

Secondary stress, vowel reduction and rhythmic implementation in Brazilian Portuguese: a preliminary study¹

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Introduction

According to Hulst (1997), language rhythmic structure results from the assignment of secondary stresses, organized in metrical feet. Secondary stress, therefore, is closely related to rhythm.

This assumption is confirmed for Brazilian Portuguese in the works of Collischonn (1993, 1994), Abaurre & Galves (1998), Frota & Vigário (2000), Sandalo et al. (2006), Sandalo & Abaurre (2007), among others.

According to Abaurre & Galves (1998), Frota & Vigário (2000) and Sandalo et al. (2006), BP favors the construction of binary rhythmic units in the implementation of secondary stresses. The purpose of this paper is to present and analyze some experimental data and to evaluate whether they can validate such assumption.

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The experimental data will be used to test the following hypotheses: (i) it is possible that sandhi processes (vowel degemination, elision and diphthongization) that occur within the prosodic word (ω), and vowel deletion/reduction processes that occur within the lexical word optimize the implementation of binary rhythmic units in BP²; (ii) the assignment of additional H tones to the tonal chain can be related to the assignment of secondary stresses in BP (cf. Tenani, 2002); and (iii) the occurrence of non-binary feet in BP as a result of secondary stress placement in the beginning of the prosodic word can be related to emphasis strategies in this variety of Portuguese (cf. Abaurre & Galves, 1998).

The paper is organized as follows: in section two, “Binary assignment of secondary stress in BP: acoustic evidence”, we define secondary stress as opposed to primary stress and we offer a brief account of the discussion concerning the existence of acoustic evidence for a binary pattern of secondary stress assignment in BP; in section three, “Corpus and methodology”, we present our data and the adopted methodology of analysis; in section four, “Results”, we present the interpretation of the relevant data and the results of the analysis; in section five, “Preliminary conclusions and questions for further research”, we present our preliminary conclusions and the aspects of the investigation that we think should be subject of a more extensive research.

2. Binary assignment of secondary stress in BP: acoustic evidence

Primary and secondary stresses define prominent syllables which play an important role in the construction of language rhythmic units. Primary stress corresponds to the main prominence of the word. In this paper, based on Hulst’s (1997) proposal, we assume, following Sandalo et al. (2006), that primary stress in BP is not defined by a metrical rule, being part of the lexical information of the word. It is well known that, in Portuguese, primary stress falls in one of the three last syllables of the word. Although its location in particular words can, to a great extent, be predicted by the metrical analyses already proposed for the language (cf. Bisol, 1992, 2000; Massini-Cagliari, 1995; Lee, 1994;

² For the definition of the prosodic word (ω) within a prosodic hierarchy, cf. Nespor & Vogel (1986); for a discussion about this specific prosodic domain in Portuguese, cf., among others, Schwindt (2000) for BP, and Vigário (2003) for European Portuguese (EP).

Wetzels, 1997, 2007), these analyses do not satisfactorily predict all cases of primary stress location without extensive recourse to the notion of extrametricality or of *ad hoc* stipulations that account for a significant number of exceptions. This fact seems to suggest that it might be more economical to assume that, synchronically, primary stress is part of the lexical information of the words of the language.

As to secondary stress, it is related to a prominence that can be considered different from the one associated to primary stress. According to Hulst (1997), primary and secondary stresses must be analysed differently: primary stress is part of the lexical information of the word³, secondary stress is assigned post-lexically. While there is a natural relationship between secondary stress and rhythm, primary stress is assigned locally, in the lexicon, and is not determined by rhythm (although it plays an important role in rhythmic organization, since primary and secondary stresses interact in speech). Primary stress is categorical, since its position is lexically fixed and cannot vary across speakers and language varieties; secondary stress placement, on the other hand, is variable. Thus, while there is no difference in primary stress placement in BP and EP, there is a huge amount of variation involving secondary stress placement in BP and EP varieties.

