Context insensitive vowel hiatus resolution in Ciyao

Darren Scott Tanner

1 Introduction

When examining phonological processes that occur as a result of morpheme concatenation, many scholars have recognized a tendency for languages to avoid dissimilar vowel sequences arising from such situations. The processes that occur as repair strategies for this disallowed configuration, collectively known as hiatus resolution, can take many forms, including diphthong formation, consonant epenthesis, vowel deletion, glide formation, and vowel height coalescence (Clements 1986; Rosenthall 1994; Casali 1996; Ngunga 2000; Pulleyblank 2003; McCarthy and Prince 2004, and references cited in these articles). The Bantu language Ciyao (sometimes also called Yao) is one such language that bans vowel hiatus. In his analysis of Ciyao done within a framework of Lexical Phonology and Morphology (LPM), Ngunga (2000) notes that the language makes use of three of the above strategies in avoiding dissimilar vowel sequences, namely height coalescence, glide formation, and vowel deletion. Stated generally, he posits that vowel hiatus created by morpheme concatenation in Ciyao is resolved by coalescence when the first vowel is low, by glide formation when the first vowel is high or round, and by deletion when the first vowel is the mid front vowel /e/ (in this case, the second vowel is deleted in favor of preserving the initial vowel).

In addition to the LPM treatment of these three processes provided by Ngunga, other scholars working within a framework of Optimality Theory (Prince and Smolensky 1993) have offered accounts of hiatus resolution by showing that surface outputs can be accounted for in terms of optimal satisfaction of a universal set of violable constraints (Rosenthall 1994; Casali 1996; Pulleyblank 2003). Casali (1996) specifically treats a problem similar to that in Ciyao, where coalescence is said to be asymmetric, i.e., where sequences of /V_1 + V_2/ resolve differently depending on the feature specification of the two vowels: sequences of a low + high vowel coalesce to a mid vowel, while sequences with an non-low initial vowel resolve either by vowel deletion (as in Xhosa, Casali 1996) or glide formation (as in both Xhosa and Ciyao)[1]. Specifically, Casali posits that asymmetric coalescence arises when both feature-sensitive and position-sensitive constraints are active in the evaluation of output candidates; that is, the feature specification [-high] must be preserved in preference to [+high], otherwise all features of the V_2 are to be preserved (p. 63). However, Casali's analysis of these processes assumes that all such sequences arise as a result of prefix + stem concatenation as in Xhosa, so that V_2 is always a segment of the lexical stem. Therefore, he is free to posit high-ranking context-sensitive faithfulness constraints, requiring faithfulness to feature specifications in a root over general context-free faithfulness to feature specifications.

Ciyao, on the other hand, shows asymmetric coalescence that does not seem to be sensitive to root/affix distinctions, where prefix + stem processes pattern identically to stem + suffix and stem + infix processes; features of stem vowels do not have the same privileged status in Ciyao. Thus, Casali's stem-faithfulness analysis cannot properly account for asymmetric coalescence phenomena cross-linguistically, as he argues. In this paper I argue that asymmetric coalescence cannot be reduced to a single language type and go on to present an analysis of asymmetric coalescence in Ciyao which does not make crucial reference to the ordering of stem and affix; rather, I propose that height coalescence in this language is a result of segmental fusion, where two segments in the

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[1] In Ciyao, sequences of dissimilar high vowels are also resolved through glide formation: e.g., /i + u/ → [yu:] and /u + i/ → [wi:].

input correspond to a single output segment (Kager 1999; Pater 2004), and a ranking of Ident(-F) over Ident(+F), where F refers to the vowel articulatory features [high] and [low].[2] In presenting this argument section two of this paper will present Casali's context-sensitive analysis of asymmetric coalescence and show that it cannot account for the process in Ciyao, section three will present my segment-fusion analysis, and section four will preview how this same analysis can also provide a unified account of other hiatus resolution strategies in Ciyao.

2 Context-sensitive height coalescence

This section presents Casali's (1996) analysis of asymmetric vowel height coalescence in Xhosa. Following this, I show data from Ciyao, a language which has an identical five vowel system to that of Xhosa (/i, e, a, o, u/) and also shows the phenomenon of asymmetric coalescence. I then show that in Ciyao, stem/affix distinctions are irrelevant to the coalescence process and that Casali's analysis cannot account for height coalescence in stem + suffix and stem + infix configurations.

