MID VOWEL NEUTRALIZATION IN BRAZILIAN PORTUGUESE

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0. INTRODUCTION *

In Brazilian Portuguese (henceforth BP), upper and lower mid vowels only contrast in stressed syllables. Moreover, a large number of neutralization rules which affect mid vowels in stressed syllables function to further neutralize the distinction between upper and lower mid. Indeed, the existing rules of neutralization together define the phonological difference between the two series of mid vowels as a contrast which is only marginally exploited in BP. As it turns out, the environments in which the aperture of the mid vowels is predictable can be divided into three classes: morphological, prosodic, and phonotactic.

A set of highly productive morphophonological rules governs the distribution of upper and lower mid vowels in the BP verb system. Also, in nouns and adjectives, there is a strong tendency towards morphologization of the distribution between higher and lower mid vowels.

As for the prosodic conditioning, the rule of unstressed vowel neutralization reduces the four-height system which occurs under stress to a three-height system in unstressed syllables, as is well-known. In many dialects, there are no mid vowels at all allowed in word-final unstressed position. Much less known, if at all, is a rule which requires all mid vowels to be lower mid in word-internal proparoxytonic syllables. It is because of this rule that the mid vowel contrast remains virtually unexploited in all but the last two syllables of the phonological word. Another prosodically conditioned regularity which has remained unnoticed bans higher mid vowels from paroxytonic syllables in words which end in a heavy rhyme.

Probably the best known phonotactic restriction on the distribution of mid vowels precludes the occurrence of /E,O/ before a nasal segment. In this study, a subset of the existing neutralization rules will be discussed against the background of lexical phonology. It will be argued that the phonology of mid vowels confirms the usefulness

of the distinction between lexical and postlexical rules, and, moreover, forcefully points to a separation of the phonology of derivation from the phonology of inflection.

1. THEORETICAL FRAMEWORK

The segmental rules discussed in this study are cast in the framework of autosegmental phonology, more precisely the version of autosegmental phonology that has been recently proposed by Clements (1991b). In autosegmental phonology, phonological operations manipulate autosegments, which are not necessarily complete phonemes. More in particular, assimilation processes are conceived as feature-spreading operations. Spreading operations reassociate autosegments within a plane, where a plane is defined by two autosegmental tiers one of which immediately dominates the other. Spreading is controlled by the No-crossing Constraint (Goldsmith 1976). This constraint prohibits operations which would create crossing association lines within a plane. Consequently, assimilations which take place between non-contiguous segments can only occur when the structure of the geometry permits non-crossing reassociations (such as vowel-to-vowel assimilations across consonants, as we will see below). 'Long distance' assimilation can also occur in cases where underspecification is used (and justified). In (1) and (2) below, the essentials of Clements' view of feature geometry is summarized:

(1) Partial representation of the sequence [ata] (adapted from Clements 1991b:78)
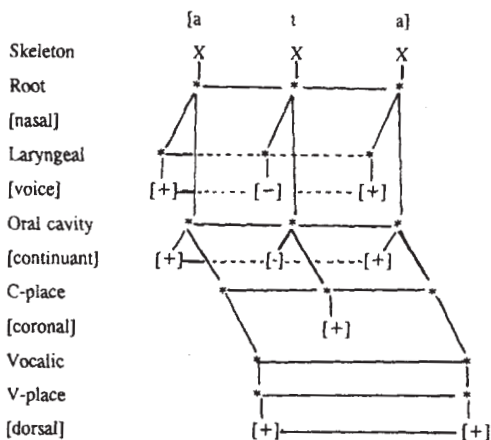
In the conception of the feature geometry adopted by Clements, the place features for consonants are directly situated under a C-place node, and the place features for vowels, which are identical to the ones used to define the place features for conso-nants, are situated under a V-place node, which is itself dominated by the vocalic node.

The resulting geometry predicts that assimilation of the vocalic node, and any feature dominated by this node, may take place across consonants, because no crossing association lines would result from such an operation. On the other hand, the spreading of the entire C-place node from one consonant to another, non-adjacent consonant would lead to crossing association lines within the Oral Cavity/ C-place plane, and is therefore prohibited. As will be shown below, consonants with a secondary articulation have both a C-place node and a V-place node.

Another innovation made by Clements (1991a), which is the one most relevant for the study undertaken in this paper, concerns the existence of an independent aperture node, which is linked to the vocalic tier. In (2) the place of the aperture node in the feature tree is indicated.

(2) The Geometry of the Vocalic Node for Vowels (cf. Clements 1991a:43); structure irrelevant to the rules to be discussed below has been omitted)
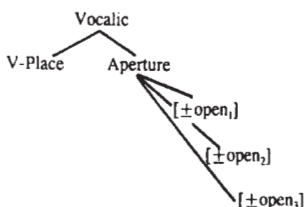
The aperture node dominates one or more [open] tiers, the precise number of which depends upon the number of vowel height distinctions within a given language. According to Clements, only vocoids bear the feature [open] contrastively. The basic height distinction is obtained by specifying all but the lowest vowel(s) as [−open] at the primary [open] tier and the lowest vowel(s) as [+open]. Further distinctions are created on subsequent [open] tiers, in such a way that the resulting system reflects the phonological solidarity of segments as it is shown by the height-sensitive rules of the language.

2. UNSTRESSED VOWEL NEUTRALIZATION

2.1 The Distribution of Unstressed Mid Vowels

If the vowel systems given as (3a) and (3b) below are compared, it can be observed that in BP two series of mid vowels are contrastive in stressed syllables, whereas no such opposition is found outside the stressed syllable (the acute accent indicates stress, capitals designate lower mid vowels):

(3a)   Stressed

abacaxí   [í]   'pineapple'   urubú   [ú]   'vulture'
canjaré   [é]   'voodoo ritual'   cameló   [ó]   'street vendor'
jacaré   [É]   'alligator'   igapó   [Ó]   'swampland'
                  maracujá   [á]   'passsion fruit'

(3b)   Pretonic

ireré   [i]   'tree duck'   ubúçu   [u]   'palm tree'
beléza   [e]   'beauty'   cordáo   [o]   'cord'
(cf. [bÉla] 'pretty')   (cf. c[Ó]rda 'cord')
                  araçá   [a]   'guava'

(3c)   Posttonic

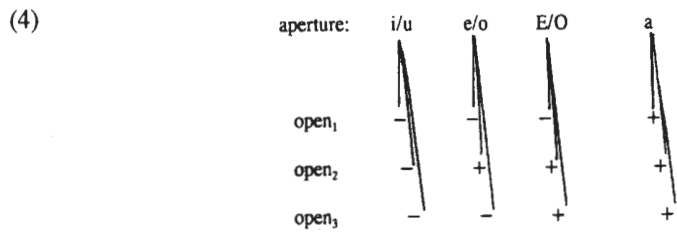ótimu   [i]   'excellent'   século   [u]   'century'
tráfego   [e]   'commerce'   fósforo   [u]   'match'
                  ébano   [a]   'ebony'

(3d)   Unstressed Word-Final

Xavánte [i]   'Indian tribe'   Boróro [u] 'Indian tribe'
                Wanináwa   [a]   'Indian tribe'

In (4) below the BP height distinctions in the stressed vowel system are
represented in terms of Clements' model:

(4)

| aperture:	i/u	e/o	E/O	a
open₁	−	−	−	+
open₂	−	+	+	+
open₃	−	−	+	+

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It is important to notice that in the classification proposed in (4), the primary and secondary [open] tiers together define the mid vowels as a single class, as opposed to /i,u/ on the one hand, and /a/ on the other, because the specifications for /e,o/ and /E,O/ are identical on both the [open$_1$] and the [open$_2$] tiers. It is only on the [open$_3$] tier that the contrast between upper and lower mid-vowels is introduced, by a further division of the [open$_2$] register. The fact that the distinction between the two series of mid vowels is expressed at the lowest [open] tier adequately formalizes the fact that in BP, as in all the Romance languages[1], the opposition between upper and lower mid vowels is, in a sense, less basic than the one between high and low vowels. It also follows from the representation that the distinction between non-low and low vowels, expressed on the [open$_1$] tier, is more essential than the one between either of these classes and a unique series of mid vowels, defined on the [open$_2$] tier. This is so because the integers used to distinguish the different [open] tiers express a hierarchical order: according to Clements, the absence of an [open$_n$] specification necessarily implies the absence of the [open$_{n+1}$] feature[2]. Indeed, both the historical evolution of the Romance languages and synchronic alternations provide strong evidence for the fact that the distinction between mid vowels is the first to be abandoned, if neutralization occurs. Observe that neutralization of the mid vowel opposition is obtained if the distinctions on the [open$_3$] tier are erased. In other words, if BP had just a five-vowel system, its representation would be identical to the one in (4) without the [open$_3$] tier. We have seen above that BP indeed has a five-vowel system in unstressed syllables. Consequently, the rule of unstressed-vowel neutralization can be formulated as in (5) below:

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[1] See Bichakjian (1986) for French, Sluyters (1991) for Italian, and Mascaró (1986) for Spanish.

[2] Notice that a chain representation would directly express the hierarchical order from which the implication proposed by Clements would immediately follow:

[open1]
|
[open2]
|
[open3]
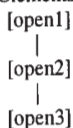
See Sluyters (1991) for such a proposal.

(5)   Unstressed Vowel Neutralization

$$[-1stress]$$
$$|$$
$$X$$ Domain: phonological word[3]
$$|$$
$$[+vocoid]$$
$$\neq$$
$$[+open_3]$$
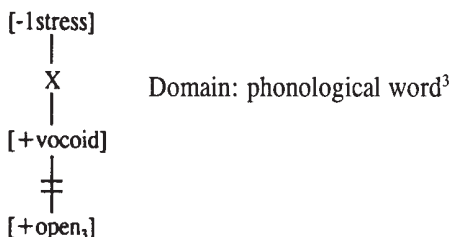
As a result of (5), a vowel which is not in main stress position within the phonological word will be dissociated from the [open₃] tier. Consequently, all unstressed vowels will acquire the representation in (4) above, without the [open₃] specification. Notice that the condition [-1stress] does not refer as such to a feature which exists in the phonological representation, on the assumption that stress is assigned, for example, along the lines of Hayes (1987), or Bisol (this volume). To see this, we shall make a short excursion into BP stress.

