HARMONY, LOWERING AND NASALIZATION
IN BRAZILIAN PORTUGUESE

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This article studies a complex interaction of two different systems of rules affecting vowel height in Brazilian Portuguese. One of these systems of rules is displayed in the phenomenon of vowel alternation. Elaborating on previous analyses, an alternative analysis of this phenomenon is provided, in which vowel alternations are shown to follow from three major rules (Vowel Harmony, Lowering and Neutralization). It is argued that two of these central rules (Vowel Harmony and Neutralization) must crucially conform to the Principle of Structure Preservation. The other system of rules affecting vowel height is found in the nasalization phenomenon. An analysis for this phenomenon is proposed, which shows the effects of nasalization on vowel height: Nasalized low vowels are raised. We then study the results that obtain when the two subsystems affecting vowel height interact and show how the complicated facts that arise can be accounted for in terms of the analysis given here.

1. Introduction

In this article I will be concerned with the interaction of three major phonological processes found in Brazilian Portuguese: Vowel Harmony, Lowering and Nasalization. The study will be limited to the verbal system, where these processes apply with a higher degree of generality.

All three processes have been object of formal analyses. The phenomena of Vowel Harmony and Lowering received initial study by Hensey (1973) and

were brought to the fore by Harris (1974), who proposed an analysis based on the 'Elsewhere Condition' (Kiparsky (1973)). Subsequent reanalyses of these phenomena are presented in important studies by Redenbarger (1981) and Lopez (1979). Aspects of Nasalization have been studied by Câmara (1970), Head (1964), Mateus (1975), Almeida (1976), among others.

In these studies, however, Nasalization has not been integrated with the study of Vowel Harmony and Lowering. As a result, the systematic effects of the interaction of Nasalization with the other two has not received the attention that they deserve. It is my objective here to provide a more accurate characterization of the processes in question and to show how Nasalization interacts with Vowel Harmony and Lowering to produce an interesting range of empirical effects.

2. Vowel Harmony, Lowering and Neutralization

In Brazilian Portuguese there is a well-known process of vowel alternation affecting verb forms whose stems end by a mid-vowel ([e], [o]) or by one of the low (low-mid in some analyses) vowels [E] and [O]. The situation can be exemplified by the facts of the present indicative of verbs of the first conjugation (*apelar* 'to appeal', *escovar* 'to brush'), second conjugation (*dever* 'to owe', *mover* 'to move') and third conjugation (*servir* 'to serve', *dormir* 'to sleep') given below:[1]

    (1) *First Conjugation* (theme vowel -a-)
        (a) 1 sg. : ap[É]lo   esc[Ó]vo
        (b) 2/3 sg.: ap[É]la   esc[Ó]va
        (c) 1 pl.   : ap[e]lámos esc[o]vámos
        (d) 2/3 pl.: ap[É]lam   esc[Ó]vam
    (2) *Second Conjugation* (theme vowel -e-)
        (a) 1 sg. : d[é]vo   m[ó]vo
        (b) 2/3 sg.: d[É]ve   m[Ó]ve
        (c) 1 pl.   : d[e]vémos   m[o]vémos
        (d) 2/3 pl.: d[É]vem   m[Ó]vem

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[1] In the 'Official Dialect' of Brazilian Portuguese — i.e. the dialect used in national broadcasts and in educated speech and writings — only four verbal persons are formally differentiated by the verb-agreement morphology, which is the system exemplified by the paradigms in the text.

(3) *Third Conjugation* (theme vowel -i-)
    (a) 1 sg. : s[í]rvo   d[ú]rmo
    (b) 2/3 sg.: s[É]rve   d[Ó]rme
    (c) 1 pl. : s[e]rvímos   d[o]rmímos
    (d) 2/3 pl.: s[É]rvem   d[Ó]rmem

Existing analyses (Harris (1974), Redenbarger (1981), Lopez (1979)) assume that the vowel alternations above are caused by the application of the rules of Vowel Harmony, Lowering and Neutralization (in interaction with other rules), although these proposals differ with respect to the details of formulation of the rules. In the discussion below I will develop an analysis for these phenomena, borrowing freely from earlier proposals (particularly Harris (1974)) and modifying them as needed.

Consider first the phenomenon of Vowel Harmony. According to Harris's analysis, the vowel harmony rule causes the mid [e, o] and the low [E, O] in the last syllable of a verb stem to agree in height with the underlying theme vowel in environments where the theme vowel is followed by a vowel. The theme vowel is systematically deleted in such environments by a rule of Truncation, regardless of whether or not Vowel Harmony applies (cf. derivation (4c) below). This rule of Truncation also interacts crucially with the Stress rule. The effect of these rules, can be illustrated by the derivations of the harmonizing forms *sirvo* 'I serve' and *durmo* 'I sleep' (cf. 3a) and the non-harmonizing form *parto* 'I leave' (all of the third conjugation):

(4a) /sErv+i+o/   (4b) /dorm+i+o/   (4c) /part+i+o/
     i   u   ------------   V. Harmony
         $\emptyset$ $\emptyset$ $\emptyset$ Truncation
     í   ú   á   Stress
   [sírvo   ]   [dúrmo   ]   [párto   ]   (intermediary)

The ultimate surface representations [sírvu], [dúrmu] and [pártu] are derived from the intermediary structures above by application of a late rule of Final Vowel Raising discussed below (cf. (9)). What is important here is that Vowel Harmony must apply before Truncation, otherwise there would be no theme vowel to cause the harmonizing. Likewise, since Stress normally stresses the penultimate vowel, it must apply after Truncation to give the right results here. As has been assumed since Kiparsky (1968) and subsequent work, ordering does not need to be stipulated, but rather follows from general principles of grammar, an assumption that I will adopt throughout the discussion.

This much seems to be largely uncontroversial among the various proposals under consideration and I will assume that this partial view of the derivations is correct. The disagreements among the various proposals have to do with specific formulation of the rules involved, as we discuss below.

But before going into the discussion proper, let us briefly discuss three of the rules mentioned above which play a role in our analysis, but which will not be the focus of the present discussion. The rules in question are Truncation, Stress and Final Vowel Raising. For presentation purposes I assume the following formulation of Truncation (cf. Harris (1974)):

(5) *Truncation*
$$V \rightarrow \emptyset \; / \; + \;\underline{\quad}\; + \; V$$

The phenomenon of stress in Portuguese was studied from a segmental point of view by Lopez (1979). A metrical approach is adopted in Major (1985) (cf. also Harris (1983) for a metrical treatment of Spanish stress). For purposes of presentation we will simply assume a rule of stress in verbs with the empirical content of (6):

(6) *Stress*
$$V \rightarrow [+\text{stress}] \; / \; \underline{\quad} \; (+ \; C \; V \; +) \; C_0 \; V \; C_0 \; \#$$

The basic cases covered by this rule are illustrated by the derivations of *lavo* 'I wash'; *lavemos* 'that I wash' and *lavássemos* 'if we washed' below (for relevant information about verb morphology, see Câmara (1970, 1972)):

(7a) /lav+a+o/ (7b) /lav+a+e+mos/ (7c) /lav+a+se+mos/

∅	∅	------------	Trunc.
á		á	Stress
[láv o]	[lav é mos]	[lav á se mos]	

The third rule that we will assume is Final Vowel Raising. It is a well-known fact that in final unstressed syllables, the seven-vowel system of Brazilian Portuguese (which I assume to be as in (12) below) reduces to five:

(8) *Final Unstressed Vowels*

	− back		+ back	
	− round		− round	+ round
+ high	i			u
− high	e		ʌ	o
− low				

The situation is brou[...]
Raising), which can be s[...]

(9) *Final Vowel Raisin[...]*
$$[\alpha \text{ low}] \rightarrow \begin{bmatrix} -\alpha \text{ hi} \\ -\text{lo}[...] \end{bmatrix}$$

The effect of this rule [...]
vale 'valley' *sapo* 'toad', [...]

(10) /vale/   /sapo/   /[...]
     á   á
     i   u
     [váli]   [sápu]   [[...]

With this background, [...]
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2.1. Vowel Harmony

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The situation is brought about by the rule of Final Vowel Raising (FV Raising), which can be stated as follows:

(9) *Final Vowel Raising (FV Raising)*

$$[\alpha \text{ low}] \rightarrow \begin{bmatrix} -\alpha \text{ high} \\ -\text{low} \end{bmatrix} / \begin{bmatrix} \underline{\hspace{1cm}} \\ -\text{stress} \end{bmatrix} C_0 \#$$

The effect of this rule is exemplified by the derivations of words such as *vale* 'valley' *sapo* 'toad', *vaca* 'cow' below:

(10) /vale/ /sapo/ /vaka/
　　　 á　　　 á　　　 á　　　Stress
　　　 i　　　 u　　　 ʌ　　　FV Raising
　　　[váli] [sápu] [vákʌ]

With this background, we now turn to the rules that are the focus of this article.

2.1. Vowel Harmony

The first major rule that we shall consider is Vowel Harmony. The formulation of the Vowel Harmony rule has been the subject of interesting discussion. There seems to be a general agreement among the analyses considered here that the general schemata of the rule is essentially (11):

(11) *Vowel Harmony* (schemata)

$$[e, o, E, O] \rightarrow [\alpha \text{ height}] / \underline{\hspace{1cm}} C_0 + \begin{bmatrix} V \\ \alpha \text{ height} \end{bmatrix} + V \dots]_{\text{Verb}}$$

The main claim made by the rule schemata (11) is that the Vowel Harmony rule affects the features for vowel height, causing the relevant vowel in the last syllable of the verb stem to adjust its height to harmonize with a prevocalic theme vowel. This much seems to be agreed upon by all analyses.

The various analyses differ, however, with respect to the precise values of the height features in Portuguese and the way to treat height. Thus, Harris (1974) assumes (with many other linguists, including Hall (1943), Reed and Leite (1947), Head (1964)) that Portuguese has a system of three vowel heights, defined in terms of tongue-body features (cf. (12) below). In his alternative to Harris's analysis, Redenbarger (1981) also claims that Portuguese has a system of three heights but assumes two layers of 'mid' vowels. In his system, high vowels are defined in terms of tongue-body ('high'); the two

layers of mid vowels are differentiated by the feature 'tense' (or 'ATR', cf. Redenbarger (1977)), while 'low' /a/ is defined in terms of the feature 'constricted pharynx' (i.e. [+cp]). Lopez (1979), on the other hand, claims that Portuguese has four vowel heights. We discuss the details of these proposals later in section 2.4.