2.1 Asymmetric coalescence in Xhosa and root sensitivity

In examining cross-linguistic vowel hiatus resolution strategies, Casali (1996) describes two types of height coalescence: symmetric and asymmetric. Symmetric coalescence, he states, is a process of hiatus resolution which neutralizes certain vowel features in preference for other features. The serial ordering of the two dissimilar vowels is irrelevant; high-ranking feature sensitive constraints determine the output segment, as in

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[2] Throughout this paper I will use the term "coalescence" to refer to height coalescence, where a low+ non-low vowel resolve as a mid vowel (i.e., a vowel alternation). The term "fusion" will refer to segmental fusion, where two input segments are mapped onto a single output segment, violating UNIFORMITY.

the language Afar, where sequences of /e + u/ and /u + e/ are both realized as [o:]. In this case, the features of [high] and [front] are lost in preference to [round] and [back]. Crucially though, the ordering of vowels in these $V_1 + V_2$ sequences has no bearing on the outcome in symmetric coalescence.

Asymmetric coalescence, on the other hand, does rely on the serial ordering of $V_1 + V_2$. As noted in the introduction, both Xhosa and Ciyao show hiatus resolution processes that operate differently, depending on the place features of V_1 and V_2, respectively. This asymmetry can be seen in the following examples from Xhosa:

(1) Height coalescence in low + high sequences (from Casali 1996, p. 62 (122))[3]

a. **/a + i/ → [e]**

w**a-**<u>**i**nkosi</u> "of the chiefs"	→	w**e**nkosi
n**a-**<u>**i**mpendulo</u> "with the answer"	→	n**e**mpendulo

b. **/a + u/ → [o]**

w**a-**<u>**u**mfazi</u> "of the woman"	→	w**o**mfazi
n**a-**<u>**u**mntu</u> "with the person"	→	n**o**mntu

(2) Gliding and deletion in high + non-high sequences (from Casali 1996, p. 63 (123))

a. **/i + non-high/ → [V_2]**

nd**i-**<u>**a**kha</u> "I build"	→	nd**a**kha
n**i-**<u>**e**nza</u> "you make"	→	n**e**nza

[3] In these data, root morphemes are underlined.

b. **/u + a/ → [wa]**

uk**u-**<u>**a**hlula</u> → uk**wa**hlula
"to divide"

uk**u**-<u>**a**mkela</u> → uk**wa**mkela
"to receive"

In (1) above, we see that sequences of low + high vowels that occur at word-internal morpheme boundaries are realized as mid vowels, with the backness and rounding of the resulting vowel corresponding to the rounding of the second vowel; in (2) we see that different processes apply when the sequence of vowels is reversed. Here, the high front vowel /i/ elides before a non-high vowel, while the high back vowel /u/ becomes the glide [w] before the low vowel /a/, thus preserving the [round] feature of the input /u/. As indicated in the introduction, Casali explains this asymmetric behavior by positing that while symmetric coalescence is sensitive to vowel articulatory features alone, asymmetric coalescence is sensitive to both articulatory and contextual position features. He states that the feature [-high] is always preserved in preference to [+high], so if either input vowel is [-high], the output will always be [-high] and that, otherwise, all features of the second vowel will be preserved in preference to those of the first vowel. Crucially, however, he assumes that this occurs in a prefix + root configuration, as in the Xhosa examples above, where features of the root vowel will be preserved, rather than the prefix vowel (p. 63). In formalizing this process within the framework of Optimality Theory (OT), he posits that preserving the feature [-high] is more important than preserving other features, either in the root or affix, via an undominated PARSE(-high) constraint. The constraints dominated by PARSE(-high) then include the context-sensitive constraints PARSE(+high)-lex, which requires that a feature [+high] present in an input lexical (root) morpheme be parsed into the output, PARSE(F')-lex[4], which requires other features of the vowel contained in the root morpheme to be parsed in the output, and PARSE(F'), which is a general faithfulness constraint requiring parsing of other vowel features, without regard to the lexical status of their input morpheme. He then shows the efficacy of this constraint ranking for both the height coalescence and vowel elision phenomena seen in Xhosa in the following tableaux:

(3) Tableaux for asymmetric coalescence in Xhosa (from Casali (1996), p. 64 (126) and (127))[5]

a.

/a + i/	PARSE(-high)	PARSE(+high)-lex	PARSE(F')-lex	PARSE(F')
A.. <a>i	*!			**
B. a<i>		*	*!	**
☞ C. e		*		**

b.

/i + a/	PARSE(-high)	PARSE(+high)-lex	PARSE(F')-lex	PARSE(F')
A. i<a>	*!		*	**
☞ B. <i>a				**
C. e			*!	**

In the above tableaux, one can see that the asymmetry in hiatus resolution strategies seen in Xhosa can be captured by assuming Casali's constraint ranking. In tableau (3a), candidate (A) fatally violates the undominated PARSE(-high) constraint; candidates (B) and (C) have nearly identical marks in the next stratum, except that candidate (B) fails to parse the feature [-back] from the input segment /i/ -- a segment in the root morpheme -- and therefore fatally violates the constraint PARSE(F')-lex, which the winning candidate (C) does not violate (the output segment in (C), [e], maintains the feature [-back]

[4] Here he uses F' to refer to "other" features, such as [±round], [±front], [±low], etc. (p. 64).