Portuguese word stress is quantity sensitive: final heavy syllables are stressed in the unmarked case, and prefinal heavy syllables can never be skipped by the stress rule. Secondary stress is not sensitive to syllable weight, is assigned from right to left, and is lexically irrelevant. In Hayes' model, primary stress would very probably be described as non-iterative, right to left footing. The relevant foot is the moraic trochee. Word stress is, necessarily, created by the End Rule on the only vowel that receives an asterisk by foot formation. As a result of foot formation and word stress assignment, the stressed syllable will end up with two asterisks in the stress plane, whereas all other syllables will have no asterisk. Some sample derivations are given in (6) (gordo 'fat'; abóbora 'pumpkin'; quadril 'hip'; hábil 'able'):

(6)	gordo	abobora	quadril	habil
morification	mm m	m m m m	m mm	m mm
extrametr.		final syl		final mora
footing	(*.)(.)	(* .)ra	(*.)	(* .)l
Word stress	*	*	*	*
	[góXdu]	[abÓbura]	[kwadríw]	[ábiw]

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[3] In defining the domain of neutralization as the phonological word, I follow Wetzels (1991). In order to explain the retention of lower mid vowels in words like *belissima* [bElísima] 'very pretty', *poetinha* [poEtíña] 'little poet', *somente* [sOménte] 'only', which are all derived words involving the stressable suffixes *-issimV*, *-(z)inhV*, and *-mente*, I am assuming that these suffixes have phonological-word status. Stress assignment and unstressed vowel neutralization apply before the rule of stress shift (or deletion), which affects the first stressed vowel of these compound-like items. This will prevent the neutralization rule from applying to the destressed mid vowels in these words. Further study of the interaction between the phonology and the morphology of BP might show that these facts are better dealt with in terms of lexical levels. For the time being, however, I have found no independent evidence for an explanation of these facts in terms of lexical strata.

Antepenultimate stress is exceptional, even in words which end in a sequence of two open syllables. Therefore, a lexical diacritic is used to mark the final syllable in a word like abóbora as extrametrical. Equally, the exceptionality of prefinal stress in words which end in a heavy syllable is accounted for by a diacritic which marks the final mora as extrametrical.

In order to obtain that the neutralization rule (5) apply to all but the primary stressed vowels, it would be necessary that it refer to the absence of asterisks in the stress plane. The feature [-1stress] should be interpreted in this way. However, it seems unnatural for rules to be able to refer to the absence of a given property. This is particularly true in the case of unspecified features, which cannot be referred to by phonological rules, until they are introduced into the representation by a redundancy rule. If this principle is extended to information assigned by foot formation and the End Rule, it is impossible to define all non-primarily stressed vowels as a natural class in a model such as the one proposed by Hayes. However, rules of neutralization typically refer to this vowel set, also cross-linguistically.

We will return to this problem below.

2.2 On Natural Domains for Unstressed-Vowel Neutralization

There are many rules which must refer to the absence of stress, either in their structural environment or in their focus. For example, vowel deletion is often triggered by unstressed vowels. Also, there are rules of lenition which typically apply to consonants between unstressed vowels. As we have seen above, unstressed vowels are preferred targets for neutralization rules. Yet, in modern stress theories, only stressed vowels can be positively identified. This severely limits the possibility of referring to unstressed vowels, which crucially lack a property (formally represented as an asterisk) in their phonological representation. In practice, unstressed vowels can only be targeted by reference to their position vis-à-vis the stressed vowel, such as unstressed vowels immediately preceding or following the stressed vowel. This possibility, however, is unsuitable for defining the vowel sets to which the neutralization rules of Brazilian Portuguese are applicable. In this section we will deal with this problem. More specifically, we will argue that rules of neutralization which apply within a word or foot domain, or at a word or foot boundary, predictably affect unstressed vowels only. It will first be pointed out that rules of neutralization can be identified on the basis of their intrinsic properties. We will then propose to provide each neutralization rule with a reference to a specific domain (foot, word). We will finally assume the existence of a universal convention which marks all vowels within the designated domain as targets for the neutralization rule, except for the stressed vowel which will be marked as not undergoing the rule. For example, if it is true that a rule like (5) can unequivocally be identified as a rule of neutralization, it will activate a principle which marks all vowels at the word level as candidates for undergoing it, except for the stressed vowel, which will be marked with a negative rule feature ([-rule 5]). In this way, the identification

of unstressed vowels is left to a convention which interprets the default trigger of neutralization rules.

With regard to the specific nature of neutralization rules, it is important to remember that in Clements' model vowel neutralization is no longer defined as a feature changing mechanism, but as an operation whose only effect is to dissociate one or more [open] features from the aperture node. Indeed, in this model, rules of neutralization are formally very different from feature changing rules. As for other rule types which cause the deletion of an association line, one can observe that the dissociation of the target autosegment is either (co)conditioned by the presence of an identical trigger (deletion-cum-default feature assignment = dissimilation), or else also involves reassociation (deletion-cum-spreading = assimilation). Consequently, neutralization operations can be identified as such on the basis of their intrinsic nature[4]. In principle, this fact creates the formal prerequisite for considering the hypothesis that a rule such as (5) MUST apply to unstressed vowels only. The question then becomes: what is the a priori plausibility for such a hypothesis, and what are its empirical (and theoretical) implications? To start with the first part, if rule (5) applied to all (stressed and unstressed) vowels, there would be no proof for the existence of an underlying mid-vowel contrast to begin with. Furthermore, if the rule applied to stressed vowels only, Brazilian Portuguese would be the only language known to date which realizes an opposition in unstressed position which it not also realized under stress (cf. Wetzels (1991a) for discussion). It seems safe to conclude that neutralization rules of the type under discussion never apply to all stressed and unstressed vowels, nor to the complete set of the stressed vowels alone. There are more logical possibilities[5]. Neutralization rules could furthermore apply

a. to a subset of the unstressed vowels,
b. to a subset of the stressed vowels, or
c. to a subset of the stressed and unstressed vowels.

According to our earlier hypotheses, it must be true that cases (b,c) are formally distinct from case (a). Ideally, it should moreover be true that, either the restricted environments in which the neutralization of unstressed vowels occur are derivable from universal principles, or else be definable in terms of the existing theoretical machinery. As it turns out, BP presents a number of neutralization rules which allow us to check these implications. We will turn to some examples of type (a) first.

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[4] This implies that the very rare cases of unconditioned changes, which are mainly historical sound changes, should be feature changing rules. Also rules of absolute neutralization, which could involve stressed vowels, should, ideally, not be definable as dissociation operations. It is a long-standing issue in phonological theory whether these rules exist at all.

[5] In the following we will not discuss cases where an unstressed vowel is neutralized when it is adjacent to a stressed vowel. As we have said, in such a case, it is the position of the unstressed vowel with respect to the stressed vowel which avoids the necessity of referring to the absence of stress. This type of very limited neutralization abundantly exists.

If one looks at the simple surface facts, one observes that in many dialects of BP unstressed [o] exclusively appears in pretonic position. Posttonically the only rounded vowel allowed is [u], as is exemplified with the word *abóbora* in (6) above. Since the vowels which appear after main stress constitute a subset of the ones that occur in pretonic position, we cannot decide on the basis of the Brazilian Portuguese facts what exactly the domain of rule (5) is: it could be identified as the sequence of unstressed vowels preceding main stress, or, as we have assumed, the complete word. If the latter hypothesis is correct, a further rule rule is called for which neutralizes the opposition between [o] and [u] in posttonic position. We will formulate this rule as in (7) below:

(7) Posttonic Vowel Neutralization

$$X$$
$$/$$
$$[+\text{vocoid}]$$
$$\times$$
$$[+\text{open}_2] \quad [\text{labial}]$$

Domain: stress foot
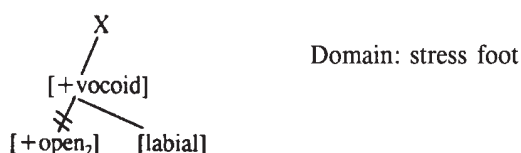
Rule (7) neutralizes the opposition between [o] and [u] in posttonic vowels. In the light of the foregoing discussion we now face the problem of formalizing the proper environment in which (7) applies. Before suggesting an answer to this question, let us look at another neutralization rule of BP, which is given in (8):

(8) Word-final Vowel Neutralization

$$X \quad)_w$$
$$|$$
$$[+\text{vocoid}]$$
$$\neq$$
$$[+\text{open}_2]$$
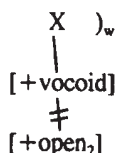
Rule (8) causes the further dissociation from the [open₂] tier of those vowels which are located in word-final unstressed (open) syllables, causing the neutralization of /i,e,E/ (to phonetic [ ]) and of /u,o,O/ (to phonetic [ ]) in that position[6]. Word-

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[6] The mid-vowel contrast is usually also neutralized in nasal vowels. However, this also happens under stress. Nasalization of vowels in BP has two different sources. It derives from a nasal mora in the syllable coda ([kã:pu] *campo* 'field'), or it is caused by a nasal onset consonant ([banãna] *banana* 'banana') (see Moraes and Wetzels, this volume). The former type of nasalization occurs both in stressed and unstressed vowels. The latter type never occurs word-finally, for structural reasons. In the dialects studied here, it does not apply to unstressed vowels either. An independent rule will therefore account for mid-vowel neutralization in nasal vowels. It should be noticed that the Linking Constraint (cf. Hayes (1986)) blocks the application of rules (5-7) to long vowels, which are represented as single-root segments linked to two timing slots. Given the fact that nasal vowels derived from a vowel+nasal mora are long vowels at the point in the derivation where rules (5-7) apply, they escape neutralization, as required.

internally as well as word-finally, late rules of phonetic implementation will specify the phonetic detail of the unstressed vowels which is, even for /i/, /u/, and /a/, different from their stressed counterparts (cf. also Cagliari (1981)).

Let us now return to the problem of defining the proper environment for the different neutralization rules. If the domains we have proposed for the different rules are the correct ones, we do not need to worry about defining the domain which corresponds to what we have informally referred to as "pretonic position". We have, instead, defined the phonological word as the relevant domain. In order to justify this decision, let us consider the following list, which recapitulates the surface contexts in which the different vowel systems of BP occur:

(9)

/i,u,e,o,E,O,a/	stressed	
/i,u,e,o,a/	pretonic	Rule (5)
/i,u,e,a/	posttonic	Rule (7)
/i,u,a/	unstressed word-final	Rule (8)

With respect to the proper application of rules (5) and (7) the important question is whether there exists a language which is identical to BP as far as stress assignment is concerned, but where the distribution of the different vowel systems is the opposite of the one found in BP; more precisely, a language where the more limited system occurs in pretonic position, and the more elaborate one in all other unstressed positions[7]. From a strictly theoretical point of view, such a language should not exist, because, as far as we can see, there is no way in which a domain could be defined, and independently justified, which comprises all and only the pretonic vowels. We will therefore make the claim that such a hypothetical language does not exist. The cross-linguistic prediction which emerges from this assumption is that, in stress system of the BP-type, a rule of neutralization which applies to all pretonic vowels must also apply to all posttonic vowels. For BP this is correct, because the system which occurs after the stressed vowel is a subsystem of the one which occurs before the stress.