The proposal to account for vowel harmony that I will argue for here shares many of the assumptions made in the earlier works. However, by combining these assumptions differently and by adding some new assumptions, I believe that the proposal given here avoids many of the problems that face the earlier proposals and provides a more adequate account of the facts of harmony.

Here I will assume with Harris and others that the underlying vowel system of Brazilian Portuguese is as in (12):

(12)

	− back − round	+ back − round	+ round
+ high	i		u
− high − low	e		o
+ low	E	a	O

To avoid terminological confusion, I am using the symbols [E, O] to represent a low non-tensed vowel (reserving the symbols [ɛ, ɔ] for low-mid non-tensed vowels such as found in English). The system above assumes that Brazilian Portuguese distinguishes three vowel heights (in keeping with Jakobson et al. (1951), Chomsky and Halle (1968), according to which three is the maximal height distinction universally allowed).

Assuming the vowel system in (12), by substituting the values for vowel height in the rule schemata (11), the rule to account for the vowel harmony phenomenon can be stated as follows: [2]

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[2] For presentation purposes, here and throughout the article I will adopt a segmental approach (Chomsky and Halle (1968)) in the formulation of the rules since this is the model utilized in the analyses discussed here and, hence, provides a useful framework for comparing the various proposals vis-à-vis the facts discussed here. In recent years there has been a great deal of controversy as to whether vowel harmony phenomena are best treated segmentally (as argued for instance by Anderson (1980, 1982), Vago (1980), Ringen (1980)) or non-segmentally (cf. Clements (1976), Goldsmith (1985), Halle and Vergnaud (1981), Van der Hulst (1985), among others). There is no evidence at this point that the facts of Portuguese have any decisive bearing on this

(13) *Generalized Vowel Harmony (GV Harmony)* (preliminary formulation)

$$\begin{bmatrix} -\text{high} \\ \alpha \text{ round} \\ \alpha \text{ back} \end{bmatrix} \rightarrow \begin{bmatrix} \alpha \text{ high} \\ \beta \text{ low} \end{bmatrix} / \underline{\quad} C_0 + \begin{bmatrix} V \\ \alpha \text{ high} \\ \beta \text{ low} \end{bmatrix} + V \ldots]_{\text{Verb}}$$

At this point, the proposal for Vowel Harmony represented by rule (13) is in agreement with Harris's proposal in two important respects. Both proposals assume the same underlying vowel system (12), and both agree in that vowel harmony affects only vowel height characterized in terms of tongue-body features. My proposal differs from Harris's, however, in some important respects. While Harris formulated the vowel harmony rule so as to apply only to the second and third conjugations, the present formulation assumes (this time in agreement with both Redenbarger and Lopez) that the rule applies generally to all three conjugations (we will therefore refer to rule (13) as 'Generalized Vowel Harmony' (henceforth GV Harmony) so as to distinguish it from Harris's rule). This represents an improvement over Harris's analysis and avoids the criticism raised against Harris's less general formulation (cf. Mateus (1975), Redenbarger (1981: ch 5), and Lopez (1979) for relevant criticism). A second difference is discussed directly below.

Although the rule, as formulated, gives the correct empirical results for the facts at hand, it seems that further improvement is possible. As noted by Harris, we must prevent verb stems containing the low vowel /a/ from undergoing the vowel harmony rule. This is necessary, otherwise the rule would apply to verbs such as *bater* 'to beat' (second conjugation) and *partir* 'to depart' (third conjugation) to produce ungrammatical forms such as those in (14):

(14a) /bat+e+o/   (14b) /part+i+o/

                            i   Harmony
                                    ∅   Truncation
      *[bʌto   ]   *[pɨrto   ]

To avoid this, Harris utilized the 'alpha-alpha' notational device (α round; α back) in the input of the vowel harmony rule, which is incorporated in the

controversy. Although I have adopted a segmental view in the presentation, it is quite possible that the same facts can also be accounted for under an autosegmental or metrical approach. This question, however, requires further study and I will leave the matter for future investigation.

formulation in (13). Although this possibility is not precluded, it seems to be an ad hoc extension of the Greek-variables notation. As an alternative, both Redenbarger and Lopez attempted to solve the problem of excluding /a/ by reanalyzing the whole underlying vowel system so that /a/ is placed in a class by itself (i.e. the only [+cp] in Redenbarger's system or the only [+low] in Lopez's system). By formulating their respective vowel harmony rules so as to exclude /a/, defined in terms of the features that they adopt, the problem in question can be avoided. These solutions, however, are not unproblematic. Thus, Lopez's proposal requires increasing the expressive power of phonological theory to allow four degrees of vowel height instead of three, while Redenbarger's proposal requires positing a rather uneconomical set of features to account for Portuguese vowels. These problems cast doubts about the adequacy of these analyses (for further discussion, see section 2.4).

A more principled approach would be to eliminate such descriptive devices and rely, instead, on general principles to account for the cases of overgeneration. If this could be done here, the formulation of the GV Harmony rule could be greatly simplified, with corresponding increase in explanatory power.

We would like now to advance a proposal seeking to accomplish this. Suppose we remove both features encoded with the alpha-alpha variables in the input of rule (13), which were imported as a residue of Harris's analysis. The rule could now be more simply stated as in (15):

(15) *GV Harmony* (final version)
$$[-\text{high}] \rightarrow \begin{bmatrix} \alpha \text{ high} \\ \beta \text{ low} \end{bmatrix} / \underline{\quad} C_0 + \begin{bmatrix} V \\ \alpha \text{ high} \\ \beta \text{ low} \end{bmatrix} + V \ldots]_{\text{Verb}}$$

Now only high vowels are excluded, something that is empirically required in all proposals to meet observational data. But notice that if no other assumption is made, the rule in (15) would, indeed, also apply to verb stems containing /a/ to produce the incorrect forms in (14).

Consider a solution to this problem. Suppose, we assume (following Kiparsky (1985: 114 ff.)) that the GV Harmony rule of Portuguese is a 'lexical rule'. Assume further that all lexical rules are subject to the Principle of Structure Preservation (Kiparsky (1985)) – henceforth PSP. In that case, application of the rule in examples such as (14) would be correctly excluded by the PSP.

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The principle in question states essentially that lexical rules cannot create forms containing new segments which are not part of the underlying inventory. Since Portuguese has the system of seven underlying vowels (12), a lexical rule such as GV Harmony can only adjust the vowel height so as to map an underlying vowel into another underlying vowel (thus preserving lexical structure). The illformedness of the examples in (14) can now be explained as violations of the PSP since the harmony rule has incorrectly applied to underlying /a/ to create forms containing a new additional eight vowel *[ʌ] or a ninth vowel *[ɨ], which is not permitted by the principle. (For a parallel situation, see for example the discussion of Vowel Harmony in Finnish in Kiparsky (1985: 115)).[3]

Reliance on the PSP thus allows us to greatly simplify the formulation of the GV Harmony rule, with corresponding gain in generality. This, of course, is an argument to support the formulation of the rule proposed here. At the same time, the fact that the rule needed to account for Vowel Harmony in Portuguese also obeys the PSP constitutes additional evidence for the universality of this principle.

2.2. Lowering, Neutralization and Vowel Harmony

In this section we propose an analysis for the phenomena of neutralization and lowering. Let us consider first the phenomenon of neutralization.

The need for a Neutralization rule is illustrated by verbal forms such as v[o]ltamos 'we return' and s[e]rvimos 'we serve' which derive from underlying representations containing /O/ and /E/, respectively. Evidence for assuming /O/ and /E/ in these underlying representations is the fact that these are the vowels that appear in the corresponding Portuguese nominal forms v[Ó]lta 'return' and s[É]rvo 'servant, respectively (cf. also their Spanish counterparts vuelta and siervo, which also suggests that the vowels are /O, E/).[4] The effect of Neutralization is illustrated in (16) (irrelevant rules omitted):

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[3] I am greatly indebted to Bruce Hayes for various suggestions in formulating this proposal (although of course I am solely responsible for any errors). For discussion of the theory of lexical phonology, see Kiparsky (1985), Mohanan (1986), Halle and Mohanan (1985) and references cited there.

[4] The determination of underlying vowels in examples containing [e, E, o, O] is no simple matter. The knowledgeable reader will notice that I follow Harris (1974) in assuming that the underlying vowels are more accurately reflected in the nominal forms.

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(16) /vOlt + a + mos/   /sErv + i + mos/
        á   í   Stress
    o   e   Neutralization
  [voltámos   ]   [servímos   ]   (derived structure)

Essentially, Neutralization converts all instances of unstressed [E, O] to [e, o]. Given our assumptions concerning the vowel system in (12), the rule can be stated as in (17):

(17) *Neutralization*

$$[+\text{syllabic}] \rightarrow [-\text{low}] / \left[\underline{\qquad} \atop -\text{stress} \right]$$

A rule to this effect is assumed by all analyses. The specific formulations will vary depending on the choice of the system of underlying vowels (cf. for instance Redenbarger (1981: 134)). But notice also that Neutralization must not apply to the low vowel /a/, lest ill-formed strings would be derived (cf. /karoso/ → *[kʌrósu] 'kernel'). But, once again, it is not necessary to complicate the statement of the rule in (17) so as to prevent Neutralization from incorrectly applying to convert the low /a/ to / the mid *[ʌ]. If we assume that Neutralization is a lexical rule, this would automatically be excluded by the PSP.[5]

A more difficult problem, however, is the characterization of the so-called lowering phenomena. Evidence for a rule of Lowering is based on forms such as *ap[É]la* 'he/you appeal' and *esc[Ó]va* 'he/you brush' that originate from stems containing the mid-vowels [e] and [o] and are lowered to [E] and [O], respectively.[6]

The formulation of the rule to account for the lowering phenomenon is at center of the controversy involving the explanatory role played by the Elsewhere Condition in Harris's (1974) analysis, which we shall now review.

Harris's analysis assumed that the process in question can be characterized

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[5] This assumption gives the correct results for Brazilian Portuguese, which is the system under analysis. This situation is complicated, however, by the facts of European Portuguese since the unstressed vowel in question appears reduced to a [ʌ] in surface structure. I will leave this matter for further study.