[5] I will not address Casali's analysis of vowel elision and glide formation here, but rather refer the reader to the original work. The crucial point being demonstrated in these tableaux is that Casali's analysis of asymmetric coalescence makes crucial reference to root/affix distinctions in feature preservation. Additionally, it is assumed that there is a high-ranking markedness constraint disallowing two adjacent, dissimilar vowels.

contained in the input root morpheme). Tableau (3b) shows that the secondary tendency to maintain features of the root morpheme in preference to those of an affix can account for vowel elision when morpheme concatenation causes a high + low vowel sequence. Candidate (C) in tableau (3b) does not parse the [+low] feature of the root segment /a/, fatally violating PARSE(F')-lex. Thus, Casali's analysis successfully models the phenomenon of asymmetric coalescence in Xhosa, while at the same time capturing the cross-linguistic (and perhaps universal) tendency to enforce faithfulness within root morphemes more strictly than in non-root morphemes (Kager 1999). However, as will be demonstrated below in Ciyao, asymmetric coalescence need not make crucial reference to a morpheme's status as root or affix, thereby creating a scenario which Casali's analysis of this pattern cannot account for.

2.2 Asymmetric coalescence in Ciyao and root insensitivity

As indicated above, Ngunga's (2000) analysis of the Bantu language Ciyao also shows asymmetric coalescence as a hiatus resolution strategy, though some details of the process in Ciyao differ from those in Xhosa. For example, in $V_1 + V_2$ sequences in Ciyao, where V_1 is low and V_2 is mid or high, the resulting vowel is always mid, with backness and roundness of the resulting vowel agreeing with those features of V_2:[6]

[6] Unlike Xhosa, hiatus resolution in Ciyao is mora preserving. For general discussion of mora preservation see Clements (1986) and Ngunga (2000). The current analysis will assume a high-ranking constraint Max(μ) that maintains moraic count between the input and output. This constraint, in turn, dominates Ident(μ), which requires the mora count of a single segment be identical between input and output.

(4) Vowel height coalescence (from Ngunga 2000)

a. **/a + i/ → [e:]**

m**a-í**só	→	m**é:**só	
'eyes'			cf. dí-ísó 'eye'
m**a-í**nó	→	m**é:**nó	
'teeth'			cf. dí-ínó 'tooth'

b. **/a + u/ → [o:]**

m**a-ú**ngu	→	m**ó:**ngu	
'pumpkins'			cf. dy-ú:ngu 'pumpkin'
m**a-ú**vá	→	m**ó:**vá	
'days'			cf. dy-ú:vá 'day, sun'

c. **/a + e/ → [e:]**

g**a-é**swé:lá	→	g**é:**swé:lá	
'white'			

d. **/a + o/ → [o:]**

m**a-ó**la	→	m**ó:**la	
'frogs'			cf. dyó:la 'frog'

In (4) above, we see examples of height coalescence in a prefix + stem context, a context similar to that which Casali analyzes in Xhosa. However, as mentioned above, Ngunga shows that height coalescence, and indeed all hiatus resolution strategies, in Ciyao seem to be blind to a morpheme's status as a root or affix, and in fact apply to suffixes that are otherwise immune to vowel processes such as vowel harmony (p 46). Although his work is not focused specifically on vowel processes in Ciyao, Ngunga provides some examples of coalescence in both stem + suffix configurations with the perfective suffix /-il-e/ and infixation scenarios with infixation of the formative /-il-/ of the perfective marker into polysyllabic verb roots:

(5) Ciyao height coalescence in suffixation and infixation contexts

a. /a + i/ → [e:] in root + perfective suffix context (Ngunga 2000, p. 46 (46))

-v**a-i**l-e	→	-v-e:l-e	
'was'			cf. '-va- 'be'

b. /a + i/ → [e:] under infixation of /-il-/ into a verb root (Ngunga 2000, p. 24 (9))[7]

-pi:k**a-i**n-e	→	pi:k**é:**ne	
'heard'			cf. –piikan- 'hear'
-div**a-i**t-e	→	-div**é:**te	
'stepped on'			cf. –divat- 'step on'
-wut**a-i**m-e	→	-wut**é:**me	
'crouched'			cf. –wutam- 'crouch'
-nyik**a-i**t-e	→	-nyik**é:**te	
'compressed'			cf. –nyikat- 'compress'

The above examples show that, in Ciyao, height coalescence takes place in context where the initial low vowel can be a member of either the lexical root or an affix. Recall, though, that Casali's analysis of asymmetric coalescence proposes that in situations where the serial ordering of adjacent dissimilar vowels is crucial to selection of the process which resolves this disallowed configuration, the grammar chooses to maintain the feature [-high] in preference to [+high], otherwise all features of the root vowel are maintained. However, such an analysis seems incompatible with the Ciyao data presented above, as seen in the following tableau applying Casali's constraints to the example from (5a) above:

[7] In these cases Ngunga claims that the infix is underlyingly /-il-/, with the /l/ undergoing deletion. The reader is referred to Ngunga's work for an explanation of consonant processes in Ciyao.

