McCarthy 1988). Clements and Hume cast this prohibition as a constraint as follows (1995: 295):

(26)   No-Crossing Constraint (NCC)

Association lines linking two elements on tier *j* to two elements on tier *k* may not cross.

This constraint prevents the [coronal] from spreading across a segment already specified as [coronal]. While consonants that are both [coronal] and [+anterior] (i.e., /t/, /d/, /n/, etc.) block the [coronal] from retracting to the previous vowel, the [−anterior] of the /i/ can still spread to the consonant after its [+anterior] feature is delinked. I assume that features spread minimally and that the [−anterior] feature is sufficient as a trace of /i/ with preceding [coronal, +anterior] segments. This yields the affricates as illustrated in (22). A different result obtains with consonants that are retroflex: *baḍiyek* 'a gun'. The [coronal] of retroflex consonants blocks the retraction of /i/'s [coronal], and the [−anterior] of /i/ cannot spread to retroflex consonants as they are already specified as [−anterior].[8] Since the /i/ is unable to leave any trace of itself, it must remain. The resulting hiatus is broken up with the epenthetic /y/.

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[8] Alternatively, one could claim that the [-anterior] feature does spread, but its effect is vacuous. However, I maintain that the ability of the /i/ to delete critically depends upon its ability to spread one or more of its features. That the [-anterior] feature of /i/ does not spread to /ḍ/ is consistent with this generalization. This holds as well for the flap *-r* which is [-anterior]: *buri* > *buriyek* 'a tier'.

(27)   baḍiyek 'a gun'

As the above examples have illustrated, with the feature geometry model of Lahiri and Evers, we can account for the Dhivehi palatalization facts in terms of the No-Crossing Constraint. This is not possible with the feature geometry proposed by Clements and Hume. As seen in (20) above, the [coronal] of /i/ and the [coronal] of the consonants are not in the same place in the geometry, and because they are not, the [coronal] of the one should not have any blocking effects on the [coronal] of the other. Clements and Hume explicitly state (1995: 283) (emphasis mine):

> By grouping all place and aperture features of vocoids under the vocalic node, *we predict that all these features should be able to spread freely across intervening consonants, even if they are specified for place features of their own.* This is because consonants (at least those with no secondary articulations...) have no vocalic node that would block them.

Clearly, the Dhivehi palatalization facts run counter to Clements and Hume's prediction. Under their proposal we would expect such illicit forms as **bayḍḍek* 'a gun' and **royddek* 'a thread' where the [coronal] feature of /i/ crosses the [coronal] feature of /ḍ/ and /d/ respectively. The Dhivehi facts indicate that the [coronal] of both /i/ and the consonants occupy the same place in the feature geometry.[9]

In this section, I have shown that given the right feature geometry, the No-Crossing Constraint (NCC) plays a critical role in accounting for Dhivehi palatalization facts. It is

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[9]The feature geometry of Lahiri and Evers is not without problems, however. Hume rightly points out that their model fails to account for vowel harmony across coronal consonants (Hume 1992: 115-17). Interestingly, Dhivehi does not have vowel harmony of this type. Perhaps there is a cross-linguistic correlation between blocking effects and the lack of vowel harmony.

necessary, therefore, to incorporate the NCC into a constraint-based analysis of Dhivehi palatalization facts. The NCC is not dominated. The addition of the NCC together with MAX-IO, ONS, and DEP-IO partially accounts for the data as illustrated in the following tableau:

(28)   Partial Constraint Satisfaction in *roddʒek* 'a thread':

/rodi/ + /ek/ 'a bulb'	NCC	MAX-IO	ONS	DEP-IO
a. ☞ roddʒek		(?)		
b. rodiyek				*!
c. rodiek			*!	
d. rodek		*!		
e. roydek	*!			

What (28) fails to indicate is how a form like *roddʒek* showing the deletion of /i/ is not a MAX-IO violation. This is taken up in the next section.