[6] Again, evidence for assuming these to be the underlying vowels comes from the fact that these are the vowels that appear in the more basic nominal forms such as *o ap[é]lo* 'the appeal' and *a esc[ó]va* 'the brush' (cf. note 3). We will make this assumption thoughout the article.

by a Lowering rule which is sensitive to Stress (in a way, doing just the opposite of his rule of Neutralization). Harris's formulation is as follows:

(18) *Lowering*

$$\begin{aligned} e &\rightarrow E \\ o &\rightarrow O \end{aligned} \Bigg/ \left[\underline{\hphantom{xxxxx}} \atop +stress \right]$$

This formulation of Lowering, however, leads to a seemingly paradoxical result in the second conjugation, as Harris noted. Since Lowering, as formulated, is sensitive to Stress it would necessarily have to apply after Vowel Harmony (which necessarily must precede Truncation, which, in turn, must precede Stress). As a consequence, if no additional assumptions were made, Lowering would incorrectly lower the harmonizing vowel to produce incorrect forms in the second conjugation, as shown in (19):

(19)   /dev + e + o/   /mOv + e + o/
       (vacuous)   o   V. Harmony
            ∅   ∅   Truncation
          é   ó   Stress
          É   Ó   Lowering
                u   u   FV Raising
       *[dÉvu   ]   *[mÓvu   ]

That is, in the case at hand Lowering would undo the job of Vowel Harmony so as to produce the ungrammatical *[dÉvu], [*mÓvu], instead of the correct [dévu] 'I owe' and [móvu] 'I move'. This constitutes what we may call the 'second conjugation paradox'.

Harris argued that the paradox above can be resolved by assuming a version of Kiparky's Elsewhere Condition. Under Harris's assumptions, due to the formal properties of the rules of Vowel Harmony and Lowering, the Elsewhere Condition would establish a disjunctive ordering relationship between them. In that case, the problematic application of Lowering in the second conjugation, as illustrated in (19), would allegedly be ruled out by the Elsewhere Condition, which would block application of Lowering in all cases where the form had first undergone Vowel Harmony. This led Harris to claim that the facts of Portuguese in question provide empirical support for the Elsewhere Condition.

Harris's utilization of the Elsewhere Condition to account for such facts, however, has been called into question by both Redenbarger and Lopez, who

make the important point that the rule involved must be morphologically conditioned so as to apply only to verb stems (rather than to all categories, as one would expect if the rule were simply sensitive to stress). Their point is that in nouns such as [apélo] 'appeal' and [eskóva] 'brush' the vowels are mid /e, o/ even though they are stressed; hence the lowering rule must be restricted to verb stems. But if the rule must be morphologically conditioned, then it is possible to have Lowering apply before Vowel Harmony and the 'second conjugation paradox' can be resolved in a different way, without loss of generality.

In my view, Redenbarger and Lopez are correct in claiming that the lowering rule is morphologically conditioned and must be formulated so as to refer to 'verb stem' (below I give an additional argument to support this claim). Assuming (with Lopez and Redenbarger) that Lowering is morphologically conditioned, given the underlying vowel system in (12), the rule can be formulated as follows:

(20) *M-Lowering*
$$\begin{bmatrix} V \\ -\text{high} \end{bmatrix} \rightarrow [+\text{low}] / \underline{\quad} C_0 \ ]_{\text{Root}} \text{---}]_{\text{Verb}}$$

This rule is equivalent to the one given in Redenbarger (1981: 167). I will refer to this rule as M-Lowering (Morphological Lowering) so as to distinguish it from Harris's rule of Lowering in (18), which is a purely phonological rule conditioned by stress.[7]

Under this assumption the paradox illustrated in (19) may be resolved in a different manner. Since M-Lowering (arguably a morphological rule) would apply before GV Harmony the output of the latter would not be interfered with, as desired. Thus instead of (19), the derivation would now proceed as in (21):

(21)
/dev + e + o/	/mOv + e + o/	
E	-------------	M-Lowering
e	o	GV Harmony
∅	∅	Truncation
é	ó	Stress
u	u	FV Raising
[dévu]	[móvu]	

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[7] As a matter of fact, Harris did contemplate the possibility of a morphologically conditioned rule of Lowering (cf. p. 72), but rejects this in favor of a phonologically conditioned rule that appeared simpler.

Likewise, interaction
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(22) /dev + e + mos/
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            é
    e
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                u
[devémus   ]

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(23) /apel + a + o/
        E
    (vacuous)
            ∅
    É

[apÉlo   ]

(24) /sErv + i + o/
    (vacuous)
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Likewise, interaction of M-Lowering with Neutralization would ensure the correct results in forms where Vowel Harmony does not apply:

(22) /dev + e + mos/   /mOv + e + mos/

E	O	M-Lowering
-------------	--------------	GV Harmony
-------------	--------------	Truncation
é	é	Stress
e	o	Neutralization
ḗ	ḗ	Nasalization (46)
u	u	FV Raising (9)
[devḗmus]	[movḗmus]	

The facts above pertain to the second conjugation. But it is easy to see that the system of rules given here can account for all the facts of vowel alternation in the other two conjugations as well. Thus compare the facts of the first conjugation in (23) and those of the third conjugation in (24) (we omit the effects of Nasalization and FV Raising, which are irrelevant to the point):

(23) /apel + a + o/   /eskov + a + o/   /apel + a + mos/   /eskov + a + mos/

E	O	E	O	ML
(vacuous)	(vacuous)	---------------	----------------	GVH
∅	∅	---------------	----------------	Tr.
É	Ó	á	á	Str.
--------	------------	e	o	Neu.
[apÉlo]	[eskÓvo]	[apelámos]	[eskovámos]	

(24) /sErv + i + o/   /sErv + i/   /sErv + i + mos/   /dorm + i + o/

(vacuous)	(vacuous)	(vacuous)	O	ML
i	---------	--------------	u	GVH
∅	---------	---------------	∅	Tr.
í	É	í	ú	Str.
---------	-------	e	------------	Neu.
[sírvo]	[sÉrvi]	[servímos]	[dúrmo]	

We see thus that the approach adopted here, with a morphologically conditioned rule for lowering (M-Lowering), can account in a plausible way for the facts in question. In fact, there seems to be good evidence to support this formulation of the rule over the phonological formulation based on stress as proposed by Harris.

One argument, provided by Redenbarger (1981:131), was already implied in the above discussion. Redenbarger argued that if the rule is phonologically formulated so as to lower stressed [e, o], as Harris proposed, it would wrongly apply to nouns giving wrong results such as *[dÉdu] instead of [dédu] 'finger', *[rÓla] instead of [róla] 'morning dove,' and many others. This would not happen, however, if the rule is formulated so as to apply only to verb stems (M-Lowering), as assumed here.

To this I would like to add a further argument for M-Lowering based on dialect variation. In Baiano, a dialect spoken in Northeast Brazil, the facts concerning lowering are somewhat different from the 'Official Dialect' that we have been describing. In Baiano the relevant stem vowel is low also in the first person plural, even though it it not stressed (cf. Silva (1981:46)). For example, the paradigms for the present indicative of verbs like *apelar* 'to appeal' and *morar* 'to live' in Baiano are as follows:

(25a) ap[É]lo	'I appeal'	(25e) m[Ó]ro	'I live'
(25b) ap[É]la	'you/he appeals'	(25f) m[Ó]ra	'you/he lives'
(25c) ap[E]llámos	'we appeal'	(25g) m[O]rámos	'we live'
(25d) ap[É]lam	'they appeal	(25h) m[Ó]ram	'they live'

To characterize this dialect under the view that lowering is purely phonologically conditioned, it would be necessary to assume that Baiano not only lacks a Neutralization rule (something that appears correct); but in addition, under this proposal, it would be necessary to assume *two* lowering rules: one to lower stressed mid-vowels (because of the facts in (25a,b,d) and another to lower also unstressed mid-vowels (because of (25c)), which seems to be rather dubious.

By contrast, under the proposal adopted here, the similarities between Baiano and the Official Dialect would be accounted for by the rule of M-Lowering, which is identical for both dialects. The two dialects would differ, however, in that the Official Dialect has a rule of Neutralization, while Baiano does not. This would be a much simpler explanation for the dialectal facts in question, in sharp contrast to the alternative discussed above. This argument in favor of M-Lowering seems to me persuasive, although the reader must be warned that a detailed description of Baiano remains to be done.

Based on the arguments presented, I conclude that the phenomenon of lowering in Brazilian Portuguese can be better accounted for by a morphologically conditioned rule (M-Lowering). Since this allows for a better solution

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(26) /eskes + e + c
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than the one allowed by the Elsewhere Condition I conclude, contrary to Harris's analysis, that this principle plays no role in the account of vowel alternation in Brazilian Portuguese. This, of course, does not invalidate the Elsewhere Condition as a principle of grammar; it simply excludes the particular phenomenon discussed here from its domain of application.

2.3 Rule interaction: M-Lowering, GV Harmony, Neutralization

In this section we show how the rules argued for in the previous sections interact in crucial ways to account for the phenomena of vowel alternation in Portuguese.

One situation already discussed is the way GV Harmony, M-Lowering and Neutralization (plus minor rules) interact in the second conjugation. Here we spell out some details which were implicit in the earlier discussion. The theme vowel in the second conjugation is the mid vowel /e/. Due to the effect of GV Harmony, if the last syllable in the stem contains a low vowel /E/ or /O/ these are raised to mid to harmonize with the theme vowel in pre-vocalic position. This is illustrated by the facts of *esquecer* 'to forget', *mover* and *escolher* 'to choose' in (26): [8]

(26) /eskes + e + o/   /mOv + e + o/   /eskoʎ + e + o/

E	--------------	O	M-Lowering
e	o	o	Harmony
∅	∅		Truncation
é	ó	ó	Stress
----------	--------------	-------	Neut.
u	u	u	FV Raising
[eskésu]	[móvu]	[eskóʎu]	

[8] As in the other cases already mentioned, evidence for the underlying vowels in (26) comes from the fact that these are the vowels found in the corresponding nominal forms. Thus we assume /O/ in /mOv + e + o/ because the vowel in the related noun *o m[Ó]vel* 'the mobile' is /O/, and we assume /o/ in /eskoʎ + e + o/ because the vowel in a corresponding noun such as *a esc[ó]lha* 'the choice' is /o/ (cf. note 4). However, in cases such as /eskes + e + o/ it is difficult to ascertain the nature of the underlying vowel since related nominal forms such as *o esqu[e]ciménto* 'the forgetfulness' since it could be either underlying /e/ or an underlying /E/ that undergoes Neutralization. But notice that this is immaterial here since the rules that we are assuming will produce the correct outputs, independent of the problem of determining the underlying vowel in such cases.

