

# Mid Vowel Alternations in Verbal Stems in Brazilian Portuguese

SEUNG-HWA LEE

## *Abstract*

*This paper proposes an alternative analysis for mid vowel alternations in verbal stems in BP, treating them as vowel coalescence, where two input vowels unite into a single output vowel that shares features of its ancestor, in the framework of Optimality Theory (Prince & Smolensky, 1993; McCarthy & Prince, 1995). The vowel coalescence in BP is triggered by the markedness constraint ONSET, which prohibits vowel initial syllables, competing with faithfulness constraints. The ranking of MAX and the markedness constraint ONSET above UNIFORMITY (no coalescence) yields coalescence instead of deletion. For vowel neutralization in BP, I assume the typology of height contrasts in relation to stress proposed by Beckman (1997) and McCarthy (1999); this typology needs to be adapted for Portuguese, since Portuguese has a seven vowel system. In addition, the faithfulness constraint IDENT-SUFFIX is introduced to explain leftward coalescence since coalescence in BP does not occur in locally adjacent segments.*

## **1. Introduction**

This paper discusses mid vowel alternations in Brazilian Portuguese (henceforth BP) in the framework of Optimality Theory (OT, Prince & Smolensky, 1993; McCarthy & Prince, 1995).

In previous derivational analyses (Harris, 1974; Quicoli, 1990; Lee, 1995; Petrucci, 1992; Wetzels, 1991, 1992, 1995), mid vowel alternations in verbal stems of the 2<sup>nd</sup> and 3<sup>rd</sup> conjugations were determined by Truncation and Vowel Harmony. Truncation triggers vowel harmony, spreading the [high] and [ATR] features of the theme vowel to lower mid vowels of verbal stems. Then the theme vowel is deleted.

In this paper, I will present an alternative analysis of verbal stem alternations in BP, treating them as vowel coalescence, where two input

vowels unite into a single output vowel that shares features of its ancestor, in the perspective of the Correspondence Theory (McCarthy & Prince, 1995). Vowel coalescence is triggered by the markedness constraint ONSET, which prohibits vowel initial syllables, competing with faithfulness constraints. In addition, this analysis dispenses with the underspecified mid vowel in UR, which is postulated in the derivational analyses.

## 2. The Facts

In BP, mid vowels contrast phonemically in stressed syllables in non-verbs, as shown in (1):

- (1) a. s[é]de            “headquarters”            s[é]de    “thirst”  
       b. av[ó]            “grandmother”            av[ó]    “grandfather”

However, when mid vowels are in unstressed position, as in the morphologically complex words in the second column of (2a, b), the contrast is obliterated by a vowel neutralization rule (cf. Wetzels, 1991, 1992, 1995) – the lower mid vowels are realized as the upper mid vowels:

- (2) a. b[é]lo            “beautiful” ->    b[e]léza            “beauty”  
       m[é]dico            “doctor” ->    m[e]dicína            “medicine”  
       b. h[ó]spede            “guest” ->    h[o]spedágem            “lodging”  
       p[ó]rta            “door” ->    p[o]rtéiro            “janitor”

On the other hand, mid vowel alternations in verbal stems in BP are predictable, even when the mid vowels appear in stressed syllables:

- (3) a. 1st conjugation    b. 2nd conjugation(-er)    c. 3rd conjugation(-ir)  
       *morar* “to reside”    *mover* “to move”        *servir* “to serve”
- Present Indicative
- |         |           |         |           |          |            |
|---------|-----------|---------|-----------|----------|------------|
| m[ó]ro  | m[o]rámos | m[ó]vo  | m[o]vémos | s[í]rvo  | s[e]rvímos |
| m[ó]ras | m[o]ráis  | m[ó]ves | m[o]véis  | s[é]rves | s[e]rvís   |
| m[ó]ra  | m[ó]ram   | m[ó]ve  | m[ó]vem   | s[é]rve  | s[é]rvem   |
- Present Subjunctive
- |         |           |         |           |          |            |
|---------|-----------|---------|-----------|----------|------------|
| m[ó]re  | m[o]rémos | m[ó]va  | m[o]vámos | s[í]rva  | s[i]rvámos |
| m[ó]res | m[o]réis  | m[ó]vas | m[o]váis  | s[í]rvas | s[i]rváis  |
| m[ó]re  | m[ó]rem   | m[ó]va  | m[ó]vam   | s[í]rva  | s[í]rvam   |

- i) in 1<sup>st</sup> conjugation verbs (a-themes), the vocalic quality of the mid vowel is determined by a vowel neutralization rule – low mid vowels occur in stressed position and high mid vowels occur in unstressed position;

- j) in 2<sup>nd</sup> conjugation verbs (e-themes), upper mid vowels occur in stressed position, when the theme vowel is truncated, as well as in non-stressed position, and otherwise low mid vowels occur in the stressed position;
- l) in 3<sup>rd</sup> conjugation verbs (i-themes), in the forms that do not realize their theme vowels, high vowels occur instead of mid vowels, regardless of stress, as in s[i]rvo, s[i]rvámos.