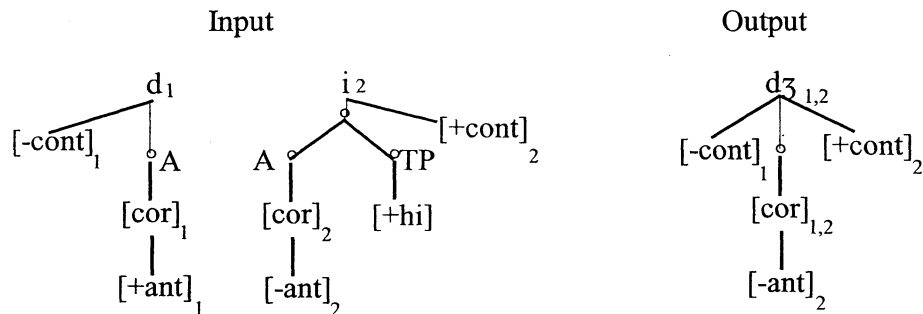## 5   *Multiple Correspondence and Coalescence

In the foregoing discussion of the feature geometry needed to account for Dhivehi palatalization, the No-Crossing Constraint (NCC) proved to be crucial. In addition to the NCC, other constraints are needed to fully account for the facts. The data show that the /i/ does not delete unless it can leave some trace of itself by either creating a diphthong in the nucleus of the preceding syllable, or by palatalizing the preceding consonant. A constraint is needed then that makes a critical distinction between deleting a segment entirely (a MAX-IO violation) and leaving some trace. For languages in which MAX -IO dominates DEP-IO, leaving a trace of a segment should be more optimal than deleting the segment altogether, because less gets deleted. To capture this intuition, Lamontagne and Rice (1996) have proposed a way to make such a distinction by introducing the Multiple Correspondence (*MC) constraint:

(29)   *Multiple Correspondence (*MC)

Elements of the input and the output must stand in a one-to-one correspondence relationship with each other. (Lamontagne and Rice 1996: 218)

Whereas MAX-IO states that every segment of the input has a correspondent in the output (McCarthy and Prince 1996), the *MC constraint assumes that the features of the I-O segments are also in a correspondence relation. When two segments coalesce as one in the output, the features of two segments merge into one. This is a *MC violation because the features of the output are no longer in a one-to-one correspondence with the features of the input. In (30) /d/ and /i/ of the input have features which correspond with themselves as indicated by the indices, but the output of [dʒ] has features which correspond to both /d/ and /i/. This results in a *MC violation:

(30)   Coalescence of /d/ and /i/ (A= Articulator node, TP= Tongue position node):

Input   Output

d_1 i_2 $dʒ_{1,2}$

$[-cont]_1$ A   A $[+cont]_2$ $[-cont]_1$ $[+cont]_2$
             TP

$[cor]_1$ $[cor]_2$ $[+hi]$ $[cor]_{1,2}$

$[+ant]_1$ $[-ant]_2$ $[-ant]_2$

Example (30) illustrates coalescence of a vowel to a consonant as seen in such words as *roddʒek* 'a thread'. Similarly in such words as *aymbek* 'a wife' from $a^{m}bi$ plus *–ek*, /ay/ is the result of coalescence of the /a/ and /i/. When any feature of the /i/ merges with either the preceding consonant or vowel of the preceding syllable, a violation of *MC is incurred. These are not MAX-IO violations, however, because the features of the input are still present in the output. In (31), I repeat (28) with the addition of the *MC constraint. As seen in the tableau, the winning candidate does not violate Max-IO.

(31)   Constraint Satisfaction in *roddʒek* 'a thread':

/rodi/ + /ek/ 'a thread'	NCC	MAX-IO	ONS	DEP-IO	*MC
a. ☞ roddʒek					*
b. rodiyek				*!	
c. rodiek			*!		
d. rodek		*!			
e. roydek	*!				

In this section, I have shown that the *MC constraint is necessary to make a critical difference between deleting a segment altogether, and leaving a trace of a segment in the form of coalescence. Since it is better to have multiple correspondence of features than it is to delete a segment, MAX-IO ranks higher than *MC. What remains is to account for the compensatory lengthening, and this is taken up in the next section.