(6) Evaluation of input /-va-il-e/ → [ve:le] using Casali's constraint ranking

/-va-il-e/	PARSE(-high)	PARSE(+high)-lex	PARSE(F')-lex	PARSE(F')
A. v<a>i:le	*!		*	**
☞ B. va:<i>le				**
☹ C. ve:le			*!	**

In this tableau we see that Casali's constraint ranking incorrectly predicts candidate (B) [va:<i>le] as the optimal output for the input /-va-il-e/, while the correct output is in fact [ve:le], candidate (c). Both candidates satisfy the high-ranking PARSE(-high) constraint; however, in the lower stratum, while both candidates share equal violations for the constraint PARSE(F'), [ve:le] fatally violates PARSE(F')-lex by not parsing the [low] feature of the input segment /a/, a segment found in the lexical root. The optimal, but incorrect, candidate [va:<i>le] maintains this root faithfulness by avoiding coalescence and remaining faithful to the input root segment /a/. Evaluations of the infixation examples from (5b) above would show similar incorrect outputs. Additionally, it seems that no possible ranking of Casali's constraints can account for languages such as Ciyao – no matter what the ranking, the optimal candidate in the tableau above will always be (B). These constraints, in any order, will favor root faithfulness over general faithfulness and produce the outcome in (6) above. Thus, it seems that despite the strengths of Casali's analysis, namely that it correctly accounts for the Xhosa data used to derive the grammar and incorporates the generalization that root-faithfulness dominates general faithfulness, the grammar that leads to phenomenon of asymmetric coalescence that he proposes does not seem to be cross-linguistically applicable, despite his arguments to the contrary. Asymmetric coalescence is therefore not a uniform phonological process restricted to prefix + stem contexts. Rather, Ciyao gives evidence that a second type of asymmetric coalescence exists. The Ciyao type operates in multiple morphological configurations, including stem + suffix and stem + infix. Therefore, given data from Ciyao cited above, I reconsider the process of asymmetric coalescence. The section that follows presents this process in light of Ciyao's insensitivity to root/affix distinctions and presents an alternative analysis grounded in OT Correspondence Theory, and posits that coalescence in Ciyao arises from general faithfulness to the features [-high] and [-low] in the input over preservation of input [+high] and [+low], coupled with general markedness constraints.

3 Asymmetric coalescence and segmental fusion

In developing the current analysis, let us begin by first adopting a markedness constraint responsible for causing the phonological alternations examined in the current study. Since it has been shown by Ngunga that strings of two dissimilar, adjacent vowels arising from morpheme concatenation are not allowed in Ciyao, there must be a high-ranking constraint militating against such configurations, NOHIATUS, which is formalized as follows:

(7) Anti-vowel hiatus markedness constraint (adapted from Pulleyblank 2003, p. 3)

```
NOHIATUS        *V   V
                 |   |
                 Rt  Rt
```

This constraint formalizes that two adjacent vowels cannot be linked to two sets of features and is not violated in Ciyao (Ngunga 2000, p. 21).

Additionally, this analysis proposes that height coalescence in Ciyao arises from segmental fusion, the process of mapping two input segments onto a single output segment (Kager 1999; Pater 2004). Formally, this process can be schematized as follows:

(8) Vowel fusion

Input: V_1 V_2

Output: $V_{1,2}$

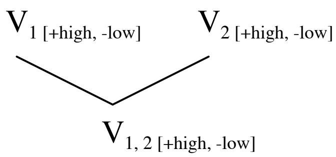
Here, both V_1 and V_2 in the input correspond to a single output vowel. Thus, I will assume deletion does not occur in the cases, and that Max(V) is high ranking.[8] Unlike segment deletion, fusion such as this maintains correspondence relationships between input and output, shown through coindexation; deletion, on the other hand, would simply obliterate any input-output correspondence relationship. Furthermore, I assume that because no segments or correspondence relationships are deleted between the input and output, each correspondent in the output must maintain identity with its correspondent in the input; mapping both input correspondents to a single output segment, however, ensures that the featural identity of both output correspondents indexed to that segment is identical. This mechanism not only avoids violations of NOHIATUS by avoiding sequences of dissimilar vowels, it also enforces that the vowel height discrepancies, such as low + high, will coalesce to a mid vowel, by making minimal changes to each correspondent. For example, when identical vowels become adjacent under morpheme concatenation in Ciyao, the resulting output is a single long vowel, which remains fully faithful to both input segments:

[8] Section 4 below will present empirical motivation for proposing that deletion does not occur.