In previous derivational analyses (Harris, 1974; Quicoli, 1990; Petrucci, 1992) mid vowel alternations in verbal stems are accounted for by rules of Truncation and Vowel Harmony, where Vowel harmony accounts for the spreading of the aperture features ([high] and [ATR]) from the theme vowel to the mid vowel in the last syllable of the verb root. Truncation deletes the theme vowel. The resulting derivations for some representative verb form are illustrated in (4):

- (4) a. mɔv e + o → móvo “to move” 1st person singular present  
 b. mɔv e + a → móva “to move” 3rd person singular present  
 c. serv i + o → sírvo “to serve” 1st person singular present  
 dɔrm i + o → dúrmo “to sleep” 1st person singular present  
 d. serv i + a + mos → sirvámos “to sleep” 1st person plural present

Wetzels (1995) argues, in an autosegmental analysis, that the truncation rule and the vowel harmony rule are treated as one simultaneous process – the truncation rule leaves the aperture node floating in a case of a feature stability<sup>1</sup>. This floating node docks to the lower mid vowel of the verbal stem. Wetzels’ rules are quoted in (5) and (6).

- (5) Truncation Rule (cf. Wetzels, 1995:19)<sup>2</sup>:  
 V]Stem V                      Domain: Verb  
 ‡                                      Operation: Delete the left V  
 Open
- (6) Vowel Harmony (VH, cf. Wetzels, 1995: 23)  
 Target: [+Open3]

The Truncation rule deletes the theme vowel before a vowel-initial suffix, but the aperture features stay behind. These features are then spread to the mid

<sup>1</sup> In Petrucci (1992), the features of the theme vowel that are stable under deletion are [ATR] and [high]. The phenomenon of feature stability was first discussed by Goldsmith (1976) to explain tone stability (see also Pigott (1987; 1992) for nasal stability). We assume the morphological structure of Verb as in (Câmara, 1970): [Root + Thematic Vowel]<sub>Stem</sub> + Tense/Mood + Number/Person.

<sup>2</sup> Wetzels (1995) assumes the feature geometry theory of Clements & Hume (1995).

vowel in the root-final syllable by Vowel Harmony. The procedure is illustrated in (7). Capital /O/ and /E/ represent mid vowels, defined as [-open<sub>1</sub>, +open<sub>2</sub>] under the aperture node, but underspecified for the feature [open<sub>3</sub>], which distinguishes, in Wetzels' proposal, upper mid vowels ([-open<sub>3</sub>]) from lower mid vowels ([+open<sub>3</sub>]). These underspecified mid vowels in non-derived verbal stem undergo the Vowel Lowering Rule (*feature-filling*) before inflectional suffixations, since the specification of feature [open<sub>3</sub>] is predictable in verb:

(7)	a. /dEve+ mos/	b. /mOve + o/	
	deve	move	Vowel Lowering
	devemos	moveo	Verbal Inflection
	NA	movo	Truncaton and VH
	devémos	móvo	Main Stress
	:	:	
	devémos	NA	Vowel Neutralization
	:	:	
	[devémus]	[móvu]	
	“must” 3rd person plural	“to move” 1st person singular	
	present indicative	present indicative	

### 3 Vowel Coalescence in OT

In this section, I will reanalyze the BP mid vowel alternations in verbal stems as a result of the interaction of universal constraints, in the framework of OT, as proposed in Prince & Smolensky, (1993) and McCarthy & Prince (1995). Before entering into this discussion, let me recall some relevant constraints that have been proposed in other OT studies:

- (8) UNIFORMITY “No Coalescence”  
No element of the Output has more than one correspondent in the Input.
- (9) ONSET  
Syllables must have Onset (\*<sub>σ</sub>[V]).
- (10) IDENT(F)  
Correspondent segments have identical values for the feature F.
- (11) MAX (anti-deletion)  
Every element of the Input has a correspondent in the Output candidate.
- (12) MAX(F)  
A feature F present in the Input must have a correspondent in the Output.