6   Moraic Prominence and Compensatory Lengthening in Dhivehi

Having identified the feature geometry needed to account for Dhivehi palatalization, I now present an analysis of the gemination. First, I illustrate gemination as compensatory lengthening in terms of a moraic account. Then, I draw upon proposals by Zec (1995, 1996) to account for these facts in terms of OT constraints.
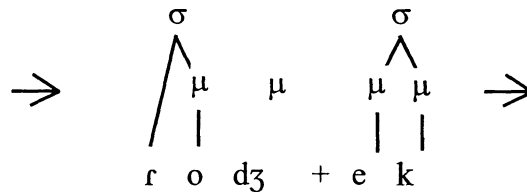
In derivational accounts, compensatory lengthening (CL) is the result of segment deletion with subsequent lengthening of a neighboring segment. Thus, CL is the result of rule ordering. In Hayes's moraic account of CL, the principle of "parasitic delinking" plays a critical role. Parasitic delinking states that syllable structure is deleted when the syllable contains no overt nuclear segment (Hayes 1989: 268). With the syllable structure obliterated, the mora that was in that syllable is free to associate with another syllable. This process is illustrated in (24) with *rodi* 'thread':
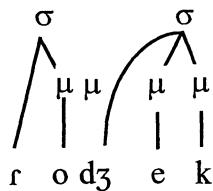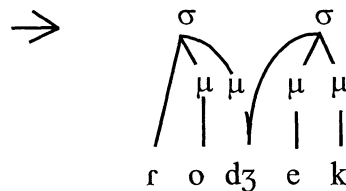
(32)   Compensatory Lengthening:

Input: Parasitic Delinking:

σ   σ   σ   σ   σ

μ   μ   μ μ   →   μ   μ   μ μ   →

ɾ o d i + e k   ɾ o dʒ + e k
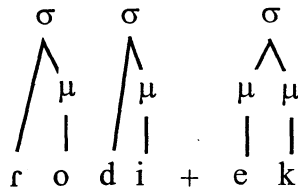
Resyllabification: Compensatory Lengthening:

σ   σ   →   σ   σ

μ μ   μ μ   μ μ   μ μ

ɾ o dʒ e k   ɾ o dʒ e k

The above rather straightforward account of compensatory lengthening is difficult to replicate within the OT framework given the more traditional repertoire of constraints. In Prince and Smolensky (1993) and other early OT accounts, segment deletion is treated as a violation of Parse. If a segment has no proper node dominating it, then the segment is unparsed, and unparsed segments have no phonetic realization (Prince and Smolensky 1993). This account of deletion fails to account for CL. Zec (1996) points out that a paradox is created by requiring the inclusion of a segment into syllable structure on the one hand, but ultimately prohibiting the occurrence of that segment on the other. Taking the alternation of *rodi* 'thread' and *roddʒek* 'a thread' as an example, the /i/ fails to have phonetic realization because it is unparsed, a Parse violation. But, if the /i/ is not parsed, then there must not be any mora dominating it. If there is no mora that is re-associated, then there is no explanation for compensatory lengthening.

The rectify this problem, Zec proposes the Moraic Prominence constraint (1995). Descriptively, this constraint states that segments project moras because of their sonority relationship with following segments. If a segment is at least equal in sonority to an adjacent segment, it projects a mora.

(33) Moraic Prominence (MORPRO)

Segment r_i projects a mora iff it is not followed by a more sonorous segment r_j.

μ

r_i r_j Condition: Son $(r_i) \geq$ Son (r_j) (Zec 1995, 1996)

In this scenario, GEN freely assigns moras to segments, but these output forms are evaluated by Moraic Prominence (MORPRO). MORPRO also expresses a faithfulness relation in that the moras projected by sonority relations of input segments are preserved in the output even when the segment responsible for the mora projection is lacking in the output. Thus, while the deletion of a segment violates Parse (or MAX-IO), a violation of MORPRO is incurred when the mora is also deleted or unparsed. Descriptively, the mora projected by the segment can remain even when the segment is deleted.

MORPRO works in tandem with MAX-IO, and four other constraints to account for compensatory lengthening:

(34) Dominance (DOM)

A mora must be filled with (i.e., must dominate) a segment.   (Zec 1996)

(35) Structural Coherence

Moraic positions have to be filled locally.   (Zec 1996)

With the Dominance constraint, moras that dominate segments are optimal. If a mora does not dominate a segment, and thus is phonetically unrealized, a DOM violation obtains. Given that a mora must dominate a segment, the question remains as to which segment it will dominate. Structural Coherence states a locality constraint of dominance. But, conformity to Structural Coherence can be expressed in one of two ways: the mora can dominate an adjacent vowel, or it can dominate an adjacent consonant. What determines the choice between these two is the relative ranking of two other constraints:

(36) *Sonority Plateau (SONPLAT)

Segments dominated by tautosyllabic moras may not exhibit a sonority plateau.