If the theme vowel is not pre-vocalic, GV Harmony does not apply, in which case the vowel height is adjusted by the rules of M-Lowering and Neutralization. As evidence for this, compare the derivations of *esqu[É]ce* 'he forgets', *esqu[e]cémos* 'we forget', *m[o]vémos* 'we move' and *esc[o]lhémos* 'we choose':

(27)

/eskes + e/	/eskes + e + mos/	/mOv + e + mos/	/eskoʎ + e + mos/	
E	E	-----------------	O	M-Lowering
----------	------------	-----------------	-----------------	Harmony
----------	------------	-----------------	-----------------	Truncation
É	é	é	é	Stress
----------	e	o	o	Neut.
----------	ḛ	ḛ	ḛ	Nasal. (46)
i	u	u	u	FV Raising
[eskÉsi]	[eskesḛ́mus]	[movḛ́mus]	[eskoʎḛ́mus]	

Consider now the facts of the third conjugation. The theme vowel is the high vowel /i/. In the environment where GV Harmony applies, if the last stem vowel is either the mid /e/ or the low /E/, GV Harmony will raise them to high /i/. On the other hand, if the last stem vowel is the mid back /o/ or the low back /O/, GV Harmony will raise them to the high back /u/. This is illustrated by the facts of *servir* 'to serve' (cf. s[E]rvo 'servant'), *ferir* 'to wound' (cf. f[e]rimento 'the wound'), *tossir* 'to cough' (cf. a t[O]sse 'the cough') in (28):

(28)

/sErv + i + o/	/fer + i + o/	/tOs + i + o/	
----------	E	----------	M-Lowering
i	i	u	Harmony
∅	∅	∅	Truncation
í	í	ú	Stress
----------	----------	----------	Neutralization
u	u	u	FV Raising
[sírvu]	[fíru]	[túsu]	

On the other hand, in environments where GV Harmony is precluded, the adjustments are made by M-Lowering and Neutralization, as usual. Compare the derivations of *serve* 'he serves', *servimos* 'we serve', *fere* he wounds', *ferimos* 'we cough', *tosse* 'he coughs' and *tossimos* 'we cough':

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+mos/

	M-Lowering
-----	Harmony
----	Truncation
	Stress
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	Nasal. (46)
u	FV Raising

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(29)

/sErv+i/	/sErv+i+mos/	/fer+i/	/fer+i+mos/	/tOs+i/	/tOs+i+mos/	
------	------------	E	E	------	------------	M-Low.
------	------------	------	--------------	------	------------	Harmony
------	------------	------	--------------	------	------------	Trunc.
É	í	É	í	Ó	í	Stress
------	e	------	e	-------	o	Neut.
------	í̧	------	í̧	-------	í̧	Nas. (46)
------	u	------	u	-------	u	FVR
[sÉrvi]	[servímus]	[fÉri]	[ferímus]	[tÓsi]	[tosímus]	

The same system of rules accounts for the facts of the first conjugation. The difference is that, since the theme vowel of the first conjugation is the low vowel /a/, prior application of M-Lowering will lower /e/ to /E/ and /o/ to /O/, which systematically results in a vacuous application of GV Harmony. This is illustrated by the facts of *apelar* 'to appeal' (cf. o ap[é]lo 'the appeal') *paquerar* 'to flirt' (cf. paqu[É]ra 'flirtation'), *escovar* 'to brush' (cf. esc[ó]va 'brush') and *colar* 'to glue' (cf. c[Ó]la 'glue') below:

(30)

/apel+a+o/	/pakEr+a+o/	/eskov+a+o/	/kOl+a+o/	
E	-------------	O	----------	M-Lowering
(vacuous)	(vacuous)	(vacuous)	(vacuous)	Harmony
∅	∅	∅	∅	Truncation
É	É	Ó	Ó	Stress
--------	-------------	------------	------------	Neut.
u		u	u	FV Raising
[apÉlu]	[pakÉru]	[eskÓvu]	[kÓlu]	

As in the previous examples, in environments where GV Harmony is impossible, the stem vowels are adjusted by M-Lowering and Neutralization, This is exemplified by the derivations of forms such as *apela* 'he appeals', *apelamos* 'we appeal', *paqueramos* 'we flirt', *escova* 'he brushes', *escovamos* 'we brush':

(31)

/apel+a/	/apel+a+mos/	/pakEr+a+mos/	/eskov+a/	/eskov+a+mos/	
E	E	---------------	O	O	M-Lowering
--------	------------	---------------	--------	---------------	Harmony
--------	------------	---------------	---------	---------------	Truncation
É	á	á	Ó	á	Stress
--------	e	e	--------	o	Neut.
--------	á̧	á̧	--------	á̧	Nasal (46)
--------	ʌ́	ʌ́	--------	ʌ́	NV Rais. (50)
ʌ	u	u		u	FV Rais.
[apÉlʌ]	[apelʌ́mus]	[pakerʌ́mus]	[eskÓvʌ]	[eskovʌ́mus]	

As we see, the system of rules that we have provided is able to account for all the vowel alternation facts presented in (1)–(3).

As a final set of facts, consider the phenomena of vowel alternation in the present subjunctive of all three conjugations:

		I	II	II
(32a)	1 sing.	ap[É]le	esqu[é]ça	s[í]rva
	2/3 sing.	ap[É]le	esqu[é]ça	s[í]rva
	1 pl.	ap[e]lémos	esqu[e]çámos	s[i]rvam
(32b)	1 sing.	esc[Ó]ve	m[ó]va	t[ú]ssa
	2/3 sing.	esc[Ó]ve	m[ó]va	t[ú]ssa
	1 pl.	esc[o]vémos	m[o]vámos	t[u]ssámos
	2/3 pl.	esc[Ó]vem	m[ó]vam	t[ú]ssam

In both the second and third conjugation all the forms appear to have undergone harmony. Similarly, in the first conjugation all but the first person plural forms appear to harmonize.

To account for this, we must examine some details of verb morphology. In Portuguese, the basic morphological structure of the verb is essentially as follows: *Root + theme vowel + tense/mood affix + personal affix* (cf. Câmara (1972)). Subjunctives have overt tense/mood affixes. For example, the tense/mood affix for the future subjunctive is {se}. Thus, a form like *lavássemos* 'if we were to wash' must be analyzed as in (33):

(33) Root + theme vowel + tense/mood + personal affix
      lav   a   +   se   +   mos

A plausible analysis of the present subjunctive in Portuguese is that the tense/mood affix is {-e} for the first conjugation and {-a} for the second and third conjugations. Under this assumption, the facts of the second and third conjugations can now be accounted for by our rules. Compare the derivations of the relevant examples below (irrelevant rules omitted):

(34) /eskes+e+a/	/eskes+e+a+mos/	/sErv+i+a/	/sErv+i+a+mos/	
E	E	---------	--------------------	M-Lower.
e	e	i	i	Harmony
∅	∅	∅	∅	Trunc.
é	á	í	á	Stress
-----------	------------------	-----------	--------------------	Neut.
[eskésa]	[eskesámos]	[sírva]	[sirvámos]	

In other words, the presence of the tense/mood affix for the present subjunctive, which happens to be a vowel, places the theme vowel in an open syllable and hence GV Harmony applies in all cases.[9] Notice also the effect of truncation, which eliminates the theme vowel, causing the impression that the theme vowel has shifted.

A similar account can be given to the facts of the first conjugation. Consider the derivation of the relevant examples in (35) (irrelevant rules omitted):

(35) /apel+a+e/   /apel+a+e+m/   /apel+a+e+mos/
       E   E   E   M-Lowering
      (vacuous)   (vacuous)   (vacuous)   Harmony
       Ø   Ø   Ø   Truncation
       É   É   é   Stress
      --------   ----------   e   Neutralization
      [apÉle   ]   [apÉlem   ]   [apelémos   ]

The difference between these examples and the examples of the second and third conjugations discussed earlier is that in the first conjugation application of M-Lowering and GV Harmony makes the stem vowel low. Because of this, application of Neutralization in the first person plural undoes the effect of M-Lowering and GV Harmony (cf. *ap[e]lémos* 'that we appeal'). This does not happen in the second and third conjugations, however, since GV Harmony converts all low vowels to either mid (second conjugation) or high (third conjugation), thus bleeding Neutralization, which is why all forms in columns II and III in (32) appear unchanged.[10]

[9] Notice that GV Harmony does not apply in the future subjunctive, since the tense/mood affix {-se} begins with a consonant and, hence, does not satisfy the structural description of the rule. The future subjunctive thus will only contain the non-harmonizing stems. Compare: *esqu[e]césse, esqu[e]césse, esqu[e]céssemos, esqu[e]céssem* ('were I/you/we/they to forget'); *s[e]rvísse, s[e]rvísse, s[e]rvíssemos, s[e]rvíssem* ('were I/you/we/they to serve').

[10] The subjunctive forms in (35) are interesting for still another reason. Here we see that forms undergoing GV Harmony (vacuously as we assume here) may also undergo Neutralization. In an analysis such as Harris's this would not be possible: since the Neutralization rule that he assumes is formally similar to his Lowering rule, application of Neutralization to a form that has undergone Harmony should also be blocked by the Elsewhere Condition. This clearly shows that Harris's proposal, as formulated, cannot simply be cosmetically adjusted to apply also to the first conjugation, since his other assumption (namely the Elsewhere Condition) would give the wrong results in the present subjunctive forms such as *apelemos* and *escovemos*. In other words, the assumption that Harmony applies to the first conjugation and Harris's assumption concerning the way the Elsewhere Condition applies to Portuguese are made mutually exclusive by the subjunctive facts in question.

To conclude this section, in the discussion above we have examined the problem of vowel alternation in all three verbal conjugations of Brazilian Portuguese. Elaborating on previous proposals, we have developed a system of rules – the most important of which are M-Lowering, GV Harmony and Neutralization. We have then shown here how this system of rules accounts for the relevant facts in a plausible way and, hence, provides support to the analysis advanced in this article.