To define the domain for posttonic neutralization we must briefly return to the application of the stress rules. In BP main stress is limited to the last three syllables of the word. One consequently finds at most two vowels after the stressed vowel. If stress is antepenultimate, the last syllable is extrametrical and the penultimate syllable is necessarily light, since otherwise it would not have been skipped by the stress rule. Since antepenultimate syllables can be either light or heavy, the prosodic structure of a word like *abóbora* is different from the prosodic structure of a word like *fósforo* 'match', as is shown in (10):

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[7] It should be remembered that we are talking about languages in which secondary stress is not relevant lexically. In languages with secondary lexical stresses, the distribution of different vowel systems might be different.

$$\text{(10)} \qquad \overset{*}{\text{a}}\overset{.}{(\text{bobo})_f}\text{ra} \qquad\qquad \overset{*}{(\text{fos})_f}\overset{.}{(\text{fo})_f}\overset{.}{\text{ro}}$$

Given that footing is non-iterative, the parsing of moras into feet will stop as soon as a moraic trochee has been created. From (10) we conclude that a posttonic vowel which is not word final can either occur as the weak member of a stress foot or as the sole member of a degenerate foot. The obvious generalization is that non-final posttonic vowels always occur at the right edge of a foot. Consequently, the introduction of a right foot boundary into the structural description of rule (7) would guarantee an observationnally adequate account of the facts under discussion. Despite this fact we have designated the domain within which (7) is applicable as the stress foot. As a matter of fact, a question similar to the one we have asked with regard to the rules (5) and (7) could be asked with respect to the rules (7) and (8): could there be a neutralization rule which applies to all posttonic vowels except to the word-final ones? Again we wish to claim that this cannot happen. If our claim is correct, our earlier suggestion to define the context for the application of rule (7) as foot-final is, although observationnally adequate, insufficient from an explanatory point of view. In other words, the concept "posttonic position" is, with reference to BP, a linguistically significant one. Therefore, the formalism should enable us to define a domain which contains all and only the posttonic vowels. This is exactly what we had in mind when we proposed to define the domain of (7) as the stress foot. Let us therefore proceed to identify this domain. Obviously, the common sense meaning of the stress foot in a language like BP is the foot which contains the primary stress, and this is the meaning we wish to adhere to here. In Hayes (1987) it is proposed that syllables which cannot be made part of a well-formed foot represent degenerate feet. For example, the final syllable of fósforo is extrametrical. The first visible syllable for foot formation is prefinal fo. This syllable cannot be combined with the second mora of fos to make a foot, because a moraic trochee should consists of one heavy or two light syllables. Therefore fó is assigned a foot on its own, albeit a degenerate one, which could never receive word stress. In Hayes (1991) a slightly different approach to this issue is adopted. Syllables which cannot be footed are simply skipped. Thus, fósforo will consist of a single foot which contains the first (heavy) syllable, followed by a syllable which remains unfooted (fo) and an extrametrical syllable (ro). The question then arises how the last two syllables are to be integrated into the higher level prosodic structure. We propose that both syllables are simply adjoined to the foot, which, in the case at hand, becomes ternary. In the same way the last (extrametrical) syllable of abóbora is attached to the foot node dominating the sequence bóbo. Nothing needs to be done in the case of regular final or prefinal stresses. As a consequence of this procedure all words end up with a (maximally ternary) foot at the right edge of the word, which is at the same time the stress foot. It is this foot which we believe to be the domain of rule (7). The final question we have to address is why it is plausible to integrate the posttonic syllables into the stress foot, and not, instead, the pretonic syllables. Our answer to this

question is identical to the one which Hayes (1981) provided to justify the footing of extrametrical syllables: the moraic trochee is a left dominant foot. The adjunction of posttonic syllables to this foot does not alter this basic property, whereas the adjunction of pretonic syllables would change the left-dominant foot into a right-dominant one. As we have observed before, secondary stress in BP is postlexical and it is not sensitive to syllable weight. The interesting fact is that posttonic syllables remain completely outside the domain of secondary stress. We can explain this fact by assuming that secondary stress is assigned from right to left, while the main stress determines its point of departure.

Let us close this discussion with a brief recapitulation. We have first shown that rules of neutralization are formally distinct from other rule types involving dissociation operations. The rules which neutralize unstressed vowels in BP have two properties which seem crucial to us. First, they all apply within the foot or the word domain, or at the word boundary, and, second, no melodic conditioning of any kind is involved. We wish to claim that rules of this type necessarily apply to unstressed vowels[8]. For all the rules discussed, the notion "unstressed vowel" need not be referred to by the rules themselves. Rather, the identification of unstressed vowels will be part of the interpretation convention for neutralization rules. Finally, we have shown that the prosodic domains which are crucial for the application of unstressed vowel neutralization rules are the ones which the theory immediately provides or permits to derive.

In lexical phonology an important distinction is made between lexical and postlexical rules. Lexical rules typically have exceptions, usually in underived words. They moreover interact with word formation, and are often active in subparts of the morphology. The rules of neutralization discussed so far have none of these properties. Posttonic neutralization is optional, although very frequent. The other rules are exceptionless and obligatory at the phonological word level. They consequently qualify as postlexical rules.

3. THE NEUTRALIZATION OF STRESSED MID VOWELS

It follows from the discussion in section 2.2 above, that neutralization rules which apply to a subset of the stressed vowels, or which apply to a subset of stressed and unstressed vowels must have properties which are at least partly different from the ones that we have identified for rules which neutralize unstressed vowels. As for the rules which neutralize stressed vowels, it is always possible to positively identify the target by referring to the presence of an asterisk in the word or foot (stress) plane. We

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[8] Notice that, at the left foot boundary, vowels are predictably stressed in a left dominant system. At the right side, they are unstressed, except for monosyllabic feet. It is unclear to us whether a rule exists which selects the unstressed vowels at the right foot edge. For BP we haven not found one.

will see, however, that in most cases, and maybe in all cases, this is not necessary, given other properties of this rule type. In this section we will discuss some examples of neutralization rules involving stressed mid vowels.

3.1 Prosodically Conditioned Rules

3.1.1 Dactylic Lowering

There exists a prosodically conditioned constraint in BP, which bans upper mid vowels from antepenultimate stressed syllables. We provisionally formulate this rule, which is never mentioned in the literature on Portuguese phonology, as in (11) below:

(11) Dactylic Lowering (DactyLow)

$$
\begin{array}{c}
* \\
\text{V } C_0 \text{ V } C_0 \text{ V } C_0 \quad \text{Domain: phonological word} \\
\neq \\
[\text{open}_3]
\end{array}
$$

Some remarks are in order. As we have done for all the rules of neutralization discussed above, DactyLow has been stated as a dissociation operation, despite the fact that its phonetic output is different from the one created by the rules which neutralize unstressed vowels: the latter always create upper mid vowels, whereas DactyLow, as many of the neutralization rules affecting stressed mid vowels, creates lower mid vowels. What all the rules of stressed and unstressed vowel neutralization have in common, is, of course, the fact that the opposition between lower and upper mid is neutralized. Exactly this fact is expressed by the dissociation mechanism which disconnects all the vowels from the [open$_3$] register in the neutralizing contexts. Therefore, what DactyLow crucially states is that vowels in proparoxitonic position do not exploit the [open$_3$] feature, which is in principle available, because necessary to distinguish (stressed) vowels in other environments. Below, we will return to the issue of the phonetic realization of mid vowels.

Consider the words which are listed in (12) below. In the first column we have provided a sample of non-derived words[9], whereas in the second column a set of derived words is given:

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[9] Of course, by calling these words non-derived, we abstract away from the problem of their thematic vowels, to which we will return.

(12) a[É]reo   'aerial'   aer[Ó]dromo   'aerodrome'
    [Ó]ptico   'optic'   aut[Ó]dromo   'autodrome'
    l[É]cito   'egg yolk'   euf[Ó]rico   'euphoric'
    dep[Ó]sito   'deposit'   egipt[Ó]logo   'Egyptologist'
    c[É]lebre   'famous'   egiptol[Ó]gico   'Egyptologic'
    n[Ó]dulo   'nodule'   cadav[É]rico   'cadaverous'
    c[É]lula   'cell'   russ[Ó]filo   'Russophile'
    ab[Ó]bora   'pumpkin'   alfab[É]tico   'alphabetic'
    pr[Ó]digo   'prodigal'   magn[É]tico   'magnetic'

The pairs given in (13) below contain mid vowels which occur in stressed position both in the base words and in the derived forms. Recall that the two series of mid vowels are only contrastive under stress. A pair like amul[é]to /dial[É]to shows this contrast, and the alternation exemplified in amul[é]to ~ amul[É]tico proves that DactyLow has a neutralizing effect on this opposition.

(13) ac[é]to   'vinegar'   ~ ac[É]tico   'acetic'
    amul[é]to   'amulet'   ~ amul[É]tico   'amuletic'
    esquel[é]to   'skeleton'   ~ esquel[É[tico   'skeletal'
    i[ó]do   'iodine'   ~ i[Ó]dico   'iodic'
    atl[É]ta   'athlete'   ~ atl[É]tico   'athletic'
    dial[É]to   'dialect'   ~ dial[É]tico   'dialectical'
    sovi[É]te   'soviet'   ~ sovi[É]tico   'soviet'
    idi[Ó]ta   'idiot'   ~ idi[Ó]tico   'idiotic'

DactyLow is almost exceptionless in non-derived words, if the antepenulti-mate syllable does not coincide with the left word edge. Otherwise, a handful of exceptions must be admitted, provided in (14):

(14) p[é]same   'condolence' c[ó]vado   'cubit'
    b[é]bado   'drunk'   f[ó]lego   'breath'
    p[é]ssego   'peach'   s[ó]frego   'gready'
    [é]xtase   'ecstasy'   c[ó]dea   'crust'
    [é]xodo[10]   'exodus'   tr[ó]pego   'limping'
    [é]xito   'result'   es[ó]fago   'gullet'
    s[é]xtuplo   'sixfold'

The list in (14) is the result of a systematic search, although we cannot exclude the possibility that one or two words have escaped our attention.

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[10] In this and the following words, the graph <x> is pronounced as [z] between vowels, and as [s] before a voiceless consonant.

The word s[ê]xtuplo[11] is particularly interesting, because it represents one of the very few examples, and possibly the only one, of an exceptional case in the category of derived forms. The only possibility we can think of to eliminate it as an exception is to consider it a non-derived word. However, such a solution strikes us as *ad hoc*, because, within the constraints set by semantics, the suffixe -(tu)plo is productive: duplo (dois), triplo (três), quádruplo (quatro), quíntuplo (cinco), sêxtuplo (seis), sétuplo (sete), óctuplo (oito), nônuplo (nove), décuplo (dez), undécuplo (onze), duadécuplo (doze), múltiplo (muito)[12]. Be that as it may, the form sêxtuplo would not suffice in itself to invalidate an otherwise exceptionless generalization.