### 3.1 Vowel Neutralization

The Portuguese vowel coalescence occurs with lower mid vowels, as shown in section 2. According to Câmara (1970) and Wetzels (1992, 1995), there are seven vowels in stressed syllable ([i, e, ε, a, ɔ, o, u]), five vowels in pretonic syllable ([i, e, a, o, u]), and three vowels in word final unstressed syllable ([i, a, u]). Vowel neutralization has been treated as positional faithfulness in OT (cf. Beckman, 1997). For vowel neutralization in BP, I assume the typology of height contrasts in relation to stress proposed in McCarthy (1999).

#### (13) Typology of Height Contrasts in Relation to Stress

Ranking	Interpretation	Example
*MID >> IDENT <sub>STR</sub> (HEIGHT), IDENT(HEIGHT)	No mid vowels anywhere.	Arabic
IDENT <sub>STR</sub> (HEIGHT) >> *MID >> IDENT(HEIGHT)	Mid vowels only in stressed syllables.	Russian, Nancowry
IDENT <sub>STR</sub> (HEIGHT), IDENT(HEIGHT) >> *MID	Mid vowels in stressed and unstressed syllables.	Spanish

(Extracted from McCarthy, 1999)

This typology needs to be adapted for Portuguese, since Portuguese has a seven vowel system, for which I will assume the feature definitions as given below:

#### (14) Brazilian Portuguese Vowel Inventory

		[-BK]	[+BK]		
[+HI]	[+ATR]	i		u	[-LO]
[-HI]	[+ATR]	e		o	
	[-ATR]	ε		ɔ	
	[-ATR]		a		[+LO]
		[-RD]		[+RD]	

This system reduces to five vowels in pretonic unstressed syllables – the mid vowels occur in pretonic syllables and in the stressed syllable. In addition, the underlying mid vowels neutralize to high vowels in unstressed word final position.

The phonemic contrast in stressed position can be explained by introducing the markedness constraint \*[-ATR, -Low, -Hi]<sup>3</sup>, which prohibits lower mid vowels (\*ε/ɔ) in the output, interacting with the faithfulness constraints IDENT<sub>STR</sub>(ATR) and IDENT<sub>STR</sub>(HEIGHT). The ranking of IDENT<sub>STR</sub>(ATR) and IDENT<sub>STR</sub>(HEIGHT) above \*ε/ɔ guarantees the surface contrast of mid vowels in the stressed position, as shown in tableaux (15a) and (15b).

(15a) IDENT<sub>STR</sub>(HEIGHT/ATR) >> \*ε/ɔ

ɔ	IDENT <sub>STR</sub> (ATR)	IDENT <sub>STR</sub> (HEIGHT)	*ε/ɔ	IDENT(HEIGHT)	IDENT (ATR)
☞ ɔ			*		
ú		*!		*	
ó	*!				*

(15b)

o	IDENT <sub>STR</sub> (ATR)	IDENT <sub>STR</sub> (HEIGHT)	*ε/ɔ	IDENT(HEIGHT)	IDENT (ATR)
☞ ɔ	*!		*		*
ú		*!		*	
☞ ó					

The ranking of the markedness constraint \*ε/ɔ above the faithfulness constraint IDENT (ATR) neutralizes lower mid vowels to upper mid vowels in pretonic unstressed position, as shown in tableau (16a).

(16) a. \*ε/ɔ &gt;&gt; IDENT (ATR)

ɔ	IDENT <sub>STR</sub> (ATR)	IDENT <sub>STR</sub> (HEIGHT)	*ε/ɔ	IDENT (ATR)
ɔ			*!	
☞ o				*

b. \*ε/ɔ &gt;&gt; IDENT (HEIGHT) &gt;&gt; IDENT (ATR)

ɔ	IDENT <sub>STR</sub> (ATR)	IDENT <sub>STR</sub> (HEIGHT)	*ε/ɔ	IDENT(HEIGHT)	IDENT (ATR)
u				*!	
☞ o					*

In addition, tableau (16b) shows that IDENT(HEIGHT) outranks IDENT (ATR) to eliminate a second candidate as optimal output.