(9) Fusion of identical vowels

a. /i + i/ → [i:]
d**i-í**ná → d**í:**ná

b.



In this case, no changes in vowel quality must take place. Both output correspondents, indexed to a single out put segment, remain faithful to their respective input correspondent in featural identity since they were identical in the input. However, when two vowels that are to be fused are not identical, fusion requires coalescence to take place. For example, in situations where V_1 in the input is specified as [-high, +low] (i.e., /a/) and V_2 is specified as [+high, -low] (i.e., /i/), the fused output vowel must undergo some sort of change in order to avoid a mismatch between the two sets of features indexed to it. In this case the output is [-high, -low] (i.e., [e:]). However, segmental fusion clearly changes the structure of the output, relative to the input, in addition to violating feature faithfulness. Therefore, it must violate some structural faithfulness constraint, in this case UNIFORMITY (segments in the output must not have multiple correspondents in the input); since UNIFORMITY is violated in Ciyao, I will assume it to be relatively low ranking.

One possible way of resolving input sequences of /a_1 + i_2/ would be diphthongization, resulting in the output [$a{:}_1y_2$]. Such a solution, which is a strategy attested in the world's languages (e.g., see Clements 1986 and Rosenthall 1994), preserves the place identity of both input segments; the modification involves a violation of Ident(μ), in that mora attached to input /i/ would undergo delinking and instead attach to /a/. However, the examples in (4) and (5) above show that Ciyao does not make use of diphthongization, but instead shows height coalescence. Therefore, in order to avoid diphthongization, we must posit that the constraint NoDiph (complex nuclei are prohibited) is high ranking in Ciyao. Glides in Ciyao seem to be limited to the same distribution as other consonants, either as onsets or part of onset clusters, and not nuclei (Ngunga 2000, p. 11).

The mechanism that causes height coalescence to take place is precisely the generalization captured by the process of segmental fusion: since the dual-indexed output segment has two input correspondents and must maintain faithfulness to two input segments, the modifications made to each segment must be minimal (Kager 1999). This gives rise to the "split the difference" process seen when a low and a high vowel coalesce to a mid vowel. Coalescing as either a high or low vowel, which would maintain the identity of one input vowel, would cause too radical of a modification to the unfaithful correspondence relationship. Additionally, since low + mid vowels also surface as mid vowels, another generalization emerges, namely that coalesced vowels in Ciyao do not show positive values for height features; coalesced vowels in are always [-high, -low].

In the framework of OT, we can capture the two generalizations mentioned above, "split the difference" and preservation of the values [-high] and [-low], under an analysis positing segmental fusion by positing that Ident(-F) outranks Ident(+F), where Ident(F) belongs to the family of faithfulness constraints that require input and output correspondents to have identical featural identity, and F refers to vowel height features. Thus, I define these constraints as follows:

(10) Identity faithfulness constraints in Ciyao coalescence

Ident(-high):	Vowels must be faithful to underlying [-high] specification
Ident(-low):	Vowels must be faithful to underlying [-low] specification
Ident(+high):	Vowels must be faithful to underlying [+high] specification
Ident(+low):	Vowels must be faithful to underlying [+low] specification

More specifically I propose the following constraint ranking:

Ident(-high), Ident(-low) >> Ident(+high), Ident(+low)

This constraint ranking makes it important to maintain the specification [-high], which is similar in spirit to Casali's PARSE(-high) constraint; however, it also equally values maintaining the specification [-low]. The following tableaux demonstrate the interaction of the constraints posited thus far in accounting for both low + high and low + mid height coalescence:

(11) Evaluation of /a + i/ with segmental fusion

$/a_1 + i_2/$	NO HIATUS	NO DIPH	Max(V)	Ident(-hi)	Ident(-lo)	Ident(+hi)	Ident(+lo)	UNIF
A. $a_1 i_2$	*!							
B. $a\text{:}_1 y_2$		*!						
C. $a\text{:}_{1,2}$					*!	*		*
D. $a\text{:}_1$			*(!)					
☞ E. $e\text{:}_{1,2}$						*	*	*
F. $i\text{:}_{1,2}$				*!			*	*

(12) Evaluation of /a + e/ with segmental fusion

$/a_1 + e_2/$	NO HIATUS	NO DIPH	Max(V)	Ident(-hi)	Ident(-lo)	Ident(+hi)	Ident(+lo)	UNIF
A. $a_1 e_2$	*!							
B. $a\text{:}_1 y_2$		*(!)		*(!)				
C. $a\text{:}_{1,2}$					*!			*
☞ D. $e\text{:}_{1,2}$							*	*
E. $e\text{:}_1$			*!				*	
F. $i\text{:}_{1,2}$				*!			*	*