(37)   *Sonority Fall (SONFALL)

Segments dominated by tautosyllabic moras may not exhibit a descending

sonority.   (Zec 1996)

A sonority plateau occurs when two non-lexical moras showing the same degree of sonority are found in the same syllable. A violation of *Sonority Plateau is incurred if long vowels are the result of compensatory lengthening. A sonority fall occurs when two non-lexical moras showing descending sonority are found in the same syllable. A violation of *Sonority Fall is incurred whenever consonants geminate as a result of compensatory lengthening. For the case of Dhivehi *SONPLAT dominates *SONFALL, and the result of the mora re-association is a geminate consonant in every case of compensatory lengthening.

One important caveat bears mentioning here. MORPRO, *SONPLAT, and *SONFALL only apply to moras inserted by GEN, and not to lexical moras. Lexical moras are found in lexical forms exhibiting either long vowels or geminate consonants (Zec 1996). Dhivehi has both. These forms are represented by moras with the subscript (L) indicating that they are lexical:

(38)   Lexical Moras in Dhivehi:

faa 'type of jungle'   batti 'light'
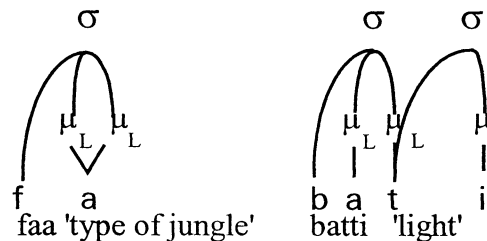
With these constraints, we have a way to account for the compensatory lengthening found in the Dhivehi palatalization phenomena. First of all, we assume that the MORPRO constraint is undominated (Zec 1996). It is also clear for Dhivehi that *SONPLAT ranks higher than *SONFALL. The most relevant constraints for compensatory lengthening are

illustrated in (39). (A thin vertical line between constraints indicate that the constraints have not been ranked in relation to each other.):

(39)   Tableau for Compensatory Lengthening:

/rodi/ + /ek/ 'a thread'	MORPRO	MAX-IO	DOM	*SONPLAT	*SONFALL
a. ☞ roddʒek					*
b. rodʒeek				*!	
c. μ rodʒek			*!		
d. roddek		*!			
e. rodek	*!	*			

In (39e), *rodek* is a violation of both MORPRO and MAX-IO in that both the segment and the mora are absent in the output. By definition a MORPRO violation will always be a MAX-IO violation since the former also deals with faithfulness (Zec 1996). In (39d), *roddek* conforms to MORPRO, but fatally violates MAX-IO since /i/ is not retained in any form. All the other candidates conform to MAX-IO, but violate low-ranking *MC as they show palatalization. In (39c), *rodʒ $^{\mu}$ek* violates Dominance as the mora does not dominate a segment. Critically, *SONPLAT dominates *SONFALL as the winning candidate in (39a), *roddʒek*, indicates in its defeat of the contender *rodʒeek*, in (39b). The relative ranking of MAX-IO, DOM, and *SONPLAT with other constraints is given in the next section.

7 Constraint Ranking

In the foregoing discussion, I have shown how the No-Crossing Constraint (NCC) and the *Multiple Correspondence (*MC) constraint are needed to account for Dhivehi palatalization; and how Moraic Prominence (MORPRO), Dominance (DOM), Structural Coherence and *Sonority Plateau (*SONPLAT) are needed to account for compensatory

lengthening. In this section, I show how these constraints interact with Max-IO, Ons, and Dep-IO to render a full account of the Dhivehi data.

Among the highest ranking constraints, four are apparently undominated in Dhivehi: *Complex (*Comp), No-Crossing Constraint (NCC), Structural Coherence, and Moraic Prominence (MorPro). The NCC and Structural Coherence are akin since they both prohibit line crossing (Zec 1996). Since these two constraints essentially do the same work, I tentatively collapse them into the following *Cross constraint:

(40)   *Cross

> Association lines may not cross.