The perception of rhythmic prominences that follow a strong/weak alternating pattern in BP has been noticed by many authors since the end of the nineteenth century, according to Frota & Vigário (2000). Such binary pattern, which, by hypothesis, is closely related to the construction of rhythmic feet in BP, has been consistently reaffirmed in subsequent phonological descriptions and analyses that have been proposed for the underlying rhythmic organization of this language (cf., among others, Carvalho, 1989; Collischonn, 1993, 1994; Galves & Abaurre, 1996; Abaurre & Galves 1998; Frota & Vigário, 2000; Sandalo et al., 2006; Sandalo & Abaurre, 2007).

Acoustically based work like that of Gama Rossi (1998), Arantes & Barbosa (2002), Moraes (2003) and Arantes (2005) have tried to find evidence for this binary rhythmic pattern proposed in phonological analyses of BP by investigating the acoustical correlates of secondary stresses. Such studies are based on the instrumental analysis of the

³ For other authors, working within the framework of Metrical Phonology, it is assigned by a rule in one of the strata of the lexical component (cf. analyses mentioned for BP, above).

phonetic implementation of syllables auditorily perceived as bearing such prominences in the language.

In order to define the phonetic nature of secondary stress in BP, Gama Rossi (1998) analyzes duration measures, vowel quality (F1) and fundamental frequency (F₀) in words with two or three pretonic syllables (e.g., ‘macacada’, ‘palhaçada’, ‘palhacinha’, ‘cachorrada’, ‘cachorrinho’ e ‘elefantinho’⁴). The words occurred in sentences of a *corpus* especially elaborated to allow comparison between duration measures of sentences produced by adults and four year old children (native speakers of BP). The subset of data used by Gama Rossi in her study of secondary stress in BP refers exclusively to sentences she herself produced. According to her results: 1) duration did not turn out to be a consistent acoustical correlate for secondary stress (and for binary alternation, for that matter), given that the results showed ascending normalized duration values starting in the initial syllable and proceeding to the syllable that bears primary stress in the words considered; 2) F₀ offers only sparse evidence (although statistically significant, in some cases) for secondary stress and for a binary alternation; and 3) vowel quality (F1) offers consistent evidence for secondary stress and for a binary alternation.. As to the results regarding fundamental frequency, Gama Rossi finds statistically significant results related to the difference of values concerning the first and second pretonic syllables of the word ‘cachorrinho’. The syllable ‘ca’ presents higher F₀ values than the syllable ‘cho’, and the author interprets these results as evidence for a binary alternation in the implementation of secondary stress in this word, with the syllable ‘ca’ bearing secondary stress. With regard to vowel quality, the author shows that, in the words ‘palhaçada’ and ‘macacada’, the vowel nucleus of the second pretonic syllable, in each case (‘pa’ and ‘ma’, respectively), show F₀ values that consistently differentiate them, in terms of vowel quality (degree of closeness or openness), from the vocalic nuclei of the subsequent syllables (‘lha’ and ‘ca’, respectively). Gama Rossi interprets these results as robust evidence for a binary alternation, since they point to secondary stress placement in the syllables ‘pa’ and ‘ma’ of the words ‘palhaçada’ and ‘macacada’, respectively.

⁴ Given the nature of the discussion presented in this paper, centered almost exclusively on phonetic aspects of segmental sequences, we will not provide translations for the Portuguese examples.