The above tableaux show that this two-stratum constraint ranking successfully predicts the correct output candidate in low + high and low + mid hiatus resolution. In each tableau, the two input vowels successfully coalesce to a mid vowel by positing segmental fusion and Ident(-F) outranking Ident(+F). For example, in tableau (11a), the hiatus (i.e., fully faithful) and diphthongized candidates (A and B, respectively) are ruled out in the upper stratum by the high ranking markedness constraints NOHIATUS and NODIPH; the candidate with the single index (D), while satisfying low-ranking UNIFORMITY, fatally violates Max(V) in the upper stratum. As for the fused candidates, the low candidate (C) [a:$_{1,\ 2}$] and the high candidate (F) [i:$_{1,\ 2}$] each violate one of the Ident(-F) constraints contained in the upper stratum. In tableau (11a) for example, candidate F, while remaining faithful to one of its input correspondents (V_2), violates Ident(-high) in the case of V_1. That is, vowel V_1 in the input is specified as [-high], while the output correspondent of V_1 is specified as [+high]. V_1 therefore incurs a violation of featural identity for Ident(-high), since the output vowel is unfaithful to the underlying [-high] specification. Similarly, the C violates Ident(-low) in the upper stratum, as V_2, while specified as [-low] in the input, is specified as [+low] in the output. The winning candidate [e:$_{1,\ 2}$] violates no constraints in the upper stratum: it avoids hiatus, diphthongization, deletion, and, crucially, maintains [-F] specifications in preference to [+F]. It does, however, violate constraints in the lower stratum, in that both the [+low] feature of V_1 and the [+high] feature of V_2 are lost, thus receiving marks for the Ident(+F). Additionally, since it is a fused candidate, it violates UNIFORMITY; however, all of the marks it receives are in the lower stratum and are therefore irrelevant, since all competing candidates received fatal marks in the upper stratum.

One phenomenon not accounted for in the above tableaux is the rounding of the output candidate when the input V_2 is either /o/ or /u/ (see (4) above). In these cases it seems that a feature [+round] in the input is maintained in the output, indicating that

Ident(+round) is relatively high ranking. Since the current analysis posits segmental fusion, it becomes apparent that since V_1 is specified as [-round] in the input and [+round] in the output, Ident(-round) must be violated in cases of fusion. Thus, I posit that in Ciyao Ident(+round) outranks Ident(-round):

(13) Evaluation of /a + u/ with segmental fusion

/a_1 + u_2/	NO DIPH	Ident(-hi)	Ident(-lo)	Ident(+rd)	Ident(-rd)	Ident(+hi)	Ident(+lo)	UNIF
A. a:$_1$w$_2$	*!							
B. a:$_{1,2}$			*(!)	*(!)		*		*
☞ C. o:$_{1,2}$					*	*	*	*
D. u:$_{1,2}$		*!			*		*	*
E. e:$_{1,2}$				*!		*	*	*

(14) Evaluation of /a +o/ with segmental fusion

/a_1 + o_2/	NO DIPH	Ident(-hi)	Ident(-lo)	Ident(+rd)	Ident(-rd)	Ident(+hi)	Ident(+lo)	UNIF
A. a:$_1$w$_2$	*(!)	*(!)						
B. a:$_{1,2}$			*(!)	*(!)				*
C. o:$_{1,2}$ ☞					*		*	*
D. u:$_{1,2}$		*!*			*		*	*
E. e:$_{1,2}$				*!			*	*

The above tableaux show, as a result of the constraint Ident(+round) in the upper stratum, the output vowel must be round when V_2 is [+round]; a feature [+round] in the input must be present in the output. However, since the optimal output candidate contains the index of an input vowel that is not round, Ident(-round) is violated in these cases. However, the candidate [o:$_{1,\ 2}$] remains the most harmonic relative to the constraint ranking and emerges from the evaluation as the winner.

The analysis of height coalescence presented above shows that this process can be accounted for in a relatively straightforward fashion using the framework of OT, and need not, in fact, make use of root-faithfulness constraints. As shown above, height coalescence in Ciyao occurs in not only prefix + root contexts, but also root + suffix and root + infix contexts. However, recall that the phenomenon in question is *asymmetric* coalescence. The hiatus resolution strategies discussed so far have only been applied to situations where a low vowel is followed by a mid or high vowel; Ciyao utilizes different strategies when a mid or high vowel is the initial vowel in sequences. The following section dicusses how the proposed constraint ranking generates not only height coalescence, but also glide formation and additionally obviates the need to posit a process of vowel deletion.