2.4. Alternative analyses of harmony: Brief discussion

In this section I discuss briefly some of the main differences between my proposal and other existing analyses. Since we have already discussed the main points of convergence and divergence between my proposal and Harris's (1974) proposal, which was our point of departure, I will instead concentrate here on the main differences between my proposal and the proposals advanced in Redenbarger (1981) and Lopez (1979).

As noted earlier, there are many areas of agreement between my proposal for vowel harmony and the proposals made by both Redenbarger and Lopez, which I consider to be serious efforts and which deserve much praise. But one can always try to make a good thing better and it is in this spirit that I will attempt to argue in favor of my proposal against the hypotheses offered in their analyses by focussing on the differences among them.

A first difference has to do with the way the analyses in question propose to account for the fact that verb stems containing /a/ do not undergo Vowel Harmony. Both Redenbarger and Lopez argue that this is to be accounted for in terms of language-specific properties of the respective vowel systems that they assume for Portuguese, which are reproduced below (for simplicity's sake we omit reference to 'back' and 'round' features): (36)

(36a) *Redenbarger (1981, 1977)*			(36b) *Lopez (1979:50)*
+hi, +tense (+ATR)	i	u	+hi, −lo, +raised
−hi, +tense (+ATR)	e	o	−hi, −lo, +raised
−hi, −tense (−ATR)	ε	ɔ	−hi, −lo, −raised
+cp, −tense (−ATR)	a		−hi, +lo, −raised

Both Redenbarger and Lopez argue that by assuming their respective vowel systems above it is possible to write the Vowel Harmony rule without utilizing the 'α back, α round' convention adopted by Harris. Since under either analysis /a/ would be in a class by itself (either the only [+cp] or the

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only [+low] vowel), it would be possible to exclude /a/ simply by not mentioning the features in question in the formulation of the Vowel Harmony rule (see below). Both Redenbarger and Lopez consider this to be an improvement over Harris's analysis and argue that this fact provides a major motivation for adopting their reanalysis of the vowel system and for their account of Vowel Harmony. However, either solution is entirely dependent on the language-specific assumptions that they make concerning the Portuguese vowel system. The analyses in question do not follow from any general principle.

By contrast, under my analysis, the solution to the problem in question is not dependent on any idiosyncratic property of the Portuguese vowel system or of Portuguese /a/. Quite independently of the choice among the various systems in question, the reason why the Vowel Harmony rule does not apply to /a/ is that this would constitute a violation of the Principle of Structure Preservation. In this way, the facts of Portuguese can be explained in a principled manner, in terms of a general principle of grammar.

The argument above, however, does not imply that the choice of vowel systems is entirely irrelevant to the problem of Vowel Harmony. On the contrary, some differences between my analysis and the alternatives under consideration do stem from assumptions concerning the vowel system.

First, the vowel systems adopted under either Lopez's or Redenbarger's proposal faces a number of problems. The feature [raised] utilized by Lopez to allow four vowel heights in Portuguese increases the expressive power of phonological theory, apparently for no good reason, since this feature has no independent motivation aside from the Portuguese facts that she discusses. In the absence of evidence for this increase in expressive power, a simpler proposal (like (12)), which allows only three vowel heights is to be preferred.

Similarly, Redenbarger's utilization of [tense]/[ATR] to characterize Portuguese vowels is not compelling. First of all, since characterization of the Portuguese vowel system already requires the features 'high' and 'low' (Redenbarger's use of 'cp' for 'low' is merely a terminological matter) we should not also include 'tense/ATR', unless strong evidence to the contrary is provided. The justification given by Redenbarger is that the addition of 'tense/ATR' is crucially needed to formulate the Vowel Harmony rule. However, as we have shown above, this is not correct. In fact, a more general rule of harmony can be given if we dispense with 'tense/ATR'.

Second, as noted in various studies, tense is usually accompanied by greater length (Chomsky and Halle (1968), Halle and Clements (1983)). This was clearly the case in Latin where the tense/lax opposition was intimately

connected with long/short. The former existed only in company with the latter. So it is natural to assume that in the evolution of Portuguese, when the long/short contrast disappeared so did the tense/lax one (cf. Schane (1984: 145) for a similar point). This seems to be evidence against positing a tense/lax distinction in Portuguese. Likewise, ATR and tense are not known to co-occur distinctively in any language and may be variant implementations of a single feature category (Halle and Clements (1983)); given that there is no evidence for the more common tense/lax implementation it is doubtful that the feature category in question plays any role in Portuguese (see also note 11). On the other hand, these problems simply do not arise for my proposal, which assumes that the vowel system is (12).

Third, and more importantly, unlike (12), the system of vowels assumed in either Lopez's or Redenbarger's analyses does not actually permit an adequate characterization of the effects of Portuguese vowel harmony (despite their explicit claims to the contrary).

Consider first Lopez's proposal in this regard. The vowel system that she adopts (36b) is based on tongue body features to characterize vowel height. The addition of the feature [raised] allows the differentiation of two layers of mid vowels, while low and high vowels are defined in terms of the features [high] and [low]. Lopez assumes (as I do) that the rule of Vowel Harmony applies to all three conjugations (p. 175) and she states the rule for Harmony as follows (p. 178):

(37) *Vowel Harmony* (Lopez (1979))

$$\begin{bmatrix} V \\ -hi \\ -lo \end{bmatrix} \rightarrow \begin{bmatrix} \alpha \text{ raised} \\ \beta \text{ high} \end{bmatrix} / \underline{\hspace{1em}} C_0 + \begin{bmatrix} V \\ \alpha \text{ raised} \\ \beta \text{ high} \end{bmatrix}_{Stem} + V \dots]_{Verb}$$

According to this proposal vowel height is defined in terms of tongue body features and these are crucially involved in the harmony process. Yet, conspicuously absent from the structural changes and the environment of the rule is the feature [low]. This is not incidental. Suppose this feature were included in the formulation of the harmony rule. Since the rule applies to all three conjugations, it would apply to first conjugation forms such as /apel + a + o/ and /mor + a + o/. Here, since the theme vowel /a/ is [+low], the vowel harmony rule would lower the mid vowels /e, o/ all the way to low [E, O], to give [apÉlo] and [mÓro], which means that at least at the level of

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surface representation, low [E, O] would have to be postulated. The problem with this of course is that, since the phonetically low [E, O] would be derived via harmony, the proposal would be led to make the incorrect claim that there is a phonetic difference between the harmonizing vowel in *apelo, moro* (i.e. +low) and the vowels in forms such as *pé, pó* which, according to the proposal, would be low-mid (i.e. [−hi, −lo, −raised]).

This problem is avoided simply because under Lopez's analysis the feature [low] is arbitrarily excluded in the formulation of the harmony rule. But this too has bad consequences. Now, because of this assumption, Lopez's vowel harmony rule yields a dubious asymmetry: In the second and third conjugations the relevant stem vowel harmonizes completely in height with the theme vowels (cf. /s[i]rv + i + o/, /d[u]rm + i + o/, /d[e]v + e + o/, /m[o]v + e + o/). But in the case of the first conjugation forms such as /apel + a + o/, /mor + a + o/, where the theme vowel is low, the stem vowel only gets lowered to low-mid ([−hi, −low, −raised] in her terms). So the picture given by Lopez's rule is that of a mixed state of affairs: The rule causes complete height assimilation (harmony) in the second and third conjugations, while in the first conjugation, it causes only a one-step lowering in the case of /e, o/ and no assimilation at all in the case of the alleged low-mid /ɛ, ɔ/. This raises serious questions about the adequacy of Lopez's Vowel Harmony rule and undermines her claim that Vowel Harmony applies uniformly to all conjugations since, clearly, it does not have the same effects in the three conjugations.

The situation above is in contrast with the symmetric effects of the GV Harmony rule proposed here. With exception of high vowels, which must be prevented from undergoing harmony in all proposals, GV Harmony establishes complete harmony in height in all three conjugations. In other words, low harmonizes with mid in the second conjugation, low and mid harmonize with high in the third conjugation, and mid harmonizes with low in the first conjugation. This, I submit, is a more homogeneous rule of harmony and is to be preferred to Lopez's rule.

Similar objections apply to Redenbarger's proposal. The vowel system that he assumes is as given in (36a). In this system the only primitive feature connected with vowel height phenomena is the feature [high]. All other height phenomena are due to secondary effects of the features [tense] (or [ATR]; cf. Redenbarger (1977)) and constricted pharynx [cp]). Under this proposal the feature 'tense' (or ATR) is used to distinguish two layers of 'mid' vowels, while 'constricted pharynx' is used to characterize the 'low' vowel /a/. Redenbarger's rule of harmony (p. 173) is then formulated as follows:

(38) *Vowel Harmony* (Redenbarger (1981:173))

$$
\begin{bmatrix} V \\ -hi \\ -cp \end{bmatrix} C_0 + \begin{bmatrix} V \\ \alpha\ high \\ \beta\ tense \end{bmatrix} + V \dots]_{Verb}
$$

$\Downarrow$

$\alpha\ high$
$\beta\ tense$

According to Redenbarger, vowel harmony in Portuguese is a 'double assimilation process. There is a simultaneous and total assimilation of both tongue-body height and of tenseness; moreover it applies in all three conjugations' (p. 174). (Subsequently, Redenbarger (1977) substitutes [ATR] for [tense], but this does not affect the argument.)[11]

But consider now some problems involving Redenbarger's proposal. First, notice that the rule in (38) presents the same asymmetry problem that we discussed in connection with Lopez's proposal. According to Redenbarger's proposal, in the second and third conjugations the relevant stem vowel would 'totally assimilate', ending up with the same height of the theme vowel (i.e. [+hi, +tense] and [−high, +tense]). But notice that the feature [+cp] must be excluded from the structural change of the harmony rule due to the same problem facing Lopez's proposal already pointed out. Now, because of this, in the first conjugation where the theme vowel is the 'low' /a/ (i.e. [+cp]) the 'high mid' [e, o] would lower only one degree to 'low mid' (with only tense being affected), while the alleged 'low mid' /ɛ, ɔ/ would not be affected at all. In short, although it could be argued that this formulation causes harmony in the second and third conjugations, it causes only a partial assimilation in the first conjugation (just like in Lopez's proposal), which seems to be again a dubious result.

This is in contrast to the effects of the Vowel Harmony rule adopted in my proposal. Under the latter, vowel harmony is a uniform and symmetrical process involving total assimilation in tongue-body height in all three conjugations.