In unstressed word final position, mid vowels neutralize to high vowels – the optimal output violates the faithfulness constraint IDENT(HEIGHT) which interacts with the markedness constraint \*MID]<sub>ω</sub> – which forbids mid vowels

<sup>3</sup> In the dialects of Bahia and northern Minas Gerais, where there are [a, ε, ɔ, i, u] in the unstressed pretonic syllables, this markedness constraint should be \*[+ATR, -Hi, -Low] to obtain the optimal output.

in unstressed word final position (\*MID]<sub>ω</sub> is a positional markedness constraint). The ranking of \*MID]<sub>ω</sub> above IDENT(HEIGHT) results in high vowels<sup>4</sup>, as shown in tableau (17):

(17) \*MID]<sub>ω</sub> >> IDENT (HEIGHT)

o	*MID] <sub>ω</sub>	IDENT(HEIGHT)
ɔ	*!	
u		*
o	*!	

### 3.2 Vowel Coalescence in OT

In Wetzels' analysis, Vowel harmony in BP is triggered by Truncation: the ATR and Height features of the theme vowel spread to lower mid vowels in verbal stems and then the theme vowel is deleted. From the point of view of OT, vowel harmony in BP can be treated as vowel coalescence (cf. McCarthy & Prince (1995), McCarthy (1999)).

The following examples show the effect of vowel coalescence in BP.

(18) Root vowel + Thematic vowel Resulting Vowel

a.	ε <sub>1</sub>	+ i <sub>2</sub>	=> i <sub>1,2</sub>
b.	ɔ <sub>1</sub>	+ i <sub>2</sub>	=> u <sub>1,2</sub>
c.	ε <sub>1</sub>	+ e <sub>2</sub>	=> e <sub>1,2</sub>
d.	ɔ <sub>1</sub>	+ e <sub>2</sub>	=> o <sub>1,2</sub>
e.	ε <sub>1</sub>	+ a <sub>2</sub>	=> ε <sub>1,2</sub>
f.	ɔ <sub>1</sub>	+ a <sub>2</sub>	=> ɔ <sub>1,2</sub>

In (18a) and (18b), the lower mid vowels changes to high, assimilating the height feature of the thematic vowel, whereas in (18c) and (18d) a lower mid vowel assimilates the [ATR] feature of the thematic vowel. Vowel Harmony is only active in the 2<sup>nd</sup> and 3<sup>rd</sup> conjugations. The lower mid vowel in the 1<sup>st</sup> conjugation forms is the regular outcome of the neutralization of stressed mid vowels in verbs, which yields lower mid qualities.

In the framework of OT, truncation is explained by the markedness constraint ONSET. This markedness constraint forces the hiatal V + V to become a single syllable, through processes like Deletion, C-Insertion, Diphthongization or Coalescence in different language. In the case of the BP vowel alternations under discussion, hiatus is resolved through Coalescence.

According to McCarthy (1999), the constraint ranking MAX >> UNIFORMITY leads to coalescence rather than deletion and there are two possible types of coalescence – IDENT-Perspective Coalescence and MAX-Perspective Coalescence.

<sup>4</sup> In BP, the word final high vowels realize phonetically as [+HI, -ATR] – [i, u].

In IDENT-Perspective Coalescence, an output segment has *two* input correspondents and it must be featurally faithful to both. In other words, fusion is total without deletion, as in Sanskrit and Korean (McCarthy, 1999), \*NC<sub>g</sub>(Pater, 1995).

Candidate (19a) looks like deletion, but formally it is distinct from MAX violation as indicated by the numerical subscripts. The ranking IDENT(+Hi) >> IDENT(-Hi) favors preservation of High (from /i/) in the coalesced candidate – preferring candidate (19b) to candidates (19a) and (19c).

## (19) IDENT(+Hi) &gt;&gt; IDENT(-Hi)

/ε <sub>1</sub> + i <sub>2</sub> /	IDENT(+Hi)	IDENT(-Hi)
a. ε <sub>1,2</sub>	*!	
☞ b. i <sub>1,2</sub>		*
c. e <sub>1,2</sub>	*!	

In (20), the ranking IDENT(+ATR) >> IDENT(-ATR) favors preservation of the [+ATR] feature of /e/ over preserving the [-ATR] feature of /ε/.