4 Deletion and glide formation

As mentioned in the introduction, Ngunga proposes that when the mid vowel /e/ is followed by the high vowel /i/, the outcome is that the high vowel deletes and mora preservation results in a surface long mid vowel [e:] (p. 31). While he predicts that /e/ followed by any high or mid vowel will trigger deletion of the second vowel, he says that combinations other than /e + i/ are unattested. Thus, we have only the following data showing the phenomenon he terms deletion:

(15) Vowel deletion

/e + i/ → [e:]

sel**e**-**i**m-e → sel**e:**m-e
'slid' cf. –selem- 'slide'

ve:c**e**-**i**t-e → ve:c**e:**t-e
'spoke' cf. –pocel- 'speak'

However, given the above analysis, one could posit that deletion is not occurring in this situation, but rather that this is another instance of height coalescence involving segmental fusion. Although V_1 in the input is not low as in the examples in the previous section, it is lower than V_2 and the resulting output is a mid vowel, which carries [-high, -

low] specifications for height features. In fact, a tableau using the same constraint ranking from above that takes Ngunga's vowel deletion as another case of height coalescence shows this to be a plausible analysis:

(16) Mid + high vowel as height coalescence

$/e_1 + i_2/$	Max(V)	Ident(-hi)	Ident(-lo)	Ident(+hi)	Ident(+lo)	UNIF
☞ A. $e{:}_{1,2}$				*		*
B. $e{:}_1$	*!					
C. $i{:}_{1,2}$		*!				*

Here we see that the correct candidate, [$e{:}_{1,2}$] emerges as the optimal. It is interesting to note, however, that if we were to follow Ngunga's analysis, and allow deletion of V_2 by demoting Max(V) so that it is inoperative in this grammar, the candidate [$e{:}_1$] would emerge from this evaluation as the optimal candidate with no other violations, just as Ngunga predicts. However, allowing deletion such as this is problematic for the analysis of coalescence in section 3 above. Take the following tableaux:

(17) Ciyao is a V_2-deleting gramar

a.

$/e_1 + i_2/$	Ident(-hi)	Ident(-lo)	Ident(+hi)	Ident(+lo)	UNIF	Max(V)
A. $e{:}_{1,2}$			*(!)		*(!)	
☞ B. $e{:}_1$						*
C. $e{:}_2$			*(!)			*(!)

b.

$/a_1 + i_2/$	Ident(-hi)	Ident(-lo)	Ident(+hi)	Ident(+lo)	UNIF	Max(V)
☹ A. $e{:}_{1,2}$			*(!)	*(!)	*(!)	
B. $e{:}_1$				*(!)		*(!)
☞ C. $a{:}_1$						*

c.

$/a_1 + e_2/$	Ident(-hi)	Ident(-lo)	Ident(+hi)	Ident(+lo)	UNIF	Max(V)
☹ A. $e{:}_{1,2}$				*(!)	*(!)	
B. $e{:}_1$				*(!)		*(!)
☞ C. $a{:}_1$						*

Tableau (17) shows that by demoting Max(V) to the lower stratum, deletion of V_2, as per Ngunga's analysis, correctly predicts the winner. However, in tableau (17b), applying this deleting grammar to low + high coalescence situations discussed in section 3 does not predict the correct outcome. In this tableau, all violations are within the lower stratum, but the correct candidate [$e:_{1,2}$] suffers three violations while the optimal, but incorrect, candidate [$a:_1$] violates only Max(V). Tableau (17c) shows a similar problem in low + mid coalescence. Positing that Ciyao has a grammar that deletes vowels would additionally run into the problem of ensuring that, while V_2 deletes in contexts such as /e_1 + i_2/, V_1 deletes in contexts such as /a_1 + e_2/, such that the output vowel would be mid.

A possible solution to this would be to assume that markedness constraints, perhaps of the form *V-hi and *V-lo, are high-ranking and active in the grammar, ensuring that output vowels are mid. This analysis, however, runs into problems on two grounds: 1) mid vowels cross-linguistically more marked relative to high and low vowels, therefore assuming mid vowels to be the unmarked case is typologically problematic, and 2) and high and low vowels are perfectly acceptable in Ciyao in other circumstances (see (9) above). Mid vowel, in this case, emerge by preservation of the input features [-high] and [-low]. Therefore, this preliminary analysis leads to the conclusion that Max(V) belongs in the upper stratum and that vowel correspondence relationships are not deleted in Ciyao; positing deletion of V_2 as in Ngunga's analysis would complicate the grammar by requiring context-sensitive constraints that would ensure that only high vowels that follow mid vowels are deleted. Incorporating Ngunga's proposed vowel deletion under the general umbrella of height coalescence eliminates a superfluous process from the grammar by accounting for multiple hiatus resolution strategies with a single constraint ranking. The analysis developed here instead generates the same satisfactory result with only general markedness and faithfulness constraints.