Second, the set of features that Redenbarger adopts for the vowel system does not seem to allow a uniform characterization of the phenomena of

[11] Although this move is, of course, problematic for the reasons given in Halle (1977). Correcting an earlier position, Halle points out that the assumption that 'tense' can be identified (and replaced) with 'ATR' is incorrect since it would predict that low vowels cannot display tense/lax distinctions. However, as Halle notes, many languages distinguish tense vs. lax low vowels (cf. German opposition [a:] vs [a] in pairs such as *Rat* 'advice' vs. *hat* 'has').

Portuguese vowel harmony. As it is, the rule claims that harmony is a 'double assimilation process' and refers to two properties that are unrelated (height of tongue body and 'tension' or advancement of tongue root). But notice that the rule could, in principle, be formulated also as a triple assimilation process if we assumed total assimilation in the first conjugation, and allowed the rule to affect also the property 'constricted pharynx'; that is, if we assumed that the 'mid' vowels are 'lowered' to the same height as /a/ (though Redenbarger does not make this assumption). The point is that, under this approach to the vowel system, the phenomenon of harmony turns out to be a heterogeneous process referring to properties that do not have much in common.

On the other hand, if we assume that vowel height is characterized by tongue body features, as I have been arguing for, a unified rule of harmony can be given, in which harmony is viewed as a uniform assimilation process involving the tongue features of height in all conjugations, which leads to a more unified proposal.[12]

Although this brief and incomplete discussion cannot be considered conclusive, I believe it does provide some evidence to show that the analysis of vowel harmony and related phenomena advanced here is tenable and represents an improvement over the already good and solid competing analyses reviewed above. I will therefore assume the analysis given here for the rest of this presentation.

3. Nasalization and Raising

In this section we examine the rules that account for vowel nasalization and some alternations affecting nasalized vowels in Brazilian Portuguese ('Official Dialect').

In the dialect of Brazilian Portuguese that we are considering, there are essentially three basic environments in which vowels can be nasalized.[13] One

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[12]   If the argument above is correct, it would have an interesting consequence. As we have seen, a hypothesis in which height is defined in terms of tongue-body features allows a uniform account of the phenomenon of Vowel Harmony in Portuguese while a hypothesis that assumes vowel height to be the by-product of three separate articulatory gestures (tongue-body movement; tension or advancement or root tongue, and pharynx constriction) does not. This seems to suggest that vowel height at least (in Portuguese) is better characterized in terms of tongue-body features regarded as primitives of phonological theory and not as an epiphenomenon resulting from three independent articulations.

[13]   Caution must be taken not to confuse the various dialects of Brazilian Portuguese in this regard. Thus, in a common dialect spoken in São Paulo and Rio, it appears that all that is

situation occurs when the vowel is stressed and followed by a nasal consonant:

(39a) f[í̃]no   – af[i]nádo   (fine   – sharpened)
(39b) p[ẽ́]na   – p[e]nácho   (feather – headpiece)
(39c) f[ṹ]mo   – f[u]máça   (tobacco – smoke)
(39d) g[ó̃]ma   – g[o]mádo   (starch   – starched)
(39e) gr[ã̃́]ma – gr[a]mádo   (grass   – turf)

This first subcase can easily be accounted for by a rule essentially like (40)

(40) *Nasalization* (subcase 1)
$$V \rightarrow [+\text{nasal}] / \left[\underline{\hspace{2cm}} \atop +\text{stress} \right] [+\text{nasal}]$$

What we have not yet accounted for in paradigm (39) is the presence of [ã̃́] instead of [ã] in (39e) *grama* 'grass', a point which will be discussed shortly in this section.

The second situation takes place when a vowel is followed by a nasal consonant in a closed syllable:

(41a) p[í̃]ngo – p[í̃]ngado   (drop   – dropped)
(41b) p[ẽ́]nte – p[ẽ́]nteado (comb   – hairdo)
(41c) f[ṹ]ndo – af[ṹ]ndado (bottom – sunk)
(41d) p[ó̃]nto – p[ṍ]nteado (stitch – stitched)
(41e) c[ã̃́]nto – c[ã̃́]ntado   (song   – sang)

The rule to account for nasalization in the examples in question can be formulated as follows (the raising of [ã] to [ã̃́] in (41e) will be discussed shortly below):

(42) *Nasalization* (subcase 2)
$$V \rightarrow [+\text{nasal}] / \underline{\hspace{1cm}} [+\text{nasal}] \$$$

---

required for vowel nasalization is the presence of a following nasal consonant. Thus in the dialect in question a word like *banana* is pronounced [bã̃nã́nʌ], whereas in the Official Dialect that we are analyzing here the pronunciation is [banã́nʌ].

This subrule, plus a rule that deletes nasal consonants in final position, will also account for nasalization in forms such as *lã* 'wool', *maçã* 'apple':

(43) /# lan #/   /# masan #/
        ã   ã   Nasalization (case 2)
        ∅   ∅   Nasal Deletion
    [lã]   [masã]   (intermediary stage)

The third situation is represented by cases where a vowel is nasalized before the palatal nasal [ñ] (spelled *nh*), regardless of stress. Examples of this are:

(44) l[í̃]nho   – l[ĩ]nháça   (linen   – linseed)
     p[ḗ̃]nha   – p[ẽ]nhásco   (rock   – cliff)
     p[ű̃]nho   – p[ũ]nhádo   (fist   – fistful)
     verg[ő̃]nha   – verg[õ]nhóso   (shame   – shameful)
     b[ʌ̃́]nho   – b[ʌ̃]nhádo   (bath   – bathed)

The rule involved can be stated simply as follows:

(45) *Nasalization* (subcase 3)
    V → [+ nasal] / ___ $\begin{bmatrix} + \text{nasal} \\ + \text{high} \end{bmatrix}$

We can collapse the three cases by using the familiar angled brackets and braces notation as follows:

(46) *Nasalization* (final version):
    V → [+ nasal] / $\begin{bmatrix} \underline{\hspace{2em}} \\ \langle - \text{stress} \rangle \end{bmatrix} \left\{ \begin{matrix} \begin{bmatrix} + \text{nasal} \\ \langle + \text{high} \rangle \end{bmatrix} \\ [+ \text{nasal}] \quad \langle \$ \rangle \end{matrix} \right\}$

That is, a vowel will be nasalized when followed by any nasal consonant; but if the vowel is unstressed, then it will be nasalized only if the following nasal consonant is either high (i.e. the palatal nasal) or is followed by another consonant or word boundary. This rule subsumes what I believe to be the core cases of nasalization in the dialect in question.[14] The treatment of nasal diphthongs, however, are beyond the scope of this work.

[14] It has been sometimes argued in the literature that we must distinguish two (sometimes even three) degrees of nasalization depending on whether the nasalized vowel occurs before an

Since the three subcases require different environments, the rule can undergo multiple applications in the same string to give interesting empirirical results, such as the ones illustrated below:

(47a) [fãndÃŋgu]   'fandango' (dance)
(47b) [kÃndõmblÉ]   'candomblé' (Afro-Brazilian ritual)
(47c) [pĩndamõñÃŋgábʌ] 'Pindamonhangaba' (a city)
(47d) [arĩñÃ́ñʌ]   'arinhanha' (otter)
(47e) [tamÃ́ŋku]   'tamanco' (clog)

Consider now the interesting problem posed by pairs such as [kamíña] *caminha* he walks' vs. [kʌmíña] *caminha* 'little bed' (same spelling). The former example poses no problem: the unstressed vowel in the first syllable is not nasalized, as predicted by our rule. What requires explanation is the latter example, since the vowel in the first syllable in the latter example is nasalized. But there is a plausible explanation for this. The latter example (unlike the former) contains the diminutive suffix *(z)inh(o)/(z)inh(a)*, which is a 'cyclic suffix' in the sense that it is attached at the word level and hence requires a new cyclic application of the stress rule (for relevant discussion of its Spanish counterpart, see Harris (1983: 92ff.)).[15] The difference between the two cases with respect to cyclic stress assignment is illustrated below (where primary and secondary stresses are indicated by acute and grave accent marks, respectively):

(48a) [kamiñ + a]   (48b) [[kam] + iña #]
          í   á   Stress
      ----------   --------
                             à   í   Stress

      [kamíña]   [kàm í   ña]

---

intervocalic nasal consonant (e.g.n *cama* 'bed') or before a nasal consonant (usually deleted) in a closed sylable (see Almeida (1976) and references cited there for relevant discussion). Whatever the experimental facts may be that motivate such distinctions, these do not appear to be linguistically (i.e. psychologically) relevant since there appears to be no language in which degrees of nasalization are employed to differentiate meaning. For this reason, I assume the difference between nasal/non-nasal in vowels to be a categorical one in the formulation of the rule.

[15] In addition to *zinho/zinha*, the class of cyclic suffixes in Portuguese includes also the superlative *issimo/issima* and the adverbial suffix *mente*. It is well-known that such suffixes behave differently from other suffixes since, for example, Neutralization is blocked in such contexts (cf. *s[O]zinho* 'lonely', *b[E]líssimo* 'most beautiful', *s[O]ménte* 'only'). Here we see that they also affect Nasalization. The explanation given in the text to account for the Nasalization facts can be readily extended to the facts of Neutralization mentioned in this note.

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Since the vowel in the first syllable in (48b) has been marked for (secondary) stress during the cycle, it would now normally undergo the Nasalization rule to ultimately produce [kãmíña], as desired.[16]

Consider now the remaining problem of how to account for the change of [ã] to [ʌ̃] in (48) (and in the examples mentioned earlier), which we now discuss.

As is well-known (at least since Hall (1943)), in the official dialect of Brazilian Portuguese there are no nasalized low vowels in surface representations. The contrasts between surface oral vs. nasalized vowels is illustrated in (49):

(49)   (a) Oral vowels   (b) Nasalized vowels

+hi, −lo:	i	u	ĩ	ũ
−hi, −lo:	e	o	ẽ ʌ̃ õ	
−hi, +lo:	E a O			

The situation above seems to provide straightforward evidence for assuming that Portuguese [E, O, a] are to be characterized as [+low] since they behave as a class when affected by nasalization – a fact which further supports the analysis of vowels in (12). To account for the facts above, we propose a rule that raises low vowels to mid when they are nasalized:[17]

(50) *Nasalized Vowel Raising (NV Raising)*
$$[+\text{low}] \rightarrow [-\text{low}] / \left[\begin{array}{c} \underline{\hspace{2cm}} \\ +\text{nasal} \end{array}\right]$$

---

[16] The explanation given in the text assumes that Nasalization is not cyclic. One might claim however that Nasalization is cyclic and follows each application of cyclic stress, which would also give the correct results here. However, given the argument that cyclicity defines lexical rules, under the latter view Nasalization would have to be a lexical rule. But this does not seem plausible, specially in view of the fact that Nasalization is not structure-preserving (another characteristic of lexical rules), which is why we preferred the account given in the text.