## (20) IDENT(+ATR) &gt;&gt; IDENT(-ATR)

/ε <sub>1</sub> + e <sub>2</sub> /	IDENT(+ATR)	IDENT(-ATR)
a. ε <sub>1,2</sub>	*!	
☞ b. e <sub>1,2</sub>		*

The tableaux (21-22) show the full interactions of constraints related to vowel coalescence in BP. In tableau (21), the candidate (21b) violates the highly ranked ONSET. Furthermore, the highly ranked MAX excludes (21a) candidates, in which the theme vowel is deleted. The ranking of IDENT(+ATR) above UNIFORMITY selects the candidate (21d) as optimal output, which changes the low mid vowel of verbal stem to upper mid vowel.

## (21) ONSET, MAX, IDENT(+ATR) &gt;&gt; UNIFORMITY, IDENT(-ATR)

ɔ <sub>1</sub> + e <sub>2</sub>	ONSET	MAX	IDENT(+ATR)	UNIFORMITY	IDENT(-ATR)
a. ɔ <sub>1</sub>		*!	*		
b. ɔ <sub>1</sub> e <sub>2</sub>	*!				
c. ɔ <sub>1,2</sub>			*!	*	
☞ d. o <sub>1,2</sub>				*	*

## (22) ONSET, MAX, IDENT(+Hi) &gt;&gt; UNIFORMITY, IDENT(-Hi)

ɔ <sub>1</sub> + i <sub>2</sub>	ONSET	MAX	IDENT(+Hi)	UNIFORMITY	IDENT(-Hi)
a. ɔ <sub>1</sub>		*!	*		
b. ɔ <sub>1</sub> i <sub>2</sub>	*!				
c. ɔ <sub>1,2</sub>			*!	*	
☞ d. u <sub>1,2</sub>				*	*



The tableaux (21) and (22) show that the constraint IDENT (+F) must outrank the faithfulness constraint IDENT<sub>STR</sub>(ATR), which preserves the [ATR] feature in stressed position.

But this IDENT-Perspective Coalescence in BP predicts that the wrong candidate is optimal, when mid vowel contrasts in stressed position are considered. In section 2, I showed that the faithfulness constraint IDENT<sub>STR</sub>(ATR) and IDENT<sub>STR</sub>(HEIGHT) dominate the IDENT(ATR) and IDENT(HEIGHT). If the IDENT<sub>STR</sub>(ATR) dominates the IDENT(+ATR), the candidate (23c) is the optimal output, since the real optimal candidate (23d) violates the IDENT<sub>STR</sub>(ATR).

(23)

ɔ <sub>1</sub> + e <sub>2</sub>	IDENT <sub>STR</sub> (ATR)	ONSET	MAX	IDENT(+ATR)	UNIFORMITY	IDENT (-ATR)
a. ɔ <sub>1</sub>			*!	*		
b. ɔ <sub>1</sub> e <sub>2</sub>		*!				
☞ c. ɔ <sub>1,2</sub>				*	*	
d. o <sub>1,2</sub>	*!				*	*

McCarthy (p.c.) suggests that the positional faithfulness constraint IDENT<sub>STR</sub>(ATR) should be two distinct constraints – IDENT<sub>STR</sub>(+ATR) and IDENT<sub>STR</sub>(-ATR), as IDENT(+ATR) and IDENT(-ATR) are distinct constraints. In (24b), IDENT<sub>STR</sub>(-ATR) is violated, because an output stressed [+ATR] vowel has an input correspondent [-ATR]. In (24a), IDENT<sub>STR</sub>(+ATR) is violated, because an output stressed [-ATR] has input correspondent [+ATR]. So if IDENT<sub>STR</sub>(+ATR) dominates IDENT<sub>STR</sub>(-ATR), the candidate (24b) is selected as optimal.

(24)

ɔ <sub>1</sub> + e <sub>2</sub>	IDENT <sub>STR</sub> (+ATR)	IDENT <sub>STR</sub> (-ATR)	ONSET	MAX	IDENT(+ATR)	UNIFORMITY	IDENT (-ATR)
a. 'ɔ <sub>1,2</sub>	*!				*	*	
☞ b. 'o <sub>1,2</sub>		*				*	*

In MAX-Perspective Coalescence, there is a deletion by MAX (segment) violation and some features of the deleted host remain and dock to a new host. This analysis is similar to the idea of autosegmental analysis. The basic idea of this analysis is very similar to the IDENT-Perspective Coalescence, but the constraint MAX(F) replaces IDENT(F). The tableaux (25) and (26) show that the ranking of MAX (+F) above MAX (-F) guarantees the optimal output in BP.