The non-derived words of (14) are in any case real exceptions. Notice that it would not make much sense to limit the application of DactyLow to words in which the stressed penultimate syllable does not coincide with the left word edge. Although this would eliminate all of the exeptions of (14), except for *es*[ó]*fago*, it would conceal the fact that a large majority of nonderived words which satisfy the structural description of DactyLow do surface with a lower mid vowel, even if their stressed syllable is word-initial. Also, and even more dramatically, the change proposed would multiply the exceptions in derived words: DactyLow would no longer account for the low vowel in words like *i*[Ó]*dico* 'iodic', [É]*pico* 'epic'.

Since there is no way to eliminate the exceptions listed in (14), it seems that DactyLow has a different status as compared to the neutralization rules discussed in section 2, which are exceptionless. It has at least one property typical of lexical rules. The lexical status of DactyLow is further confirmed by the fact that is does not apply in verbs:

(15) pluperfect, 1/2 plural   imperfect subjunctive, 1/2 plural
                                aprender 'learn'
    aprend[é]*ramos*   *aprend*[é]*ssemos*
    aprend[é]*reis*   *aprend*[é]*sseis*

As we will see below (section 3.2), Portuguese verbs contain theme vowels as conjugation markers. Among the theme vowels, the second conjugation marker /e/ is the only mid vowel. In the forms of the verb *aprender* given in (15), which are representative for all the regular verbs of the second conjugation, this vowel occurs in

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[11] And some other proparoxitonic words derived from *sexto* 'sixth'.

[12] Sétuplo et décuplo undergo Dactylic Lowering. Nônuplo represents a systematic exception, which is explained by a postlexical rule which raises all non-high nasal(ized) vowels. Finally, óctuplo respects the rule, but would be independently explained by a constraint which requires all mid vowels to be upper mid in a syllable closed by a stop.

proparoxitonic position[13]. In that position it would constitute a possible target for DactyLow. However, the rule must be blocked. It is not at first sight obvious how the behavior of verb forms with regard to DactyLow should be explained. In terms of lexical phonology one could think of the existence of different strata inside the Portuguese lexicon, one derivational, on which DactyLow is active, and one inflectional, where DactyLow does not occur. As for the interaction between DactyLow and the derivational morphology this solution would work quite adequately. We have seen that all the exceptions, (except for one) concern nouns and adjectives which have, apart from their theme vowels {o, a, e}, no internal morphological structure. The question then is: where does theme formation for nouns and adjectives take place? Nominal theme vowels are traditionally understood as inflectional elements expressing gender[14]. If this is correct, it seems natural to assume that theme formation for nouns and adjectives occurs at the inflectional stratum. Consequently, DactyLow should also function at this level, which would then leave the behavior of verbs unexplained. It seems equally implausible to assume that nouns and adjectives are listed with their theme vowels in the deepest lexicon. Portuguese very productively forms nouns from verbal roots. The deverbal nominal root obligatorily chooses one of the theme vowels {o,a,e}: *procurar* 'to search' > *procura* 'search'; *sustentar* 'to support' > *sustento* 'support'; *destacar(se)* 'to stand out' > *destaque* 'eminence'. Nevertheless, if theme formation for nouns and adjectives were to precede (other?) derivational processes, the fact that exceptions occur precisely in this category would be easier to understand, since in lexical phonology we expect exceptionality to correspond with processes that occur at deeper lexical levels. It is a theoretical possibility to have a lexical stratum at which theme formation for all thematic categories takes place. As for verbs, it is commonly admitted that theme formation is a derivational operation. What we propose is that the same is true for nominal theme formation, which is a process which is formally very similar. The fact that the choice of the thematic vowel for non-verbs is to a large extent unpredictable also justifies its adjunction at a deep lexical level. Moreover, if the last vowel of a verbal root is one of the mid vowels, its quality is often unpredictable in the derived noun: *p[é]rda* 'loss' (< *perder* 'to loose'), but *conv[É]rsa* 'conversation' (< *conversar* 'to talk'). Noun formation, then, possibly involves two arbitrary choices. This being the case, we must assume that the output of deverbal noun formation immediately triggers the lexicalization of a nominal root which, in one way or another, carries the unpredicatable properties acquired in the derivational process. This feedback is under-standable if this morphological operation is located at the very first lexical stratum,

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[13] It is not clear to us whether the sequence /seis/ of the second person plural must already be considered monosyllabic at this point of the derivation. If so, it would not be a counterexample to TriLow. We will see below that we expect the theme vowel in this word to be low for independent reasons.

[14] See also Kuiper (1993) for a similar point of view. On the basis of morphological arguments, Kuiper concludes that all nominal roots are lexicalized with their theme vowels. The proposal that we will develop, which is mainly based on phonological arguments, is relatively close to his.

where it probably ranks among the first morphological operations. The inflectional level could consequently be reserved for verbal inflection and plural formation for nouns and adjectives. Within a lexicon which is structured in this particular way, it becomes possible to exclude DactyLow from the inflectional stratum. This immediately explains why verb forms are not subject to this rule: the conditions for DactyLow would be created by the adjunction of inflectional suffixes at level 2, where DactyLow does not function. This conception of the lexicon is provided in (16):

(16) A Stratified Lexicon of Brazilian Portuguese
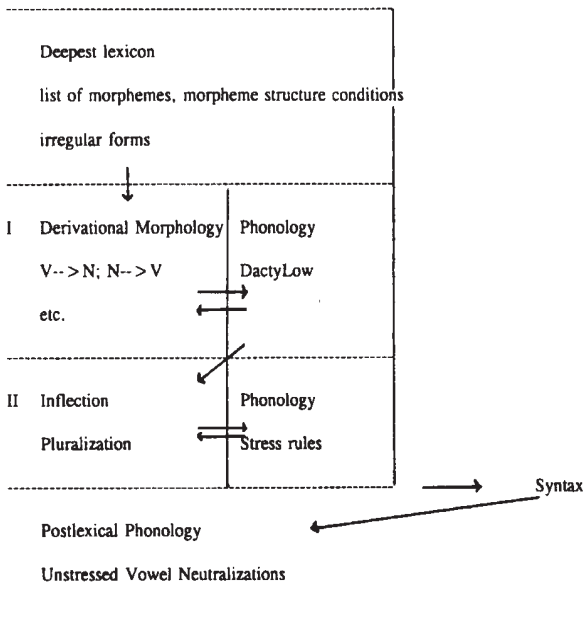
In order to account for the fact that mid vowels in words like *ab*[Ó]*bora* normally surface as lower mid, we must briefly return to BP stress. We have seen earlier that exceptional word-internal stresses[15] in BP are of two types. In *ab*[Ó]*bora* stress is exceptionally assigned to the antepenultimate syllable. In *d*[Ó]*lmen* the final heavy syllable is exceptionally skipped. In order to guarantee the correct stress placement in these words, we have proposed, in line with current practice, that they contain lexical diacritics. The first category has been marked as undergoing final syllable extrametricality, the second category as being subject to final mora extrametricality. Obviously, if this is the right approach, the interpretation of the feature [extr. syl.] must be made effective only after the theme vowels have been adjoined to

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[15] As opposed to exceptional word final stress as in *café*, *abricó*, etc.

their roots, because these vowels form the syllable peaks which will be neglected by the stress rules. Formally, this can be achieved by assuming that theme formation is obligatory, that it precedes all other derivational processes, and that there is a statement in the grammar to the effect that the interpretation of syllable extrametricality occurs at level 1.

The next important question is how exactly DactyLow functions at level 1. The natural assumption that it dissociates vowels from the [open$_3$] tier posits the problem of what the underlying specification of the targeted mid vowel is in a lexical root like /abVbor/ (where V represents the mid vowel). One possible answer would be to say that its quality corresponds to the one which appears when the vowel is under stress, usually lower mid, because the unstressed quality is always predictable by rule. DactyLow would then dissociate V from its [+open$_3$] specification at level 1, where the appropriate context for its application is derived. However, there are some facts which make this solution somewhat unattractive. First, at some point in the derivation exactly the same value [+open$_3$] must be reassociated to these vowels. Furthermore, we would need a rule feature to prevent DactyLow from applying to the exceptional cases listed in (14), because, as a lexical rule, DactyLow will also apply in exceptional roots as soon as the theme vowel has been adjoined. Finally, DactyLow would not apply to underived words like *Pen*[É]*lope*, *H*[É]*rculés*, *En*[É]*eas*, etc., since footing, which is structure-building instead of structure-changing, does not, according to some phonologists, create the derived environment necessary for lexical rules to be applicable. Therefore, if these words are also lexically represented with a lower mid vowel, its quality would be purely accidental. This is all the more surprising, because we have not found a single exception to DactyLow in non-thematic underived words (of the H[É]rcules type)[16]. Finally, in view of this fact, it is surprising to observe that the class of exceptions exclusively contains words derived by theme formation at level 1.

How, then, could all these problems be avoided? We think that the cue to the understanding of the functioning of DactyLow resides in the fact that all thematic nouns and adjectives to which DactyLow will apply are not productively derived from verbs. Recall that DactyLow exclusively applies to forms which have exceptional antepenultimate stress. Indeed, all the nouns productively derived from verbs have regular stress. This strongly suggests that the isolated nouns and adjectives are listed in the non-dynamic part of the lexicon. Let us, in the light of this hypothesis, reconsider the problems mentioned above, and discuss its further consequences.
Since all the stems[17] with dactylic rhythm remain in the permanent lexicon, it is not necessary to interpret the extrametricality statement at level 1. We could, furthermore,

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[16] A word like Pl[é]iade, which is underived, is only an apparent exception. The high mid quality of the mid vowel is explained by a postlexical rule of hiatus raising which will not be discussed here. For a comprehensive treatment of mid vowel neutralization, see Wetzels (in preparation).

[17] Following traditional terminology, we will use the word 'stem' for forms which excusively consist of a root and a theme vowel.

use the diacritic to formulate a rule to predict lexical underspecification of the appropriate vowels in the following way:

(17) In words which have an extrametrical syllable, the vowel which occurs
      in the penultimate metrical syllable is not associated to the [open$_3$]
      tier, except for the words listed in (14), which are specified as
      [-open$_3$].

There is, however, a more insightful way to state the same generalization. We have seen in section 2 that, for the appropriate application of posttonic neutralization, it was necessary to derive a ternary foot. The words for which a ternary foot had to be created are the ones which have a lexical extrametricality marking. The very fact that there is no rule in BP which treats extrametrical vowels or vowels contained in a degenerate foot differently from those which occur in the weak position of a wellformed foot, makes the formal distinction between weak syllable, extrametrical syllable, and degenerate syllable itself suspicious. Also, the class of words for which a derived ternary foot had to be constructed exactly matches the class which constitutes the target for DactyLow. Finally, rule (17) uses a diacritic as the basis for a generaliz- ation which is actually based on the fact that the words for which it is valid have a different rhythm. It strikes us as odd that one part of the regularity (the lexical redundancy rule) is stated on the basis of a diacritic, whereas the other part (the level 1 dynamic rule) is stated in terms of a specific rhythmic pattern. We are therefore tempted to believe that antepenultimate stress is lexically represented as a (ternary) leftheaded foot[18]. If this is true, (17) can be replaced by (18):

(18) The vowel located in the head of a Dactylic foot is not attached to the
      lowest [open] tier, except for the words listed in (14), which are
      specified as [-open$_3$].