Arantes & Barbosa (2002) have studied the behavior of durational patterns in a polysyllabic word like ‘macacada’, when inserted in a particular position of a set of sentences especially constructed to allow for the investigation of a possible alternation involving duration of prominent and non-prominent units.⁵ The statistical analyses of the data did not show a significant difference in the mean durational values of the first and second syllables of the word. Duration showed an increasing pattern from the initial to the main prominence of the stress group, and did not show an alternating pattern. The results presented by Arantes & Barbosa seem to indicate that duration only cannot be taken as a sufficiently robust correlate for a binary rhythmic pattern in BP, organized on the basis of an alternation of strong (longer)/weak (shorter) syllables. Given the results obtained by these authors, as well as the results presented by Gama Rossi (1998), one is led to believe that, as regards secondary stresses in BP, the perception of such prominences, responsible for the rhythmic alternation, can be based not only on the acoustic parameter of duration, but on other acoustic parameters as well, or even on a combination of parameters (as shown in Moraes, 2003). It is also possible that acoustic parameters related to syllables adjacent to those perceived as bearing secondary stress can play a role in the perception of such prominences.

Moraes (2003) investigates whether the strong/weak alternation that supposedly underlies the implementation of secondary stress in BP exhibits a consistent phonetic correlate, or whether such alternation should be regarded as a phonologically justifiable concept, only, with no phonetic counterpart. The author based his perceptual and acoustical study of secondary stress in BP on recorded data obtained from sentences which provided context for the insertion of words containing from two to five pretonic syllables (e.g., ‘canibal’ / ‘canibalismo’ / ‘canibalizar’ / ‘canibalização’), occurring in final (strong) or internal (weak) position in the intonational phrase. The sentences were read by four native speakers of BP. Acoustic measures for duration, F₀ values and intensity were extracted for the words considered, and a perceptual study was conducted based on data thus obtained. In the perceptual study, ten informants were asked to listen to the sets of recorded data and to

⁵ The authors expected to find a binary alternation in the duration of syllables with and without secondary prominence based on acoustical descriptions of the primary stress in BP (cf. Moraes, 1984; Massini-Cagliari, 1991). According to these descriptions, duration is the most robust phonetic correlate of primary stress in the language.

identify the syllables with secondary stress. The results of the acoustic measures and of the perceptual study were the following: (i) informants systematically perceived one secondary stress in words with more than one pretonic syllable; (ii) there is a strong tendency to perceive only one secondary stress per word (on the leftmost syllable) in words containing from two to five pretonic syllables; (iii) the position of the syllable perceived as prominent can vary according to two basic patterns: secondary stress follows a binary alternation, or it falls on the initial syllable of the word; (iv) the number of syllables of the word interferes with secondary stress placement: in short words with two pretonic syllables, the presence of a secondary stress is not consistent; (v) the position of the word within the intonational phrase does not interfere with the implementation of secondary stress; (vi) the acoustical correlate of secondary stress is not stable, although a clear correspondence between the perception of prominent syllables and a modification in the acoustic signal could be attested. The analyzed data indicated that the correlate could either be a variation in F_0 values, or a combination of duration and intensity.

Arantes (2005) gives a phonetic description of secondary stress in BP in terms of acoustic correlates such as duration, F_0 and formant configuration. The author extracts acoustical measures of pretonic syllables in words with two to five pretonic syllables (e.g., 'arataca', 'arapabaca', 'colonoscopia', 'dirigibilidade'). The words were inserted in sentences produced by BP speakers and especially built to allow for control of the relevant variables. According to Arantes, the results for the parameter of duration do not support the claim that there is an alternating pattern of secondary stresses in pretonic syllables; duration values show a progressive increase towards the syllable that carries the lexical stress in the word, as already mentioned by Gama Rossi (1998) and Arantes & Barbosa (2002). With regard to F_0 , Arantes claims not to have found evidence that a variation in the values of this parameter could reveal the occurrence of a binary pattern in secondary stress implementation. The author mentions a rise in F_0 value in the first syllable of words with two pretonic syllables and also in the first syllable of words with three pretonic syllables. In the latter case, the rise can also be observed in the second syllable of the word. For Arantes, the rise of F_0 values in his data should be related not to the existence of an alternating binary pattern resulting from secondary stress assignment, as proposed by Gama Rossi (1998), but to the phonetic manifestation of a word-initial prominence, in the language.