(25) MAX(+Hi) >> MAX(-Hi)

/ɛ <sub>1</sub> + i <sub>2</sub> /	MAX(+Hi)	MAX(-Hi)
a. ɛ <sub>1,2</sub>	*!	
☞ b. i <sub>1,2</sub>		*
c. e <sub>1,2</sub>	*!	

(26)  $\text{MAX}(+\text{ATR}) \gg \text{MAX}(-\text{ATR})$ 

/ $\varepsilon_1 + e_2$ /	$\text{MAX}(+\text{ATR})$	$\text{MAX}(-\text{ATR})$
a. $\varepsilon_{1,2}$	*!	
☞ b. $e_{1,2}$		*

The features [+Hi] and [+ATR] of the deleted theme vowel dock to a lower mid vowel, yielding [i] and [e]. In this analysis, the constraint UNIFORMITY is less important, but the high ranking constraints  $\text{MAX}(+\text{F})$  and ONSET have crucial role to determine vowel coalescence in BP.

(27)  $\text{MAX}(+\text{ATR}), \text{MAX}(+\text{Hi}) \gg \text{UNIFORMITY}$ 

/ $\varepsilon_1 + i_2$ /	ONSET	$\text{MAX}(+\text{Hi})$	UNIFORMITY
a. $\varepsilon_{1,2}$		*!	*
☞ b. $i_{1,2}$			*
c. $e_{1,2}$		*!	*
d. $\varepsilon_1$	*!		

In relation to the stressed position these constraints also dominate the positional faithfulness constraints  $\text{IDENT}_{\text{STR}}(\text{HEIGHT})$  and  $\text{IDENT}_{\text{STR}}(\text{ATR})$ .

## (28) 1st person singular of present indicative

$m\text{ɔ}_1ve_2+o_3$	$\text{MAX}(+\text{ATR})$	ONSET	$\text{IDENT}_{\text{STR}}(\text{HEIGHT})$	$\text{IDENT}_{\text{STR}}(\text{ATR})$	UNIFORMITY	$\text{MAX}(-\text{ATR})$
a. 'mɔ <sub>1</sub> vo <sub>3</sub>	*!					
b. 'mɔ <sub>1</sub> ve <sub>2</sub> o <sub>3</sub>		*!				
c. 'muvo			*!			*
☞ d. 'mɔ <sub>1,2</sub> vo <sub>3</sub>				*	*	*

The tableau (28) shows that the ranking  $\text{IDENT}_{\text{STR}}(\text{HEIGHT})$  above  $\text{IDENT}_{\text{STR}}(\text{ATR})$  guarantees the optimal candidates (28d) over the candidate (28c). This means that the mid vowel is preserved, when the deleted theme vowel is non-high.

In tableau (29), the candidate (29b) violates the highly ranked ONSET. Furthermore, the highly ranked  $\text{MAX}(+\text{Hi})$  excludes dɔrmo/dormo candidates, in which the theme vowel is deleted. Since there is no coalescence in the forms (29a) and because in (29c) the resulting mid vowel only preserves the ATR feature of the deleted theme vowel, these forms represent non-optimal candidates.  $\text{MAX}(+\text{Hi})$  above  $\text{IDENT}_{\text{STR}}(\text{HEIGHT})$  selects the candidate (29d) as optimal output, which changes the low mid vowel of verbal stem to high vowel.

(29)

$d\alpha_1 rmi_2 + \alpha_3$	MAX (+Hi)	ONSET	IDENT <sub>STR</sub> (HEIGHT)	IDENT <sub>STR</sub> (ATR)	UNIFORMITY	MAX (-Hi)
a. 'd $\alpha_1 rmo_3$	*!					
b. 'd $\alpha_1 rmi_2 \alpha_3$		*!				
c. 'd $\alpha_{1,2} rmo_3$	*!			*	*	*
d. 'd $\alpha_{1,2} rmo_3$			*		*	*

In tableau (30), which contains a form to which truncation has not applied, the mid vowel quality of verbal root is not changed in the output.

(30) 3<sup>rd</sup> person singular of present indicative

m $\alpha$ ve	MAX (+F)	ONSET	IDENT <sub>STR</sub> (HEIGHT)	IDENT <sub>STR</sub> (ATR)	UNIFORMITY	MAX (-Hi)
m $\alpha$ ve						
'muve			*!			*
'move				*!		