[17] This, of course, is just the opposite of what happens in French, where all nasalized vowels in surface structure are low [ɛ̃, œ̃, ɔ̃, ã]. But notice that the logic of the argument for vowel height is the same: since nasalization causes the vowels to become [+low], the lowering of mid vowels [e, ø, o] into [ɛ, œ, ɔ] under nasalization provides compelling evidence to show that [e, ɔ] are therefore [+low]. Since French [ɛ, ɔ] sounds very much like the sounds I am representing by [E, O], the French facts reinforce the analysis given in (12), according to which these are [+low]. For relevant discussion of vowel height in French, see Schane (1968).

Like Nasalization, NV Raising applies to all categories; some of its effects are illustrated by the derivations of nouns such as *cama* 'bed', *fonte* 'fountain' and *tempo* 'time,' all of which are assumed to have underlying low vowels in stressed position:

(51) /kama/   /fOnte/   /tEmpo/
         á   Ó   É   Stress
         ã́   Õ̂   Ẽ́   Nasalization
         ʌ̃́   õ̂   ẽ́   NV Raising
      [kʌ̃ma]   [fõnte]   [tẽmpo]

The claim implicitly made by the rule of NV Raising (50) is that it applies only to vowels that have undergone Nasalization. That is, NV Raising is fed by Nasalization (or is perhaps part of the Nasalization rule itself). This is an empirical claim and it is in contrast to the view adopted in Redenbarger (1981), according to which the raising phenomenon in question involves 'tensing' of vowels before a nasal consonant. Redenbarger's rule is reproduced below (with irrelevant notational changes):

(52) *Pre-Nasal Tensing* (cf. Redenbarger (1981: 138))
      $V \rightarrow [+ \text{tense}] / \underline{\quad} [+ \text{nasal}]$

According to Redenbarger's hypothesis the conditioning factor in the raising of the vowel in question is the presence of a preceding nasal consonant, regardless of whether or not the vowel is nasalized. However, this view seems to be incorrect. As shown in the examples in (39), (41) and (47) the raising process in question applies only to vowels that have undergone nasalization. Thus in examples such as (39e) *gr[ʌ̃]ma* 'grass', the vowel is 'raised' because it is nasalized, but in *gr[a]mádo* 'turf' (and many others), contrary to Redenbarger's proposal, the vowel is unaffected by Nasalization and remains low [a] (or 'non-tensed' in his terminology) even though it is followed by a nasal consonant.

Similarly, in words such as *tamanco* [tamʌ̃ŋku] 'clog' in (47e) we see that /a/ preceding a nasal consonant is raised only when nasalized but not when it is not nasalized. Also, contrary to what rule (52) predicts, non-nasalized /a/ remains unaffected in examples such as *def[a]mar* 'to defame'; *C[a]nadá* 'Canada'; *rab[a]nada* 'flip of the tail', while nasalized /a/ systematically raises, as noted. I take these facts as evidence against Radenbarger's rule (52) and in favor of the NV Raising rule proposed here.

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The phenomenon of nasalized vowel raising in Portuguese relates to a broader issue concerning nasalization and vowel height. As analyzed here, Portuguese low nasalized vowels are raised to mid. On the other hand, as is well-known, in several languages (cf. French) high nasalized vowels are also lowered.

Such interactions involving nasalization and vowel height have been recently studied in detail in an important work by Beddor (1982). Based on a sample of 75 languages Beddor notes that when nasalization affects high vowel height, high vowels are lowered (p. 143). On the other hand, when nasalization affects low vowel height, low vowels raise ('the data clearly indicate that when nasalization affects low vowel height low vowels raise', p. 144). Mid vowels, on the other hand, do not reveal a uniform raising or lowering tendency (p. 144), but when variables other than vowel height are taken into account (i.e. vowel context and vowel backness) if they are affected by nasalization they are in general lowered (cf. pp. 144ff.; p. 248). Beddor attributes these effects to the 'acoustic-perceptual characteristics' of the nasal vowels. Nasalization introduces extra acoustic effects which appear to affect perceived vowel height (p. 149ff.).

The generalizations established by Beddor's analysis seem to be entirely consistent with the analysis of nasalization given here. We can account for Portuguese by assuming nasalization affects only low vowel height. Under the assumption made here that Portuguese has three underlying low vowels /E, O, a/, the fact that these three are raised to mid [ẽ, õ, ã] when nasalized (NV Raising), is in accord with the universal generalizations found by Beddor. This, again, provides further support for the analysis of Portuguese vowels in (12) and for the analysis of nasalized vowels adopted here.

4. Rule interaction: GV Harmony, M-Lowering and Nasalization

In this last section we shall illustrate the main empirical effects caused by the interaction of the major rules discussed so far: Generalized Vowel harmony (GV Harmony); M-Lowering; and the complex Nasalization and Nasalized Vowel Raising (NV Raising).

Consider initially the contrasts that obtain in the first conjugation when the last syllable in the stem contains an oral vowel (already presented in (1)–(3) and reproduced in the paradigms below) as opposed to a nasalized vowel:

(53)

	I			II	
(a)	ap[É]lo	'I appeal'	(a)	r[ẽ]mo	'I row'
(b)	ap[É]la	'he appeals'	(b)	r[ẽ]ma	'he rows'
(c)	ap[e]lámos	'we appeal'	(c)	r[e]mámos	'we row'
(d)	ap[É]lam	'they appeal'	(d)	r[ẽ]mam	'they row'
(e)	m[Ó]ro	'I live'	(e)	ab[õ]no	'I certify'
(f)	m[Ó]ra	'he lives'	(f)	ab[õ]na	'he certifies'
(g)	m[o]rámos	'we live'	(g)	ab[o]námos	'we certify'
(h)	m[Ó]ram	'they live'	(h)	ab[õ]nam	'they certify'

The pattern containing a stem-final oral vowel (column I) displays the typical low/mid alternation caused by M-Lowering, GV Harmony and Neutralization already discussed (cf. section 2). However, in the pattern containing a stem-final nasalized vowel (column II) the stem-final vowel is mid in all examples.

There are essentially two hypotheses that one could consider to account for these facts. One hypothesis is that nasalized vowels do not undergo M-Lowering and GV Harmony. This hypothesis, however, runs into several problems. First, M-Lowering and GV Harmony (which are 'morphologically' conditioned) apply before Nasalization, so there is no plausible way to condition their application to Nasalization. Second, as we show later in connection with the facts of the third conjugation, there is evidence that Nasalization and GV Harmony both *do* apply to the same form. We will therefore reject this proposal here.

The other hypothesis, which we adopt here, is that the effects noted on the stems containing nasalized vowels result from the application of Nasalization and NV Raising to the output of M-Lowering and GV Harmony. It is easy to see that this hypothesis accounts for the facts in (53) in a straightforward manner. The derivation of relevant examples such as [apÉlo] 'I appeal', [apÉla] 'he appeals' as opposed to [rẽmo] 'I row' and [rẽma] 'he rows' is given below to illustrate this proposal:

(54)

/apel + a + o/	/apel + a/	/rem + a + o/	/rem + a/	
E	E	E	E	M-Low.
E (vacuous)	----	E (vacuous)	-------	GV Harm
∅	----	∅	-------	Truncation
É	É	É	É	Stress
-----	----	-----	-------	Neut.
-----	----	Ẽ	Ẽ	Nasal

'y

	'I row'
	'he rows'
mos	'we row'
m	'they row'
o	'I certify'
a	'he certifies'
ámos	'we certify'
am	'they certify'

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/rem + a/	
E	M-Low.
-------	GV Harm
-------	Truncation
É	Stress
-------	Neut.
Ẽ́	Nasal

		é̃	é̃	NV Raising
-----	----			
[apÉlo]	[apÉla]	[rẽ̆mo]	[rẽ̆ma]	

Thus, vowels that become low by M-Lowering/GV Harmony and which subsequently undergo Nasalization are automatically raised to mid position by NV Raising, just like underlying low vowels that undergo nasalization (cf. section 3).

The facts of the second conjugation present a similar situation. Compare:

(55)
	I			II	
(a)	d[é]vo	'I owe'	(a)	tr[é̃]mo	'I shake'
(b)	d[É]ve	'you owe'	(b)	tr[é̃]me	'you shake'
(c)	d[e]vémos	'we owe'	(c)	tr[e]mémos	'we shake'
(d)	d[É]vem	'they owe'	(d)	tr[é̃]mem	'they shake'
(a)	m[ó]vo	'I move'	(a)	esc[ó̃]ndo	'I hide'
(b)	m[Ó]ve	'you move'	(b)	esc[ó̃]nde	'you hide'
(c)	m[o]vémos	'we move'	(c)	esc[õ]ndémos	'we hide'
(d)	m[Ó]vem	'they move'	(d)	esc[ó̃]ndem	'they hide'

The examples in column I show the already familiar alternation caused by M-Lowering and GV Harmony discussed previously in section 2. The facts in column II are examples of forms containing a nasalized vowel in stem-final position; as in the first conjugation, we see also here that the nasalized vowel is mid in all examples.