We will consequently reformulate DactyLow as in (19):

(19) Dactylic Lowering (Final Version)

$$f(s\ s\ s)$$
$$|$$
$$V$$
$$\not|$$
$$[open_3]$$

---
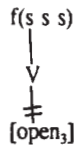
[18] Of course, the decision to allow for exceptional ternary feet in a language as BP, is plausible only if this foot type is necessary at all from a broader theoretical perspective. The theory must also contain a principle that explains why languages with a regular (leftheaded) trochaic pattern, respect leftheadedness in their exceptional feet.

Due to (18), mid vowels remain unassociated to the [open₃] tier in lexical items like h[É]rcules, ab[Ó]bora, etc. Since, in the derivational part of the lexicon, DactyLow does not apply to nonderived forms, the exceptions listed in (14) will surface with upper mid vowels. DactyLow functions as a static condition in the permanent lexicon, and as a feature-changing rule at level 1. Notice that there is no need for DactyLow to supply lexically unspecified values to nonderived words, simply because it is formulated as a dissociation operation, rather than as a feature changing rule. We conclude that the approach proposed avoids all the problems mentioned earlier.

In order to have a consistent representation of antepenultimate stress, we will assume that the suffixes such as *-ico*, *-logo*, which induce dactylic rhythm, are marked with an instruction to form a dactylic foot, which can happen as soon as they are attached to their bases. One of the very important consequences of treating exceptional stress, not as the consequence of lexical extrametricality, but as an exceptional foot, is that there is no need to assume that (regular) trochaic footing is present at level 1, precisely because DactyLow only applies to feet which are lexically present, or triggered by lexically marked level 1 suffixes. Of course, this argument would gain in force if it could be shown that there exists a complete match between exceptional stresses and stress sensitive level 1 rules in BP. Below we will argue that also this is true.

Let us, as a last element in our discussion of DactyLow, consider the following verb forms:

(20a) pluperfect   imperfect subjunctive
              aprazer 'to please'
        aprouv[É]ramos   aprouv[É]ssemos
        aprouv[É]reis   aprouv[É]sseis
              dizer 'to say'
        diss[É]ramos   diss[É]ssemos
        diss[É]reis   diss[É]sseis

(20b)   *ir* 'to go'
        f[ó]ramos   f[ó]ssemos
        f[ó]reis   f[ó]sseis
              ser 'to be'
        f[ó]ramos   f[ó]ssemos
        f[ó]reis   f[ó]sseis

In (20) we give examples of the pluperfect and the imperfect subjunctive of some irregular verbs[19]. In the forms of the verbs *aprazer* and *dizer* a stressed lower mid vowel appears, whereas the (homophonic) forms of the verbs *ir* and *ser* contain an upper mid vowel. All these forms are for independent reasons irregular. It seems

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[19] The class of irregular verbs in BP is relatively small, especially compared to French.

therefore natural to assume that they are listed in the permanent lexicon. Consequently, one expects that among the irregular forms at least some undergo DactyLow. Indeed, the majority of irregular forms does respect DactyLow.

3.1.2 Spondaic Lowering

There is another prosodically conditioned rule of neutralization in BP, which is in many respects similar to DactyLow. Consider the examples in (21):

(21)
|			
m[Ó]vel	'mobile'	c[É]sar	'Caesar'
c[Ó]dex	'codex'	del[É]vel	'erasable'
d[Ó]lar	'dollar'	el[É]tron	'electron'
rep[Ó]rter	'reporter'	est[É]ril	'sterile'
d[Ó]cil	'docile'	[É]ster	'ester'
d[Ó]lmen	'dolmen'	F[É]lix	'Felix'
D[Ó]ris	'Doris'	h[É]lix	'helix'
ign[Ó]bil	'ignobile'	g[É]rmen	'germ'
m[Ó]rmon	'Mormon'	[É]den	'Eden'
t[Ó]rax	'thorax'	n[É]ctar	'nectar'
p[Ó]len	'pollen'	proj[É]til	'projectile'
pr[Ó]ton	'proton'	r[É]ptil	'reptile'
rev[Ó]lver	'revolver'	t[é]xtil	'textile'

Final heavy syllables in BP usually attract stress. Among the words which have exceptional prefinal stress, the examples in (21) represent cases where the stress is carried by a mid vowel, which, in almost all cases, surfaces as lower mid. The co-occurrence between exceptional stress and the lower quality of the stressed mid vowel is not the only resemblance between these words and the ones that undergo DactyLow. All the words of (21) are either underived, or are derived by derivational suffixes (cf. m[Ó]v-el, del[É]v-el). The rule does not apply when the heavy weight of the final syllable is obtained by the adjunction of inflectional suffixes. For example, the adjunction of plural /s/ at level 3 never causes a shift in mid vowel quality. Equally, verbal suffixes which make heavy rhymes do not create environments for lowering, as is shown by the following examples:

(22)
esquecer	'to forget'	
esqu[é]ças	esqu[é]çam	
mover	'to move'	
m[ó]vas	m[ó]vam	

The forms in (22) represent the second person singular (first column) and the third person plural of the present subjunctive of the second conjugation verbs *esquecer*

and *mover*. We will see later that all present subjunctive forms undergo a rule of Vowel Harmony which causes the mid vowels to surface as upper mid. If Lowering were ordered after Vowel Harmony, we would expect the words of (22) to contain lower mid vowels. If it were ordered before Harmony, there would be no proof for the rule to have applied to these forms. Since DactyLow provides strong evidence for a seperate inflectional stratum, we conclude that the lowering rule under discussion does not function at that stratum either. We will call this rule Spondaic Lowering, and formulate it as in (23):

(23)   Spondaic Lowering (SLow)

$$
\begin{array}{c}
f(s \quad s) \\
m(m) \ mm \\
| \\
V \\
\equiv \\
[open3]
\end{array}
$$
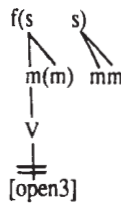
In line with the approach adopted in the previous section, we will assume that exceptional foot structure is present in the lexical representation of the underived words. Consequently, the structural environment of SLow functions to identify positions of underspecification in the permanent lexicon, whereas at level 1 it defines the appropriate contexts for mid-vowel neutralization. The level 1 suffixes which create the conditions for this rule will carry a lexical diacritic triggering spondaic foot formation after suffixation. The lexical diacritic [+extr. mora] is no longer necessary.

As far as we have been able to check, there are no processes at level 1, neither morphological nor phonological, which depend on information assigned by regular trochaic stress. This fact provides strong evidence in favor of the approach defended here, which is that exceptional feet do not result from the application of the unmarked stress followed by stray adjunction of extrametrical syllables. If only exceptional feet exist at these levels, it is a prediction inherent in the approach defended that in this part of the lexicon only rules can exist which are sensitive to the presence of exceptional rhythmic patterns.

This observation is strikingly confirmed by a rule of truncation, which is active at level 1. The rule deletes an unstressed word-final vowel before a vowel-initial suffix: compare *abricoteiro* 'apricot (tree)' (< *abricó* 'apricot') with *mangueira* 'mango tree' (<*manga* 'mango'). Words like *abricó* have exceptional final stress. The rule of truncation could be formulated as in (24):

(24)   Truncation

Delete X/ __   X
          | |
       [+voc]   [+voc]

Being lexical, rule (24) only applies in derived environments. Following up on our discussion in section 1, where we tried to find a way for rules to apply to unstressed vowels without referring to the absence of stress, we will assume the principle in (25a), from which we derive the interpretation convention for truncation rules given in (25b):

(25)   Vowel Truncation Hierarchy
    a. If a rule of vowel truncation applies to stressed vowels, it must also
        apply to unstressed vowels.
    b. If a rule of Vowel Truncation does not refer to the stress plane,
        stressed vowels will be marked for not undergoing the rule; if it
        refers to the stress plane, no vowels will be marked for not undergoing the rule.

Since rule (24) does not refer to the stress plane, stressed vowels will not undergo truncation. As it turns out, the stressed vowels which block truncation all belong to morphemes bearing stress on a word-final open syllable, which is an exceptional (lexicalized) stress type.

It should also be noticed that DactyLow and Slow do not mention any asterisks. This is due to the fact that in BP feet are left-headed. Consequently, the syllable which occurs at the left edge of a foot is the stressed syllable. Independently of this fact there is another factor which would make reference to asterisks unnecessary. As was shown in (3a) above, mid vowels are contrastive in stressed word-final open syllables. This stress type is exceptional, and must be lexically marked. We have argued earlier that it should be impossible for a rule to exist which neutralizes an opposition in all stressed syllables. However, as far as we are aware, there is no reason to suppose that a neutralization rule could not affect all *ir*regular stresses. Since this does not happen in BP, it is not possible to obtain the results of DactyLow and Slow by formulating a lexical (level 1) rule which simply refers to stressed vowels. This being the case, the specific environments in which neutralization occurs must be stated. Both for DactyLow and Slow this results in a rule type which defines a vowel in a specific sequence of syllables as the target for neutralization. We believe that conditionings of this type are typical for stressed vowel neutralization.

Of course, as noted before, there certainly are rules of neutralization which affect unstressed vowels in a sequence, such as pre- or poststress neutralizations, which are common, for example, in the Germanic languages. However, in these cases the structural environment within which the targeted vowel is neutralized cannot be defined

in terms of a specific number of vowels/syllables. What is crucial here is the presence of a contiguous stressed vowel, a factor which must as such be referred to by the rule.

As a final observation, if our idea that syllable-counting neutralization rules necessarily target stressed vowels is correct, one could conclude that in the case of DactyLow and Slow reference to foot structure is unnecessary. Strictly speaking this is true. It is also true that, given the lexical (level 1) irrelevance of regular moraic trochees, SLow does not necessarily need to mention the (heavy) weight of the second syllable. For the same reason it is true that DactyLow and Slow could be collapsed into a single rule: what they have in common, and what distinguishes them from lexically marked morpheme-final stress, is the fact that there is at least one more syllable following the head. However, since we can only guess what the linguistically relevant factors are from the language learner's point of view, and since it is our guess that it is the exceptional rhythmic patterns which consitute the basis of his generalizations, we will stick to the formulations given as (19) and (23).

4. MORPHOLOGICALLY CONDITIONED NEUTRALIZATION; THE DISTRIBUTION OF MID VOWELS IN VERBS.

In this section we will briefly[20] discuss another rule of mid-vowel lowering, as well as a rule of vowel harmony, which are, together with the neutralization rules discussed in the previous section and the phonotactic rules which will be discussed below, responsible for the distribution of mid vowels in the BP verb system. In order to determine the function and nature of these rules, we must examine some aspects of BP verb morphology. Some examples of inflected verb forms are given in (26).