Usually, coalescence occurs between two adjacent segments. However, in Portuguese vowel coalescence does not occur in adjacent vowel pairs. Instead the aperture features of the theme vowels spread leftwards towards the verb stem. According to McCarthy (1999) coalescence occurs only in locally adjacent segments, as in Korean, French, Indonesian, Navajo, and Sanskrit. How then can it be explained that in BP the same process applies to non-adjacent segments? What is the motivation for leftwards feature spreading? From this point of view, the constraint interactions presented in (29) predict that a better candidate would be one in which coalescence effects contiguous vowels, as shown in tableau (31).

(31)

$d\alpha_1 rmi_2 + \alpha_3$	MAX(+F)	ONSET	IDENT <sub>STR</sub> (HEIGHT)	IDENT <sub>STR</sub> (ATR)	UNIFORMITY	MAX (-F)
a. 'd $\alpha_{1,2} rmu_{2,3}$			*!	*	**!	*
b. 'd $\alpha_1 rmu_{23}$					*	
c. 'd $\alpha_{1,2} rmo_3$			*!	*	*	*

How can the leftward feature spreading be explained in OT analysis?

In an autosegmental analysis, feature spreading is well motivated as a phonological operation: the floating features spread to a lower mid vowel in verbal roots, not to the inflectional suffix.

In OT, the set of possible inputs is universal and unrestricted by the principle of Richness of the Base (Smolensky, 1996) – There are no language-particular restrictions on the lexicon. The contrasts are derived by interactions of OT constraints in the output. The mid vowel contrast is

unpredictable in non-verbal words and predictable in verbal words in BP. The tableau (32) shows that an ungrammatical output is chosen as optimal, when the vowel quality of input vowel is upper mid. The real optimal output [mɔve] violates the highly ranked constraint IDENT<sub>STR</sub>(HEIGHT/ATR).

(32)

move	IDENT <sub>STR</sub> (HEIGHT)	IDENT <sub>STR</sub> (ATR)	IDENT(HEIGHT)	IDENT(ATR)
'move				
'mɔve⊗	*!			*
'muve	*!		*	
☞'move●				

Hence, tableaux (30) and (32) show that in BP verbal stems the input quality of a mid vowel quality has to be lower mid, not a underspecified mid vowel.

Then, how can the OT analysis interpret the prediction presented in auto-segmental analysis?

One possible solution to this problem is to introduce the following faithfulness constraint.

## (33) IDENT-SUFFIX

A suffix must have a correspondent in the output.

This constraint prohibits the alternation of suffix, when the suffix is attached to the stem. This faithfulness constraint interacts with MAX(HEIGHT/ATR) and ONSET, forcing the deletion of thematic vowel by ONSET and spreading floating features to root final mid vowel by MAX(HEIGHT/ATR). Tableau (34) shows that the candidate (34a) is excluded by ONSET. (34b) and (34d) are non-optimal because they violate the highly ranked IDENT-SUFFIX. Finally the candidate (34c) is optimal, although it violates the lowest ranked UNIFORMITY and IDENT<sub>STR</sub>(HEIGHT) and IDENT<sub>STR</sub>(ATR). The unstressed word final high vowel is the result of neutralization, not of coalescence.

(34) IDENT-SUFFIX &gt;&gt; UNIFORMITY

sE <sub>1</sub> rvi <sub>2</sub> +O <sub>3</sub>	MAX(+F)	ONSET	IDENT-SUFFIX	IDENT <sub>STR</sub> (HEIGHT)	IDENT <sub>STR</sub> (ATR)	UNIFORMITY	MAX(-F)
a. 'sE <sub>1</sub> rvi <sub>2</sub> O <sub>3</sub>		*!					
b. 'servu <sub>2,3</sub>			*!			*	
☞ c. si <sub>1,2</sub> rvi <sub>3</sub>				*	*	*	
d. 'servu <sub>2,3</sub>			*!			*	*

#### 4. Conclusion

In this paper, I have analyzed the mid vowel alternations in verbal stem in the framework of OT. In OT, the mid vowel alternations of verbal stem in BP are treated as vowel coalescence, where the ranking of MAX and markedness constraint ONSET above UNIFORMITY (no coalescence) yielding coalescence instead of deletion. In addition, I have presented two possible analyses account for BP stem vowel alternations: IDENT-Perspective Coalescence and MAX-Perspective Coalescence (Cf. McCarthy, 1999). In IDENT-Perspective Coalescence analysis, BP coalescence is motivated by Onset >> Uniformity and Ident (+F) has a crucial role in determining the correct output. In MAX-Perspective Coalescence analysis, BP coalescence is triggered by the deletion of the theme and the high-ranked Max (+F) plays a crucial role in the selection of the optimal candidate. This approach is very similar to the autosegmental analysis presented in Wetzels (1995). I will not discuss here which analysis is better for BP coalescence – I will leave this question open for future studies.