These facts can also be accounted for under the hypothesis of interaction of Nasalization/NV Raising with M-Lowering/GV Harmony that we are assuming here. The derivation of relevant examples ([móvo] 'I move', [mÓve] 'he moves' vs. [eskó̃ndo] 'I hide', [eskó̃nde] 'he hides') under this hypothesis is illustrated below:

(56)
/mov + e + o/	/mov + e/	/eskond + e + o/	/eskond + e/	
O	O	O	O	M-Low.
o	------	o	-----	GV Harm.
∅	------	∅	-----	Trunc.
ó	Ó	ó	Ó	Stress
------	------	-----	-----	Neut.
------	------	ó̃	Ó̃	Nasal
------	------	-----	ó̃	NV Rais.
[móvo]	[mÓve]	[eskó̃ndo]	[eskó̃nde]	

But crucial evidence supporting the interaction proposal advanced here comes from the contrasts observed in the third conjugation:

(57)   I   II
   (a) s[i]rvo   'I serve'   (a) m[í]nto   'I lie'
   (b) s[É]rve   'you serve'   (b) m[é]nte   'he lies'
   (c) s[e]rvímos 'we serve'   (c) m[ẽ]ntímos   'we lie'
   (d) s[É]rvem   'I serve'   (d) m[é]ntem   'they lie'

The facts in column I present the familiar patterns produced by M-Lowering and GV Harmony and are unproblematic. The facts in column II, under the proposal advanced here, arise from the interaction of M-Lowering/GV Harmony with Nasalization/NV Raising. In particular, the existence of examples such as [mínto] 'I lie' clearly shows that forms undergoing GV Harmony also undergo Nasalization, as assumed here. To illustrate, the derivation of crucial examples under this hypothesis would proceed as follows:

(58) /sErv+i+o/   /sErv+i/   /ment+i+o/   /ment+i/
        -----   -----   E   E   M-Lowering
         i   -----   i   ------   GV Harmony
             ∅   ∅   ------   Truncation
         í   É   í   É   Stress
        -----   -----   ------   ------   Neutralization
        -----   -----   í   É́   Nasalization
        -----   -----   ------   é̃   NV Raising
      [sírvo]   [sÉrvi]   [mínto]   [ménti]

The derivation of [sírvo], [sÉrvo] requires no discussion. But consider the forms containing nasalized vowels. In the derivation of [ménti] 'he lies', the stem vowel is underlyingly mid. It is then lowered by M-Lowering, then, after Nasalization has applied, it is made mid again by NV Raising. This is on a par with other examples that we have been considering.

More significant, however, as noted above, is the existence of [mínto] 'I lie'. Such examples show, quite unequivocally, that Nasalization *does* apply to forms that also undergo GV Harmony. Here the stem vowel is raised to high by GV Harmony and is then Nasalized. This fact rules out the hypothesis considered (and rejected) earlier according to which nasalized forms could not undergo GV Harmony. At the same time, the existence of such facts constitutes evidence for the hypothesis advanced here, which claims that the

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References

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contrasts between stem-final oral vs. nasalized vowels are due to the complex
interaction of Nasalization/NV Raising with M-Lowering and GV Harmony.

That languages would display such a curious see-saw in which vowels are
lowered by one rule only to be raised by another is no doubt surprising. Yet,
this seems to provide only a further illustration of the abstract nature of the
processes found in natural languages.

5. Conclusion

In the discussion above we presented an analysis for the phenomena of
vowel alternation and nasalization in Brazilian Portuguese. Elaborating on
earlier work by Harris (1974), Redenbarger (1981) and Lopez (1979) we
advanced an account of vowel alternation based on three major rules (GV
Harmony, M-Lowering and Neutralization) and provided a detailed study of
the way these rules interact to account for an interesting realm of empirical
facts. It was claimed that the rules of GV Harmony and Neutralization can
be given a much improved formulation under the assumption that they are
lexical rules and hence are subject to the Principle of Structure Preservation
(Kiparsky (1985)). If this result can be maintained the facts in question
provide additional support for this principle.

Next, we examined the phenomenon of Nasalization. We provided an
analysis for this phenomenon which is based on two major rules (Nasaliza-
tion and Nasalized Vowel Raising) and the way these two rules interact with
cyclic stress to explain some unusual effects. We then turned to the central
part of the article, in which we examined the complex interaction of the rules
of GV Harmony, M-Lowering and Neutralization with the rules of Nasaliza-
tion and Nasalized Vowel Raising and attempted to show how the system of
rules proposed in the article accounts in a natural way for a substantive range
of very complex empirical phenomena that are involved. To the extent that
the analysis given here correctly accounts for the phenomena of Vowel
Alternation and Nasalization in Portuguese, the facts in question can be said
to constitute empirical support in its favor and in favor of the general
principles upon which it is based.

References

Almeida, A., 1976. The Portuguese nasal vowels: Phonetics and phonemics. In: J. Schmidt-
Radefeldt (ed.), Readings in Portuguese linguistics. New York: North-Holland.

Anderson, S., 1980. Problems and perspectives in the description of vowel harmony. In: R. Vago (ed.), Issues in vowel harmony, Amsterdam: Benjamins.

Anderson, S., 1982. Differences in rule type and their structural basis. In: H. van der Hulst and N. Smith (eds.), The structure of phonological representations (Part II). Dordrecht: Foris.

Beddor, P.S., 1982. Phonological and phonetic effects on vowel height. Ph.D. Dissertation, University of Minnesota, Minneapolis.

Câmara Jr., J.M., 1953. Para o estudo da fonêmica Portuguêsa. Rio de Janeiro: Organização Simões.

Câmara Jr., J.M., 1970. Estrutura da língua Portuguêsa. Petrópolis: Editora Vozes.

Câmara Jr., J.M., 1972. The Portuguese language. (Translated by A. Naro). Chicago, IL: University of Chicago Press.

Chomsky, N. and M. Halle, 1968. The sound pattern of English. New York: Harper and Row.

Goldsmith, J., 1985. Vowel harmony in Khalkha Mongolian, Yaka, Finnish and Hungarian. Phonology Yearbook 2, 253–275.

Hall, R.A., 1943. The unit phonemes of Brazilian Portuguese. Studies in Linguistics 1, 1–15.

Halle, M., 1977. Tenseness, vowel shift, and the phonology of the back vowels in modern English. Linguistic Inquiry 8, 611–625.

Halle, M. and G.N. Clements, 1983. Problem book in phonology. Cambridge, MA: MIT Press.

Halle, M. and K.P. Mohanan, 1985. Segmental phonology of modern English. Linguistic Inquiry 16; 57-116.

Halle, M. and J.R. Vergnaud, 1980. Harmony processes. In: W. Klein and W. Levelt (eds.), Crossing the boundaries in linguistics. Dordrecht: Reidel.

Harris, J., 1974. Evidence from Portuguese for the 'Elsewhere Condition' in phonology. Linguistic Inquiry 8, 611–625.

Harris, J., 1983. Syllable structure and stress in Spanish. Cambridge, MA: MIT Press.

Head, B., 1964. A comparison of the segmental phonology of Lisbon and Rio de Janeiro. Unpublished Ph.D. dissertation, University of Texas, Austin.

Hensey, F., 1973. Portuguese vowel alternation. In: J. Casagrande and B. Saciuk (eds.), Linguistic studies in Romance languages. Rowley, MA: Newbury House.

Jakobson, R., C.G. Fant and M. Halle, 1951. Preliminaries to speech analysis. Cambridge, MA: MIT Press.

Kiparsky, P., 1968. Linguistic universals and linguistic change. In: E. Bach and R.T. Harms (eds.), Universals in linguistic theory. New York: Holt, Rinehart & Winston.

Kiparsky, P., 1973. Elsewhere in phonology. In: S.R. Anderson and P. Kiparsky (eds.), A Festschrift for Morris Halle. New York: Holt, Rinehart & Winston.

Kiparsky, P., 1982. Lexical phonology and morphology. In: I.S. Yang (ed.), Linguistics in the morning calm. Seoul: Hanshin.

Kiparsky, P., 1985. Some consequences of lexical phonology. Phonology Yearbook 2, 85–138.

Lopez, B.S., 1979. The sound pattern of Brazilian Portuguese. Ph.D. dissertation, UCLA, Los Angeles.

Major, R.C., 1985. Stress and rhythm in Brazilian Portuguese. Language 61, 259–282.

Mateus, M.H., 1975. Aspectos da fonologia Portuguêsa. Centro de Estudos Filológicos, Lisboa.

Mohanan, K.P., 1986. The theory of lexical phonology. Boston, MA: Reidel.

Redenbarger, W.J., 1977. Lusitanian Portuguese [ɐ] is [+ATR] and [+CP]. In: M.P. Hagiwara, ed., Studies in Romance linguistics. Rowley, MA: Newbury House.

Redenbarger, W.J., 1981. Articulatory features and Portuguese vowel height. Department of Romance Languages, Harvard University, Cambridge, MA.

Reed, D.,
Paulista
Ringen, C.
vowel h
Schane, S.
Schane, S.
Silva, M.E
Vago, R.,
Issues ir
Van der F
Dordrec

vel harmony. In: R. Vago

In: H. van der Hulst and
II). Dordrecht: Foris.
ight. Ph.D. Dissertation,

de Janeiro: Organização

litora Vozes.
A. Naro). Chicago, IL:

York: Harper and Row.
Finnish and Hungarian.

n Linguistics 1, 1–15.
owels in modern English.

bridge, MA: MIT Press.
nglish. Linguistic Inquiry

in and W. Levelt (eds.),

ondition' in phonology.

IA: MIT Press.
on and Rio de Janeiro.

: and B. Saciuk (eds.),
use.
1alysis. Cambridge, MA:

Bach and R.T. Harms
Vinston.
1 P. Kiparsky (eds.), A

(ed.), Linguistics in the

/ Yearbook 2, 85–138.
lissertation, UCLA, Los

e 61, 259–282.
dos Filológicos, Lisboa.
.eidel.
:P]. In: M.P. Hagiwara,

height. Department of

Reed, D., and Y. Leite, 1947. The segmental phonemes of Brazilian Portuguese: Standard
    Paulista dialect. In: K. Pike, Phonemics. Ann Arbor, MI: University of Michigan Press.
Ringen, C., 1980. A concrete analysis of Hungarian vowel harmony. In: R. Vago (ed.), Issues in
    vowel harmony. Amsterdam: Benjamins.
Schane, S.A., 1968. French phonology and morphology. Cambridge, MA: MIT Press.
Schane, S.A., 1984. The fundamentals of particle phonology. Phonology Yearbook I, 129–155.
Silva, M.B., 1981. Leitura, ortografia e fonologia. São Paulo: Ed. Ática.
Vago, R., 1980. A critique of suprasegmental theories of vowel harmony. In: R. Vago, 1980.
    Issues in vowel harmony. Amsterdam: Benjamins.
Van der Hulst, H. and N. Smith (eds.), 1982. The structure of phonological representations.
    Dordrecht: Foris.