As prohibitions on line crossing are universal, the *Cross constraint is undominated. Putting the undominated constraints together with the lower ranked constraints, we come up with the following ranking:

(41)   Ranking of Constraints in Dhivehi:

*Comp	>>	Max-IO	>>	Ons	>>	Dep-IO	>>	*MC
MorPro				Dom, *SonPlat				*SonFall
*Cross								

Constraints on the left outrank those to their right, but constraints within the same column are not ranked in relation to each other. The constraints in the first row have a bearing on Dhivehi syllable structure and palatalization, and those in the second row account for compensatory lengthening as gemination. The *Cross constraint interacts with constraints that deal with both gemination and palatalization. The ranking of Dom and *SonPlat in relation to Max-IO has not been determined. I tentatively rank Max-IO higher. Recall that *SonPlat outranks *SonFall as discussed in Section 6. I place *SonFall with *MC, another low ranking constraint.

Critically, Dom and *SonPlat outrank Dep-IO in Dhivehi. At first blush, this appears odd in that it is not immediately apparent how constraints dealing with mora reassignment relate to a constraint against adding segments (Dep-IO). In the following tableau, I show that this must indeed be the case, and that the ranking I have given in (41)

is the correct one. The critical data that establish this ranking are words of the type found in (18) which feature Ci preceded by a closed syllable. I illustrate this constraint ranking with *bontiyek* 'an unopened frond' in the following tableau:

(42)   Constraint Satisfaction in *bontiyek* 'an unopened frond':

/bonti/ + /ek/ 'unopened frond'	*COMP	MORPRO	MAX-IO	ONS	DOM	*SON PLAT	DEP-IO
a. ☞ bontiyek							*
b. bontʃeek						*!	
c. bontʃek (μ)					*!		
d. bontiek				*!			
e. bonteek			*!			*	
f. bontek		*!	*				
g. bonttʃek	*!						

The winning candidate *bontiyek* violates DEP-IO with the addition of the epenthetic /y/, but this is done to insure conformity to ONS, a higher ranking constraint. Note especially the ranking of DOM and SONPLAT in relation to DEP-IO. If DEP-IO outranked DOM, (42c) *bontʃ$^{\mu}$ek* [bontʃek], whose mora has not been reassigned, would be the optimal candidate. Also, if DEP-IO outranked *SONPLAT, (42b) *bontʃeek* would win out, because having mora reassignment result in a long vowel (a sonority plateau) would be more optimal than adding an epenthetic /y/. Thus, it must be the case that DOM and *SONPLAT outrank DEP-IO. The possibility of a mora reassignment resulting in a geminate consonant, a low ranking *SONFALL violation, is prevented by the undominated *COMP constraint that does not permit consonant clusters in either the coda or onset as seen in (42g) *bonttʃek*. In addition, a form like *boontʃek* would violate *CROSS because the mora would not be reassigned locally. So, the ranking of the constraints as

given in (41) accords well with the data in (18) above where the Ci follows a closed syllable.[10] This ranking is also in harmony with the other palatalization and gemination patterns seen in the data as the following tableaux demonstrate:

(43)   Constraint Satisfaction in *roddʒek* 'a thread':

/rodi/ + /ek/ 'thread'	*CROSS	MORPRO	MAX-IO	ONS	DOM	*SON PLAT	DEP-IO	*MC
a. ☞ roddʒek								*
b. rodiyek							*!	
c. rodʒeek						*!		*
d. μ rodʒek					*!			*
e. rodiek				*!				
f. roddek			*!					
g. rodek		*!	*					*
h. roydek	*!				*			

---

[10] I have found only one word that does not conform to this pattern: *saanti* 'mat', *saantʃek* 'a mat'.