The faithfulness constraint IDENT-SUFFIX was introduced to explain the leftward coalescence since the coalescence phenomenon in BP does not occur in locally adjacent segments. In addition, I have proposed an alternative analysis for vowel neutralization in BP, by adopting the typology of McCarthy (1999). Some constraints related to ATR features are added to explain BP vowel neutralizations.

#### Acknowledgement

A previous version of this paper was presented at the LSK 2002 Summer International Conference. I wish to thank John McCarthy, Leda Bisol, Leo Wetzels, Luiz Carlos Cagliari and Marco Antônio de Oliveira for their valuable comments on an earlier version of this paper. Needless to say that all errors that remain are my own.

#### References

- Beckman, Jill (1997) *Positional Faithfulness*. Doctoral dissertation, University of Massachusetts, Amherst.
- Câmara Jr, M. (1970) *Estrutura da Língua Portuguesa*. Petrópolis, Rio de Janeiro: Vozes.
- Clements, G. N. & E. V. Hume (1995) The Internal Organization of Speech Sounds. In *The Handbook of Phonological Theory* (J. A. Goldsmith, editor). Oxford: Basil Blackwell.
- Goldsmith, J. A. (1976) *Autosegmental Phonology*. Doctoral dissertation, MIT, Cambridge, Mass.

- Harris, J. W. (1974) Evidence from Portuguese for the 'Elsewhere Condition'. *LI* 5, 61-80.
- Lee, S.-H. (1995) *Morfologia e Fonologia Lexical do Português do Brasil*. Tese de Doutorado Unicamp – IEL Campinas.
- Lopez, M. B. S. (1979) *The Sound Pattern of Brazilian Portuguese*. Doctoral dissertation, UCLA.
- McCarthy, J. (1999) *Introductory OT on CD-ROM*. Version 1.0. GLSA. Amherst.
- McCarthy, J. & A. Prince (1995) Faithfulness and reduplicative identity in Prosodic Morphology. In *Papers in Optimality Theory* (D. Beckman & Urbanczyk, editors), pp. 249-384. Amherst, MA: GLSA.
- Pater, Joe (1995) Austronesian nasal substitution and other NC effects. Ms., McGill University. To appear in *The Prosody Morphology Interface* (R. Kager, H. van der Hulst & W. Zonneveld, editors) [ROA-160].
- Petrucci, P. R. (1992) Fatos de Estabilidade no Português Brasileiro. In *Cadernos de Estudos Linguísticos* 23. Campinas: UNICAMP.
- Piggott, G. L. (1987) *On the Autonomy of the Feature Nasal*. CLS 23, 223-238.
- Piggott, G. L. (1992) Variability in Feature Dependency: The Case of Nasality. *Natural Language and Linguistic Theory*, 32-77.
- Prince, A. & P. Smolensky (1993) *Optimality Theory*. ms. Rutgers Univ.
- Quicoli, A. C. (1990) Harmony, Lowering and Nasalization in Brazilian Portuguese. *Lingua* 80, 295-331.
- Redenbarger, W. J. (1981) *Articulator Features and Portuguese Vowel Height*. Department of Romance Languages and Literatures of Harvard University: Cambridge.
- Smolensky, P. (1996) The initial state and 'richness of the base' in Optimality Theory. Technical Report JHU-CogSci-96-4, Cognitive Science Department, Johns Hopkins University, Baltimore, MD. ROA-154.
- Wetzels, W. L. (1991) Contrastive and Allophonic Properties of Brazilian Portuguese Vowels. In *New Analyses in Romance Linguistics* (D. Wanner & D. A. Kibbee, editors), pp. 77-99. Amsterdam: J. Benjamins.
- Wetzels, W. L. (1992) Mid Vowel Neutralization In Brazilian Portuguese. In *Cadernos de Estudos Linguísticos* 23, 18-55. Campinas: UNICAMP.
- Wetzels, W. L. (1995) Mid-Vowel Neutralization in Brazilian Portuguese. *Verb. Phonology* 12, 281-304.

*Seung-Hwa Lee*

Universidade Federal de Minas Gerais/CNPq

Belo Horizonte-MG, Brazil

[shlee@letras.ufmg.br](mailto:shlee@letras.ufmg.br)