Coherent with the interpretation offered for durational values, Arantes argues, in the case of vowel formant configuration, that his data offer evidence for a culminative nature of the prominence chain across the stress group. He also claims that the consistently different openness value found for the first vowel of the words is a result that should be added to the results concerning durational values for the v-v unit. Both results, according to him, are evidence for the existence of a word-initial prominence phonetically realized by greater duration of the first V-V unit and by high positive variation rates in the first vowel of the analysed words.⁶

It should be noted that the above considerations regarding the lack of evidence for a binary alternating pattern for secondary stresses in BP are based exclusively in the results of analyses that try to identify acoustical parameters that could be consistently associated to the phonetic realization of prominences perceived on syllables. It is important to notice, however, that the phonetic implementation of secondary stresses does not necessarily correspond to an underlying (abstract) rhythmic pattern, postulated in a representational level. It is possible, therefore, that the underlying rhythmic units constructed as a result of the application of a metrical algorithm that places secondary stresses in alternating syllables are not realized phonetically, in some cases, or are realized in a different way. In a prosodic word like (na cafeteria) ω , for instance, secondary stresses are phonologically assigned according to a binary pattern that associates prominences to the syllables ‘na’ and ‘fe’: (na cafteria) ω ⁷. The stresses thus generated, can, however, be realized differently, as follows: 1) they can all be realized phonetically (na cafteria) ω ; 2) only the first secondary stress is realized (na cafteria) ω ; 3) only the second secondary stress is realized (na cafteria) ω ; 4) none of the secondary stresses is realized (na cafeteria) ω , and 5) only one secondary stress is realized, on a syllable not predicted by the algorithm (na cafeteria) ω .⁸ Variation in secondary stress implementation depends, among other factors, on choices that have to do with rhythmic

⁶ The extraction of durational measures for V-V units (units that include all segments occurring between two *onsets* of subsequent vowels), also called ‘groups between *p-centers*’, is based on the assumption that such units are the *locus* of stress culminance (cf., among others, Vassière, 1983; Barbosa, 1994, 1996).

⁷ Cf. the metrical algorithm for secondary stress assignment in BP proposed by Collischonn, 1993, 1994: “Construct left-headed binary constituents from right to left” (Collischon, 1994:48). The domain of application of the algorithm corresponds to the set of syllables preceding the syllable that bears lexical stress.

⁸ In the examples, bold syllables represent syllables with lexical stress; bold underlined syllables represent syllables with secondary stress.

optimization within particular chains of prosodic words and also with phenomena related to the the discursive context.⁹

It is also possible that cues can be found, in the acoustic signal, that might indirectly point to the underlying binary pattern resulting from secondary stress assignment. Such cues might be found not on the syllable marked by the algorithm as receiving such prominence, but on adjacent syllables. This is a discussion that will not be pursued in this paper, for it depends on the results of further research centered specifically on this topic.

Taking the above discussion into consideration, in this paper we identify and discuss some cues that are present in the acoustic signal and that can be related to phonological phenomena (application of sandhi rules and vowel reduction/deletion) leading to syllabic/stress readjustments in the segmental chain. We also discuss the hypothesis that some cases of H-tone assignment to particular syllables can phonetically indicate secondary prominence in the prosodic word. The occurrence of such phenomena can, by hypothesis, be related to a general tendency to optimize an alternating binary rhythmic pattern in BP, as we will try to show in the subsequent sections

3. *Corpus* and methodology

3.1. *Corpus*

The *corpus* for this research is composed of digital recordings of a text read by seventeen native speakers of a same variety of BP. The informants are all from the state of São Paulo, and are speakers of the so-called “paulista dialect” from the interior of the state. They are all from the same age group and degree of instruction (university students).

The text read by the informants is a chronicle published in a weekly Brazilian magazine.¹⁰

⁹ According to Abaurre & Galves (1998), the implementation of secondary stress in the initial position of a prosodic word in BP can occur in emphatic contexts. In EP, on the other hand, this seems to be the default choice.