The above constraint ranking also accounts for Ngunga's proposed third hiatus resolution strategy in Ciyao: glide formation. In this language glide formation occurs when V_1 is either high or round. While a full explanation of the nuances of this process is beyond the scope of this paper, I will present this phenomenon by focusing on one specific scenario: gliding of /i/ when it precedes /e/. Ngunga gives us the following examples showing this process:

(18) Gliding of V_1

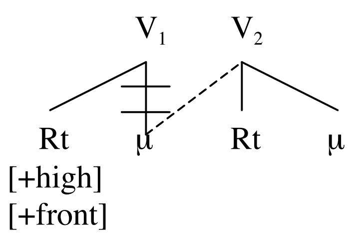
/i + e/ → [ye:]

m**i-**<u>**é**sí</u> → m**yé:**sí
'moons' cf. di-ésí 'moon'

d**i-**<u>**é**nu</u> → d**yé:**nu
'yours'

One way of formalizing gliding of high vowels is as follows:

(19) Glide Formation: /i/→ [y]



In this case, an initial vowel undergoes delinking with its associated mora, which , by mora preservation, attaches to V_2; V_1, however, maintains its attachment to its root node, preserving articulatory features. The result is surfacing of the nonmoraic high, front segment [y]. Rosenthall (1994) addresses glide formation such as this within OT and posits that it results from two needs within the grammar: avoiding hiatus and maintaining place features. In the previous section we saw that maintenance of [+F] height features was secondary to maintenance of [-F] height features. That is, when the second vowel in a two-vowel sequence was higher than the first, the vowel that emerged was always mid, i.e., a vowel that shows the features [-high, -low]. Additionally, I demonstrated that this strategy emerged in preference to diphthongization, occurring by gliding of the second, higher vowel, so that it was more important to have a simple nucleus than to maintain vowel features (NODIPH >> Ident(-F)). Diphthongization is avoided because Ciyao avoids complex nuclei in general; however, glides are licit in syllable onsets and part of onset clusters in Ciyao. Thus, when V_1 contains a feature that can be contained on a glide, such as [+high] or [+round], gliding of the initial vowel in order to maintain its features remains a viable strategy that both avoids hiatus and maximizes segmental identity between input and output. Therefore, taking the same constraint ranking from above, the grammar being developed here correctly allows for gliding of initial high vowels, while disallowing gliding of high vowels in second position:

(20) Gliding of initial high vowel

/$i_1 + e_2$/	NO HIATUS	Ident(-hi)	Ident(-lo)	Ident(+hi)	Ident(+lo)	Ident(μ)	UNIF
A. i_1e_2	*!						
☞ B. $y_1e\!:_2$						*	
C. $e\!:_{1,2}$				*(!)		*(!)	*(!)
D. $i\!:_{1,2}$		*!				*	*

In this tableau we see that the correct candidate (B) emerges from the evaluation as the winner. The faithful candidate (A) violates high-ranking NOHIATUS, while the other suboptimal candidates (both showing vowel fusion) fatally violate either Ident(-F) or Ident(+F) constraints. The optimal candidate, on the other hand, incurs only one violation: Ident(μ) because the mora count for both segments 1 and 2 changes between the input and output. However, since this constraint seems to be frequently violated in Ciyao, both in coalescence and glide formation processes, it is hypothesized to be relatively low-ranking. What is clear in the above tableau is that although Ident(-F) is subordinate to Ident(+F) in Ciyao; glide formation avoids violating either of these sets of constraints by maintaining segments' feature identity. Rather, moraic identity is violated in preference to articulatory identity.

5 Conclusion

The analysis developed above for asymmetric coalescence provides a beginning account for this phenomenon in Ciyao. The earlier analysis of asymmetric coalescence by Casali could not account for the Ciyao data, which shows no preference to preserve features of vowels found in lexical roots. Therefore it seems that languages using asymmetric coalescence as a hiatus resolution strategy fall into (at least) two classes: those that are context (root) sensitive and those that are context insensitive. The current analysis addresses this second type and posits that height coalescence occurs as the result of segmental fusion and a ranking of Ident(-F) over Ident(+F). Additionally, this same constraint ranking correctly predicts that initial high vowels will undergo gliding, thereby preserving individual articulatory features and furthermore eliminates the need to posit a separate deletion module of the grammar. Thus, the current analysis of Ciyao has the advantage that is provides a parsimonious account of what were previously analyzed as disparate phenomena (coalescence, deletion, and gliding) as actually being different manifestations of a single process.

While this analysis represents a promising start in accounting for the phenomenon hiatus resolution in Ciyao, a full explanation of the processes involved and the efficacy of the grammar being proposed remain an area for future work. Furthermore, an extension of the current analysis to the broader cross-linguistic phenomenon of asymmetric height coalescence, which might include other processes such as the deletion seen in Xhosa as part of the asymmetry, is a rich area for research possibilities.

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