(26)   [[lav + a]$_{St}$ + se + mos]   lavássemos   'if we were to wash'
         [[lav + a]$_{St}$ + va + mos]   lavávamos   'we washed'
         [[lav + a]$_{St}$ + ø + o]   lávo   'I wash'

(where *se* and *va* represent the future subjunctive and imperfect markers respectively)

Notice that in the last example of (26) the theme vowel, which in these forms is /a/, does not surface. This is the effect of a rule of truncation, which will be discussed below. The sequences in (26) are instantiations of the general scheme that underlies the verbal paradigms of BP given in (27) (cf. Câmara (1970:94)):

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[20] A more elaborate account of these rules is provided in Wetzels 1992. Here we will concentrate upon the advantages of a lexical model to account for the phonology of mid vowels in verbs. Moreover, a more elegant formulation of Truncation/Harmony will be proposed.

(27) Morphological structure of the BP finite verb form
[Root + Theme]$_{Stem}$ + Tense/Mood/Aspect + Person/Number

Consider now the quality of the verb root vowels as illustrated in (28), taken from Harris (1974:62):

(28)

1st Conjugation (*a*-themes) *morar* 'reside'	2nd Conjugation (*e*-themes) *mover* 'move'	3rd Conjugation (*i*-themes) *servir* 'serve'

a. Pres. Ind.

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

b. Pres. Subj.

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

c. Imper.

m[Ó]ra m[o]rái	m[Ó]ve m[o]véi	s[É]rve s[e]rví

In the verb forms provided above we find three types of mid vowels: stressed lower, as in *m[Ó]ra*, unstressed upper, as in *m[o]rámos*, and stressed upper, as in *m[ó]vo*. There is general agreement among phonologists working on BP on the question of how these alternations are to be explained (cf. Harris (1974), Lopez (1979), Redenbarger (1981), Quicoli (1990)). The forms containing [O,E] have all undergone a lowering rule which affects mid vowels in root-final position: *m[O]ra* 'he resides', *s[E]rve* 'he serves'. Where stressed [e] and [o] appear on the surface, as in the forms of *mover* which are underscored in (28), their degree of aperture results from a harmony rule, which assimilates a subset of the root vowels to the height of the underlying theme vowel: *m[ó]vo (<mov+e+o)* 'I move', *d[é]vo (<dev+e+o)* 'I must'. Finally, since lower mid vowels are only allowed in stressed syllables, the occurrence of [e,o] in unstressed roots is exactly what we expect: *m[o]vémos* 'we move', *d[e]vémos* 'we must'.

4.1 Mid-Vowel Lowering in Verb Roots.

We will now consider in more detail the application of mid-vowel lowering in verbal stems. Consider the words given in (29):

(29) Noun   Verb 3p.sing.pr.ind.

dem[Ó]ra   'delay'   dem[Ó]ra   'delays'
f[ó]rça   'force'   f[Ó]rça   'forces'
esc[ó]va   'brush'   esc[Ó]va   'brushes'
s[É]rvo   'servant'   s[É]rve   'serves'
conv[É]rsa   'conversation'   conv[É]rsa   'talks'
ap[é]lo   'appeal'   ap[É]la   'appeals'

The nouns listed in the left-hand column of (29) show a contrast between upper and lower mid-vowels, whereas the same distinction is neutralized in the corresponding verbs. On the assumption that there is a synchronic derivational relationship between the two lexical categories, one could posit, following Harris (1974:72), that the underlying quality of the final root vowel in the verbs in (29) corresponds to the stressed vowel that surfaces in the related nouns. Since both noun-to-verb and verb-to-noun derivation are productive synchronic processes, one could furthermore suppose that, as soon as a noun is derived from an existing verbal root, the verbal root is itself eliminated from the permanent lexicon. This can be justified by the fact that, first, whenever necessary, the verb can be derived from the nominal root, second, the nominal root must be lexically listed anyway given the unpredictability of the nominal theme vowel and of the mid vowel quality in nominal roots, and, third, both the theme vowel and the quality of the root-final mid vowel is predictable in verbs. Alternatively, one might suppose that the verbal root remains in the lexicon, and that the derived nominal root is simply added to the permanent list of morphemes. In both scenarios lexical underspecification can be used to express the fact that vowel height is never used contrastively for mid vowels in verbal roots[21]. However, even if the second option is preferred, one would need a dynamic neutralization rule, because we still must provide for the possibility that new verbs can be derived from isolated nouns. Therefore, one's view upon the lexical consequences of the processes of nominal and verbal theme formation is in principle irrelevant to the way vowel lowering functions in the BP lexical phonology. The only crucial fact is that the distinction between upper and lower

---

[21] Notice that this generalization concerns all mid vowels in verbal roots, whatever their position. This follows from the fact that, first, the difference between upper and lower mid is only contrastive under stress, and that, second, even under stress, this opposition is not exploited in verb roots. A slightly different way of expressing the same generalization is to say that any lexical morpheme of BP only contains a single instance of the [open₃] feature (which will be realized under stress in at least one of its surface appearances), except for the category of verb roots, for which the value of [open₃] is predictable for all vowels.

mid vowels remains systematically unexploited in verbs, a fact which must somehow be accounted for in the grammar of BP.

We formulate Vowel Lowering in Verbs (henceforth VoLoVe) as in (30):

(30) VoLoVe   VoLoVe $V C_0 V]_{Verb}$

[open₃]
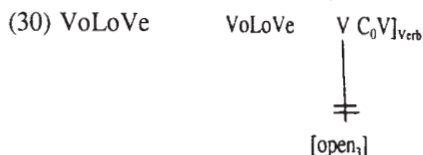
Rule (30) defines the morphophonological environment in which only a five vowel system is realized. Being located at level 1, it applies vacuously in lexically present verbal roots to which the verbal theme has been added. It creates a five vowel system in the same position whenever a verbal theme is derived from a nominal root.

It will be clear that VoLoVe must be prevented from applying to the harmonic forms, because otherwise the effect of the harmony rule would be completely destroyed. In the analysis proposed here, the adequate distribution of mid vowels follows from the fact that VoLoVe is located at level 1. On the other hand, Vowel Harmony, which crucially depends upon the adjunction of inflectional suffixes resides on level 2. Finally, unstressed vowel neutralization is a postlexical rule.

4.2 Mid-Vowel Harmony in Verbs

As we have shown in (27), verb roots take theme vowels as conjugation markers. It was moreover illustrated in (28) that all first person singular present indicative and all present subjunctive forms contain root vowels which have the same height as the underlying theme vowel. It is important to see that *harmonizing forms are the ones in which the theme vowel is underlyingly in prevocalic position*. The only vowel-initial suffixes which follow the theme vowel are precisely the first singular present indicative morpheme $+o+$ and the tense/mood/aspect suffixes $+e+$ (first conjugation) or $+a+$ (second and third conjugations) in all the forms of the present subjunctive. In order to determine the conditions under which harmony applies it is crucial to observe that the harmonizing forms (and only these) appear at the surface without the theme vowel. An adequate account of BP phonology must in some way or another give a principled account of the fact that the height of the root vowel in these forms is the same as that of the theme vowel which surfaces in all the other forms. We know that the deletion of a vowel in hiatus is a very common phonological process. Moreover, from a large number of autosegmental studies we know that deletion does not necessarily affect complete segments, but that parts of segments may show stability effects. For example, the following rule type is common in tone phonology where it accounts for vowel deletion with tone stability (for discussion, see Goldsmith (1976:30-33)):

(31)   Vowel Deletion with Tone Stability (where T stands for any tone)

$$
\begin{array}{cc}
T & T \\
\end{array}
$$

It is predicted by the theory of feature geometry proposed by Clements that examples of stability can be found which involve the aperture node: there exists a class node which dominates all and only the different ocurrences of the feature [open]. This fact makes it possible to formulate a rule which deletes the vowel, but which at the same time saves the aperture node. In other words, we can formulate a rule which is mutatis mutandis identical with the one necessary to account for stability effects of tone specifications. We propose the rule in (32):

(32) Vowel Deletion with Aperture Stability (VoDAS)

$$
\text{Delete} \quad X \, / \, \underline{\quad} \, X
$$

$$
\begin{array}{cc}
| & | \\
r & r \\
| & \backslash \\
[+voc] & [+voc] \\
\end{array}
$$
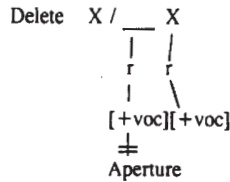
Aperture

It is assumed here that the deletion of a timing slot involves the deletion of all nodes that are attached to it, as well as the erasure of association lines which connect X directly or indirectly to shared nodes. Since the aperture node has been simultaneuosly dissociated, it escapes deletion at this point of the derivation. The 'floating' aperture node must be associated to another vowel in order to receive phonetic realization. This is achieved by the following rule, which is Vowel Harmony proper:

(33) Vowel Harmony (VH)

Trigger: $[\text{-open}_3]$

Target : $\begin{bmatrix} \text{-open}_1 \\ +\text{open}_2 \end{bmatrix}$
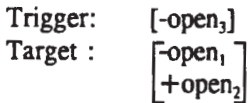
Rule (33) is stated in its simplest possible form, which is based on the following considerations. We have assumed that the way in which VoDAS was stated demands that the floating aperture node is reassociated. If the floating node were not reassociated, it would be deleted at the end of the derivation, and there would be no justification for its dissociation to start with. Since only the theme vowels /i,e/ affect the quality of the mid vowels, we must put a condition on the reassociation of the floating aperture node: $[\text{-open}_3]$ defines /i,e/ as a natural class, to the exclusion of /a/. As for the target, we must specify that only mid vowels are affected. However, it is

usually the case, especially in tonal phonology, that the properties which remain stable in the process of deletion are realized on the triggering vowel. This is not true for BP, where the vowel which triggers the deletion occurs to the right of the deleted vowel, but where reassociation occurs with the (mid) vowel located at its left.

The reason for this deviant directionality follows from the definition of the trigger, which concerns a feature ($[-open_3]$) which is only contrastive in stressed vowels. It can therefore be predicted that the floating node will be reassociated to the stressed vowel, which is located to its left. We conclude that the direction of reassociation does not need to be stipulated.

The association of the floating aperture node to the vocalic node of the root vowel leads by convention to the dissociation of the aperture node that was present on the target vowel previous to the association introduced by (33)[22]. As a consequence of VH, a (left-) adjacent mid vowel in the stem becomes upper mid before the theme vowel +e+, or closed before the theme vowel +i+: /serv+i+o/ > sirvo 'I serve', /engol+i+o/ > engulo 'I swallow', /mov+e+o/ > movo 'I move', beb+e+o > bebo 'I drink'.