3.2. Methodology

The methodology followed in this paper includes the following steps: (i) auditory identification, in the *corpus*, of the types of phonetic feet delimited by the occurrence of perceived secondary stresses in prosodic words with two or more pretonic syllables; (ii) auditory identification of occurrences of vowel shandi within the prosodic word (in the vast majority of the cases considered), and of vowel reduction/deletion within the lexical word; and (iii) segmental and intonational analysis of the acoustic signal corresponding to the

¹⁰ The text of the chronicle is the following:

Complicabilizando

Não, por favor, nem tente me disponibilizar alguma coisa, que eu não quero. Não aceito nada que pessoas, empresas ou organizações me disponibilizem. É uma questão de princípios. Se você me oferecer, me der, me vender, me emprestar, talvez eu venha a topar. Até mesmo se você tornar disponível, quem sabe, eu aceite. Mas, se você insistir em disponibilizar, nada feito.

Caso você esteja contando comigo para operacionalizar algo, vou dizendo desde já: pode tirar seu cavalinho da chuva. Eu não operacionalizo nada para ninguém. Tampouco compactuo com quem operacionalize. Se você quiser, eu monto, eu realizo, eu aplico, eu ponho em operação. Se você pedir com jeitinho, eu até implemento. Mas, operacionalizar, jamais.

O quê? Você quer que eu agilize isso para você? Lamento, mas eu não sei agilizar nada. Nunca agilizei. Está lá no meu currículo: faço tudo, menos agilizar. Precisando, eu apresso, eu priorizo, eu ponho na frente, eu dou um gás. Mas agilizar - desculpe, não posso, acho que matei essa aula.

Outro dia mesmo queria reinicializar meu computador. Só por cima do meu cadáver virtual! Prefiro comprar um computador novo a reinicializar o antigo. Até porque eu desconfio que o problema não seja assim tão grave. Em vez de reinicializar, talvez seja o caso de simplesmente reiniciar, e pronto.

Por falar nisso, é bom que você saiba que eu parei de utilizar. Assim, sem mais nem menos. Eu sei, é uma atitude um tanto quanto radical da minha parte, mas eu não utilizo mais nada. Tenho consciência de que a cada dia que passa mais e mais pessoas estão utilizando, mas eu parei. Não utilizo mais. Agora eu só uso. E recomendo. Se você soubesse como é muito mais elegante, também deixaria de utilizar e passaria a usar.

Sim, estou me associando à campanha nacional contra os verbos que acabam em "ilizar". Se nada for feito, daqui a pouco eles serão mais numerosos do que os terminados simplesmente em "ar". Todos os dias os maus tradutores de livros de marketing e administração disponibilizam mais e mais termos infelizes, que imediatamente são operacionalizados pela mídia, reinicializando palavras que já existiam e eram perfeitamente claras e eufônicas.

A doença está tão disseminada que muitos verbos honestos, com currículo de ótimos serviços prestados, estão a ponto de cair em desgraça entre pessoas de ouvidos sensíveis. Depois que você fica alérgico a disponibilizar, como você vai admitir, digamos, "viabilizar"? É triste demorar tanto tempo para a gente se dar conta de que "desincompatibilizar" sempre foi um palavrão.

Precisamos reparabilizar nessas palavras que o pessoal inventabiliza só paracomplacabilizar. Caso contrário, daqui a pouco nossos filhos vão pensabilizar que o certo é ficar se expressabilizando dessa maneira. Já posso até ouvir as reclamações: "Você não vai me impedibilizar de falabilizar do jeito que eu bem quilibiliser". Problema seu. Me inclua fora dessa.

prosodic words perceptually identified as showing occurrences of secondary stresses, vowel sandhi and vowel reduction/deletion processes.