(44) Constraint Satisfaction in *boykkek* 'a bulb':

/boki/ + /ek/ 'bulb'	MORPRO	MAX-IO	ONS	DOM	*SON PLAT	DEP-IO	*MC
a. ☞ boykkek							*
b. bokiyek						*!	
c. boykeek					*!		*
d. μ̣ boykek				*!			*
e. bokiek			*!				
f. bokkek		*!					
g. bokek	*!	*					

8 Exceptional Data

While the constraints given above in their current ranking account for the data presented in Section 3, two exceptional cases remain unexplained, words ending in either /ʂi/ or /hi/. Such words when inflected with vowel-initial suffixes show compensatory lengthening from /i/ deletion but without any trace of palatalization:

(45) Gemination without Palatalization:

Coronal [–ant]:	kaʂi	'thorn'	kaṭṭek	'a thorn'
Glide:	fuhi	'boredom'	fussek	'boredom'

Given *kaʂi*, we would expect **kaʂiyek* in light of how other retroflex consonants behave, and in the case of *fuhi* perhaps **fuyssek* depending on how the /h/~/s/ alternation is treated. These examples run counter to the generalization that /i/ only deletes when it can leave a trace of its features behind. In terms of constraints, they show a ranking of ONS >> DEP-IO >> MAX-IO, for it is better to delete the /i/ altogether than it is to add a segment to form a an onset. The forms in (45) are reflexes of a diachronic change whereby /s/ and /ʈ/ became /h/ and /ʂ/ respectively between vowels, but in geminates they were retained. This is not the CL associated with the Dhivehi palatalization found in the

other data. Still, the question remains as to how a language can maintain DEP-IO >> MAX-IO for some types of words, but the reverse ranking for the vast majority.

9   Concluding Remarks

In this paper, I have given an OT account for Dhivehi coalescence (palatalization) and compensatory lengthening (gemination). First, I demonstrated that the type of feature geometry needed to account for the coalescence has to be one in which coronal consonants and /i/ share a common place in the geometry as evidenced by the opacity effects of coronals in relation to /i/. Having established the required geometry, I used the *Multiple Correspondence constraint (Lamontagne and Rice 1996) to deal with the palatalization facts in Dhivehi. Compensatory lengthening was handled through Moraic Prominence and related constraints (Zec 1995, 1996). I was then able to show how these constraints together with some of the more standard ones (e.g., ONS, DEP-IO, etc.) are ranked to yield the optimal candidates as found in the data. Critically, Dominance and *SONPLAT outrank DEP-IO in Dhivehi. The ranking of constraints dealing with compensatory lengthening in relation to a constraint against adding epenthetic segments proved necessary to achieve the correct output. Optimality Theory thus provides the means to account for the fascinating combination of phenomena found in Dhivehi palatalization.

With a derivational approach, however, the results are more equivocal. An account of which segments allow palatalization and which ones block it can be rendered by Feature Geometry (McCarthy 1988) given the right representation of coronals, and the gemination facts are easily accounted for as compensatory lengthening in Moraic Theory (Hayes 1989). However, derivational approaches fail to capture a significant generalization of the facts; namely, the /i/ can only delete if it can either palatalize the preceding segment, or form an off-glide on the previous vowel. In a derivational approach, a rule for /i/ deletion has to be ordered after palatalization, but the formal apparatus does not make it clear as to why the first rule feeds the second. Why is it the case that the /i/ which causes palatalization also deletes? In other words, how is it that

forms like *rodʒiyek 'a thread' do not surface? In the OT account, such a result would violate DEP-IO, and would thus give way to roddʒek.

An even more difficult problem arises in accounting for forms like bontiyek 'unopened frond' and nappiyek 'bad food' in derivational terms. Why is it the case that the /i/ can neither palatalize the /t/ of the former, nor form an off-glide for the latter? In the case of the failure of *bontʃek, it is reasonable to assume that because the /n/ is homorganic with /t/, the latter resists assimilating to /i/. But, such an analysis does not work in accounting for the failure of *nayppek. For this we would have to assume that somehow a consonant in the coda position blocks the retraction of any trace of /i/ to the preceding syllable. Thus, a derivational rule has to stipulate that both coronal consonants, and any other non-coronal which bears a mora, block /i/'s coalescence with the nucleus of the preceding syllable. Such a rule fails to capture any significant generalization, and the two types of blocking are not related in any interesting way.

While this OT approach overcomes many of the difficulties of a derivational one, it failed to account for all the facts, however. Forms such as kaaṭṭek 'a coconut' from kaaﬁ (where /i/ deletes without any kind of feature spreading) suggest a different ranking co-existing in its phonological system. How this could be the case is a matter for further study.

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