5. PHONOTACTIC CONSTRAINTS ON THE DISTRIBUTION OF MID VOWELS.

VH in BP is very clearly a lexical rule: not only does the rule make reference to the morphological structure of the verb, it also has some arbitrary exceptions, as in [pÓsso] posso 'I can', [pOssa] possa 'I can-subj.' from the verb poder (e-theme). The same is true for VoLoVe, which also has a set of arbitrary exceptions. A more interesting fact about VoLoVe from a phonological point a view is the existence of classes of systematic exceptions. To be precise, VoLoVe does not seem to affect mid vowels followed by a nasal consonant. Also, when a root ends in a palatal consonant the root vowel tends to surface as upper mid[23]. In (34-35) illustrations of the relevant forms are provided:

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[22] This convention is called the 'Branch Pruning Convention' by Clements (1989b:9). In Wetzels (1991b) it is shown that the presence of VH in the grammar of BP is automatically triggered by the presence of Truncation. The only complexity added is the definition of the trigger and the target defined in (33), which may be considered as a supplement to rule (32).

[23] Moreover, VoLoVe is ineffective in first conjugation verbs whose roots end in a mid vowel, cf the type *perdoar* 'to forgive', or *passear* 'to walk'. We believe that a phonological explanation is possible for the behavior of these verbs. However, assumptions about lexical representations need to be made which ask for independent motivation. Complete discussion of the facts can be found in Bisol, Mira Mateus and Wetzels (to appear).

(34)

c[ó]mpro,	c[ó]mpras,	c[ó]mpra, etc.	'buy 1,2,3sg., pres., ind.'
apr[é]ndo,	apr[é]ndes,	apr[é]nde, etc.	'learn 1,2,3sg., pres., ind.'

(35)

t[é]lho,	t[é]lhas,	t[é]lha, etc.	'tile 1,2,3sg., pres., ind.'
t[é]lhe,	t[é]lhes,	t[é]lhe, etc.	'tile 1,2,3sg., pres., subj.'

The exceptions involving vowels in prenasal position are only apparent, because there is an independently necessary postlexical condition in BP which forbids the occurrence of lower mid vowels in that position. We will formulate the rule as in (36):

(36) Nasal Vowel Raising (NaVoR)

$$
\begin{array}{c}
\text{X} \\
| \\
[+\text{voc}] \\
\end{array}
$$

Ap [+nasal]
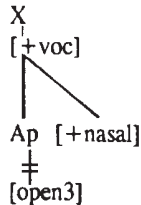
[open3]

In (36), Nasal Vowel Raising is defined as a rule of neutralization. All vowels are disconnected from the [open₃] tier, an operation which erases the distinction between /E,O/ and /e,o/, but which maintains the contrast between /a/, /i,u/, and a single class of mid vowels, in such a way that rules of phonetic implementation dispose of the necessary information to discriminate between the three aperture classes.

An equally general solution is not possible, however, when the surface exceptions to VoLoVe occur in the environment of a palatal segment. First of all, there is no general phonotactic constraint in BP which requires mid vowels to be upper mid before an intervocalic palatal consonant. This can be seen in the words given in (37), which belong to the category of nouns (where <ch> and <x> correspond to a voiceless, <j> to a voiced palatal fricative, and where <lh> represents a palatal /l/:

(37)   br[É]cha 'break'
       br[Ó]xa 'brush'
       cab[Ó]je 'sheatfish'
       m[o]lho 'gravy'
       m[O]lho 'bundle'

The only intervocalic palatal consonant which is consistently preceded by upper mid vowels is /ñ/. However, this distributional fact is independently explained by Nasal Vowel Raising. As for the behavior of the other palatal consonants the facts are much less clear. First of all, the (relatively few) second and third conjugation verb roots which end in a palatal consonant show regular lowering in the non-harmonizing forms: *ele m*[E]*xe* 'he stirs', from the verb *mexer*; ele *fr*[E]*ge* 'he fries' from the verb *frigir*. In first-conjugation forms the clear exceptions concern verbs that are productively derived from nouns which surface with a stressed upper mid vowel: compare 'regular' *ele inv*[E]*ja* 'he envies' (cf. *inv*[E]*ja* 'envy') with *ele (se) averm*[e]*lha* 'he reddens' (cf. *verm*[e]*lho*) 'red'). This pattern, then, explains why second- and third-conjugation forms always regularly undergo Vowel Lowering: in Brazilian Portuguese noun-to-verb derivation almost exclusively yields first-conjugation verbs. Moreover, dorsal mid vowels do not show the irregular behavior of their coronal correlates: *ele* [O]*lha* 'he looks' (cf. [o]*lho* 'eye'), *ele f*[O]*lha* 'he covers with leaves' (cf. *f*[o]*lha* 'leaf'). The facts also suggest that we are not really dealing with a process of raising, as suggested by Harris (1974:64) and Redenbarger (1981:142), but with the blocking of the rule of Vowel Lowering. Since this blocking can occur before palatal consonants only, we would expect that the explanation for this fact is somehow related to the nature of palatal consonants. Since the rule of Vowel Lowering is exclusively defined over aperture features, we suspect that the crucial factor concerns the height definition of palatals, which are traditionally considered to be [+high] (cf. Chomsky & Halle (1968:307)).

We have seen above that VoLoVe dissociates mid vowels from the [open$_3$] tier. According to the Linking Constraint (cf. Hayes (1986)), association lines mentioned in the focus of a phonological rule should be interpreted exhaustively. It is therefore predicted that VoLoVe will be blocked if the [open$_3$] feature mentioned in its focus is associated to more than one aperture node. In order to derive the blocking of Vowel Lowering it would be enough to justify that the [open$_3$] feature of a coronal mid vowel is shared by the aperture node of a following palatal consonant. As was pointed out earlier, palatal consonants are usually described as being redundantly [+high]. In Clements' model aperture features are considered to be vocalic features. When these features become phonologically relevant for consonants, the consonants realize a vocalic node, just like vowels. As for the height specification of high consonants, we will assume the following principle:
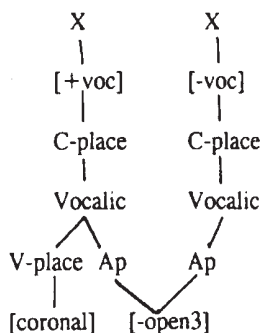
(38)   Specification of Height in Consonants
         High consonants receive an aperture specification which is identical to the
         highest vowel of the system, at the level of the derivation where it becomes
         phonologically relevant.

Consequently, the aperture specification of a palatal consonant in BP will be represented as [-open$_{1,2,3}$]. In BP, this specification must be present lexically, because VoLoVe is an early level 1 rule. On the assumption that the Obligatory Contour

Principle[24] is active at the [open₃] tier, a shared feature will be created for /e/ and a following palatal consonant. This OCP effect is exemplified in (39) below (where the first X defines a coronal upper mid vowel and the second X a palatal consonant):

(39)

```
        X            X
        |            |
      [+voc]       [-voc]
        |            |
      C-place      C-place
        |            |
      Vocalic      Vocalic
       /\            /
  V-place  Ap      Ap
      |      \     /
  [coronal]  [-open3]
```

In (39) the [-open₃] feature is shared by the aperture nodes of the mid vowel and the palatal consonant. We suppose that secondary height specification is only relevant in palatal consonants. Given that VoLoVe requires this feature to be singly linked to the aperture tier, its application will be blocked in structures like (39). Notice that, in order to derive the desired surface pattern, we must limit the activity of the OCP to nouns[25], otherwise we would also block lowering in second and third conjugation verbs.

5. THE PHONETIC REALIZATION OF MID VOWELS.

In sections 2 to 4 above we have discussed several types of neutralization rules. In all cases neutralization has been described as a dissociation operation. As was mentioned, this approach to neutralization is relatively abstract, because it only predicts that of the two possible mid vowel series, only one will be phonetically realized. Nothing is predicted with regard to the precise phonetic quality of the mid vowels resulting from the different neutralization processes. In BP this is a nontrivial issue, since in some cases the upper mid series is realized, and in other cases the lower mid series. Given the large number of neutralization rules that BP has, it looks as if we need to stipulate for each individual process what the phonetic output will be. However, we

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[24] The Obligatory Contour Principle prohibits sequences of adjacent identical autosegments. At the deepest lexical level, OCP violations are usually resolved through fusion of the identical adjacent elements, as illustrated in (23). See McCarthy (1986) and especially Odden (1986) for a discussion of this principle.

[25] For some speakers, blocking does not occur for all first conjugation verbs which have the required properties. For those speakers, fusion of the [-open₃] feature must be achieved by lexical stipulation.

believe that important generalizations can be made. Before we can demonstrate this, we must discuss a type of neutralization not yet explicitly mentioned, but which will turn out to be relevant for our discussion.

The great majority of the rules discussed so far, represent cases where neutralization is not caused by any specific phonological material present in the melodic make-up of BP words. The only rule we have explicitly referred to as a rule of neutralization which was clearly melodically conditioned, was the rule of Nasal Vowel Raising. Why nasal vowels in BP realize only three contrastive aperture degrees, is not clear, but the motivation for the neutralization seems to be segment-internal and has to do with nasality. Other cases of phonotactically conditioned neutralization rules are better looked upon as assimilation, or dissimilation processes. As an example of the former rule type one could consider vowel raising before a tautosyllabic palatal glide (*l*[é]*ite* 'milk', *l*[é]*ito* 'bed', etc.). Probably the high tongue-body position of the palatal glide is responsible for the non-occurrence of lower mid vowels in this environment. If this is the correct way of looking upon this phenomenon, this rule should be formulated as a spreading operation by which the mid vowel picks up its [-open$_3$] feature from the palatal consonant. As a consequence, the upper mid vowels surface with a complete set of aperture features. BP also presents examples of dissimilatory neutralization. In hiatus before /a/, we only find upper mid /o/, as in *lag*[ó]*a* 'lagoon', *perd*[ó]*a* '(s)he forgives', *cor*[ó]*a* 'crown', *Lisb*[ó]*a* 'Lisbon', *can*[ó]*a* 'canoe', *t*[ó]*a* 'tow'. Formally, this could be described as the epenthesis of a [-open$_3$] feature triggered by the following [+open$_3$] feature, which is part of the representation of /a/. Again, the targeted mid vowel surfaces with all its aperture features specified. We will distinguish this type of feature-specifying neutralization from rules like DactyLow, NaVoR, etc., where neutralization has the effect of underspecifying a segment. With regard to this distinction, a more difficult case is represented by a constraint that we will refer to as Closed Syllable Adjustment (CloSAd). CloSAd expresses the generalization that in syllables closed by a nonsonorant stop only lower mid vowels occur[26]: *n*[É]*ctar* 'nectar', *s*[É]*xo* 'sex', *sin*[Ó]*pse* 'synopsis', *in*[Ó]*x* 'inox'. Although there is some degree of melodic conditioning involved, there is no obvious way in which the exclusive occurrence of lower mid vowel could be explained on the basis of the phonetic properties of nonsonorant stops. Probably the crucial factor here is that the syllable is closed[27], which is primarily a prosodic fact. Consequently, we will consider CloSAd an underspecifying neutralization rule. Turning now to the question of the phonetic interpretation of neutralized vowels, it will be clear that we only need to consider the

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[26] Cf. Azevedo de Freitas (this volume).

[27] A similar rule exists in French, where upper and lower mid vowels show a strong tendency towards complementary distribution: upper mid vowels appear in open syllables, whereas lower mid vowels, almost exclusively show up in closed syllables: compare the words *pr*[o]*fesseur* 'professor' and *agr*[e]*gation* 'agregation' with their abbreviated forms *pr*[O]*f* and *agr*[E]*g*.

output of underspecifying neutralization rules. The following list recapitulates the rules of this type, with the properties which are relevant for our discussion.

(40)   Underspecifying Neutralization Rules of BP

Rule	Vowel Quality	Examples
Unstressed Word Domain	Upper Mid	see (3b)
Unstressed Stress Foot	Upper Mid/High	see (3c)
Unstressed Word Final	High	see (3d)
DactyLow	Lower Mid	f[Ó]sforo
SLow	Lower Mid	d[Ó]lar
CloSAd	Lower Mid	in[Ó]x
VoLoVe	Lower Mid[28]	m[Ó]ve
NaVoR	Upper Mid	c[ó]mpra

The first three rules exclusively apply to unstressed vowels. When neutralization only affects the two mid vowel series, the phonetic realization of the remaining one is identical to the upper mid series as it is contrastively realized under stress. When high vowels are also involved, all non-low vowels surface as high. Formally, what we need to assure is that in contexts in which the feature $[open_3]$ is unspecified, it takes the value $[-open_3]$ for vowels specified as $[-open_1]$ (all vowels but /a/), but the value $[+open_3]$ for the only vowel specified as $[+open_1]$. When both $[open_2]$ and $[open_3]$ are underspecified, as in word-final neutralization, all vowels defined as $[-open_1]$ acquire the specifications $[-open_{2,3}]$, whereas the features $[+open_{2,3}]$ are assigned to the vowel specified as $[+open_1]$. As far as unstressed vowels are concerned, we can predict the phonetic value of the underspecified height features with the following two principles:

(41)   Aperture Specification of Unstressed Vowels
        Missing aperture specifications are provided
        a) by the application of the existing redundancy rules, and, in the absence of any redundancy rule,
        b) by the assignment of the unmarked (negative) feature values.

Of these principles, only the first is applicable to neutralized stressed vowels. Since stress-conditioned neutralization exclusively affects the mid vowel series, we only need to account for the fact that the underspecified $[open_3]$ feature is realized as $[+open_3]$ in stressed vowels. However, we then create a problem with regard to the

---

[28] We have seen that stress was irrelevant for the definition of VoLoVe and NaVoR. The mid vowel quality mentioned is the one which appears under stress. In unstressed position, the rules of unstressed vowel neutralization apply, with the ensuing upper mid quality.

realization of stressed nasal mid vowels, which are always upper mid. For these vowels, a special proviso is necessary. The following is a proposal to provide the missing feature values for all neutralized vowels:

(42)

a) $\begin{bmatrix} +\text{nas} \\ -\text{open}_1 \\ +\text{open}_2 \end{bmatrix}$ $\rightarrow$ $[-\text{open}_3]$

b) $[+\text{open}_1]$ $\rightarrow$ $[+\text{open}_3]$ $(=41\text{a})$

c) $[\emptyset\ \text{open}_X]$ $\rightarrow$ $[+\text{open}_X]/\ [V\ \overline{+\text{stress}}]$

$[-\text{open}_X]/\ $ elsewhere $(=41\text{b})$

Rule (42a) does not to distinguish between specified and unspecified values, because all nasal vowels are underspecified for the $[\text{open}_3]$ feature. This is also true for (42b) which expresses a generalization over all BP vowels. It applies redundantly to fully specified low vowels, and in a feature-filling fashion in neutralized environments. Rule (42c) must refer explicitly to the absence of [open] specifications, because stressed vowels may be fully specified at the point in the derivation where the feature-filling rule applies. This is the case in environments in which the $[\text{open}_3]$-tier is contrastive, or where the $[\text{open}_3]$ feature has been filled in by specifying neutralization rules. Although X in (42c) ranges over all aperture features, only missing values will be provided. Whereas stressed vowels only lack the $[\text{open}_3]$ specification, post-tonic unstressed vowels may also lack the $[\text{open}_2]$ specifications.

Notice that the rules listed in (42) will yield the correct surface specification irrespective of their relative order.

In (40) we have listed eight different rules of underspecifying neutralization. By formally treating neutralization processes as dissociation operations, we have been able to separate the phonological aspects of neutralization (absence *vs.* presence of phonological contrast) from its phonetic realization. The ensuing question of predicting the height of the derived underspecified segments turned out not only to be unproblematical, but to permit the expression of generalizations which would have remained implicit if we had had to state the phonetic output for each process individually.

6. CONCLUSION.

In our analysis of neutralization in BP, we have adopted a representation of hierarchically ordered vowel-height features, as proposed in Clements (1991a). It was

this system which permitted us to formalize neutralization as a dissociation operation. This, in turn, allowed us to adequately predict the direction of neutralization (mid vowel contrast first, mid-high contrast second), to separate the phonological from the phonetic aspects of neutralization, and, following from this, to express the generalization that mid vowel neutralization of non-nasal stressed vowels always yields lower mid vowels, whereas the neutralization of unstressed mid vowels always yields upper mid vowels at the phonetic surface.

In sections 3-4 above, we have discussed examples of several types of neutralization rules. We have argued that rules of neutralization which apply to vowel sequences in a prosodic domain or at the word boundary predictably apply to unstressed vowels. This observation was the basis for our suggestion that the identification of unstressed vowels can be left to an interpretation convention which governs the application of this rule type. On the other hand, rules which refer to stressed vowels can be formalized by directly referring to the presence of stress in the relevant domain. However, in BP, these rules typically target a specific vowel in a vowel sequence. It seems to us that this can only happen if the targeted vowel is stressed. We have also seen that the domains within which neutralization of unstressed vowels occurs are the ones that the theory predicts to exist or permits to derive. From the striking fact that level 1 rules of phonology and morphology exclusively apply to exceptional stresses we have drawn the conclusion that, for BP, extrametricality does not seem the correct mechanism to account for exceptional stress patterns.

Several facts pointed to the usefullnes of a distinction between derivational phonology/morphology and inflectional phonology/morphology. We saw that DactyLow and SLow only applied at the derivational level, that the output of noun formation from verbs had to feed back into the permanent lexicon, and that the rule of truncation functions differently in derivation as compared to inflection, where it is combined with the dissociation of the aperture features.

BIBLIOGRAPHY

BICHAKJIAN, Bernard, 1986, "A New Feature for the Specification of Four-Height Vowel Systems", Leo Wetzels and Haike Jacobs (eds), **Gramma, Themanummer Fonologie**, 105-118.

AZEVEDO DE FREITAS, Mirian, this volume, "Empréstimos, Teoria Auto-Segmental e Abertura Vocálica".

BISOL, Leda, Maria Helena Mira Mateus, and Leo Wetzels, In preparation, **Assuntos de Fonologia do Português. Uma Introdução à Fonologia Moderna.**

CÂMARA Jr., Joaquim Mattoso, 1970, **Estrutura da Língua Portuguêsa**. Petrópolis: Vozes.

CAGLIARI, Luiz-Carlos, 1981, **Elementos de Fonética do Português Brasileiro**. Unp. manuscript, Universidade Estadual de Campinas.

CHOMSKY, Noam and Morris Halle, 1968, **The Sound Pattern of English**, New York: Harper and Row Publishers.

CLEMENTS, George N., 1989, **On the Representation of Vowel Height**, Manuscript, University of Cornell.

CLEMENTS, George N., 1991a, "Vowel Height Assimilation in Bantu Languages", **Working Papers of the Cornell Phonetics Laboratory 5**, 37-76.

CLEMENTS, George N. 1991b, "Place of Articulation in Consonants and Vowels: a Unified Theory", **Working Papers of the Cornell Phonetics Laboratory 5**, 77-123.

GOLDSMITH, John, 1976, **Autosegmental Phonology**, Bloomington:IULC.

HARRIS, James, 1974, "Evidence from Portuguese for the 'Elsewhere Condition' in Phonology", **Linguistic Inquiry** 5, 61-80.

HAYES, Bruce. P. 1981, **A Metrical Theory of Stress Rules**, Bloomington: IULC.

HAYES, Bruce, P. 1986, "Inalterability in CV Phonology", **Lg**, **62**, 321-352.

HAYES, Bruce. P. 1987, "A Revised Parametric Metrical Theory", **NELS**, **17**

HAYES, Bruce P., 1991, **Metrical Stress Theory. Principles and Case Studies**, Manuscript, UCLA.

KUIPER, Gerson, 1993, **Klassemarkeerders in het Portugees**, Manuscript, Free University of Amsterdam.

LOPEZ, Barbara S., 1979, **The Sound Pattern of Brazilian Portuguese**, Ph.D., UCLA.

MORAES, João, and Leo Wetzels, this volume, "Sobre a Duração dos Segmentos Vocálicos Nasais e Nasalizados em Português. Um Exercício de Fonologia Experimental".

MASCARÓ, Joan, 1986, **A Reduction and Spreading Theory of Voicing and other Sound Effects**, Manuscript, Universitàt Autónoma de Barcelona.

McCARTHY, John, 1986, "OCP Effects: Gemination and Antigemination", **LI 17**, 207-263.

ODDEN, David, 1986, "On the Role of the Obligatory Contour Principle in Phonological Theory", **Lg**, **62**, 353-383.

QUICOLI, A. Carlos, 1990, "Harmony, Lowering and Nasalization in Brazilian Portuguese", **Lingua 80**, 295-331.

REDENBARGER, Wayne J., 1981, **Articulator Features and Portuguese Vowel Height**, Cambridge: Department of Romance Languages and Literatures of Harvard University.

SLUYTERS, Willebrord, 1991, **Representing Diphthongs**, doctoral dissertation, University of Nijmegen.

WETZELS, W. Leo, 1991a, "Contrastive and Allophonic Properties of Brazilian Portuguese Vowels", Dieter Wanner and Douglas A. Kibbee (eds.), **New Analyses in Romance Linguistics**, Amsterdam: John Benjamins, 77-99.

WETZELS, W. Leo, 1991b, "Harmonização Vocálica, Truncamento, Abaixamento e Neutralização no Sistema Verbal do Português: Uma Análise Auto-segmental", **Cadernos de Estudos Lingüísticos 21**, 25-58.

WERZELS, W. Leo, to appear, in Bisol, Mira Mateus and Wetzels.