The auditory perception of secondary stress, vowel sandhi and vowel reduction/deletion occurrences was conducted by one native speaker of the paulista dialect of BP and evaluated by two other judges. *Praat* software was used in the segmental and intonational analysis of the acoustic signal.¹¹ Intonational analysis of the data was based on the works of Pierrehumbert (1980), Beckman & Pierrehumbert (1986), Pierrehumbert & Beckman (1988), Ladd (1996), and on works that deal specifically with BP intonation and which are based on the same theoretical and methodological assumptions: Cunha (2000); Frota & Vigário (2000), Tenani (2002), Fernandes (2007), among others.

4. Results

The results presented in this section fall under two types: (1) results obtained for all the relevant data; and (2) results of case studies. Type (1) results refer to the analysis of the types of phonetic feet formed by the informants' choice of secondary stress assignment. Type (2) results, on the other hand, refer to the analysis of the relationship between the application of vowel sandhi or vowel reduction/deletion, and the manifestation of a binary rhythmic pattern in BP. Type (2) results also refer to the analysis of the relationship between the assignment of additional tones, emphasis and secondary stress implementation in the language.

4.1. Types of phonetic feet

1486 prosodic words with two or more pretonic syllables were identified for the seventeen speakers in the BP *corpus*. Secondary stresses were perceived in 97% (1436) of the prosodic words, and in only 3% (50) no occurrence of secondary stresses was registered, as shown in Fig. 1.

¹¹<http://www.fon.hum.uva.nl/praat/>.

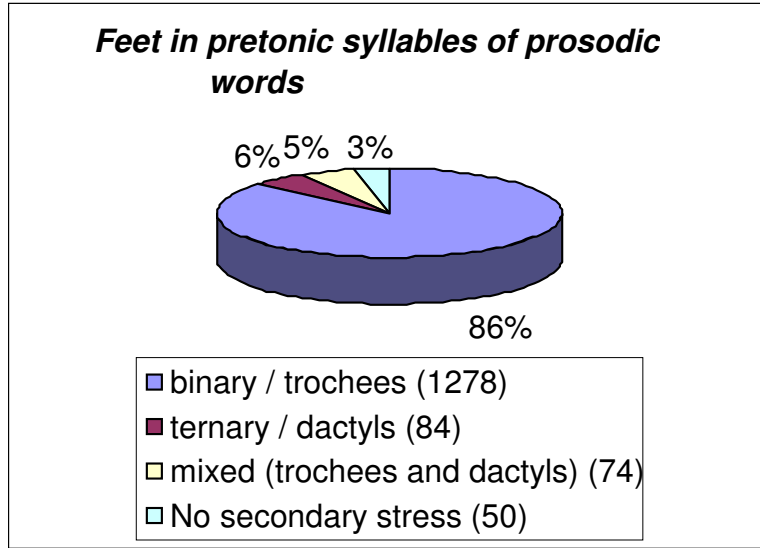


Fig. 1: Types of feet

Fig. 1 also provides other interesting information regarding secondary stress assignment in the BP data: the predominance of binary left-headed feet (86% of phonetic trochees); the small percentage of ternary left-headed feet (6% of phonetic dactyls); and the equally small percentage of mixed feet (5% of trochees and dactyls) – i.e., of binary and ternary feet – in the same prosodic word (context: prosodic words with five syllables).

4.2. Vowel sandhi processes and binary rhythm optimization

The cases of vowel sandhi analysed in this paper occur predominantly within the prosodic word, and are instances of: (i) *degemination* (deletion of the first of a sequence of two identical vowels across lexical word boundary); (ii) *elision* (deletion of the first of a sequence of two distinct vowels across lexical word boundary); and (iii) *diphthongization* (diphthong formation in the context of two contiguous vowel nuclei in lexical word boundary).¹²

¹² Cf. Bisol, 1990, 1992, 1994, 1995, 1996, 1999, 2000, 2002, 2003 for extensive analyses of vowel sandhi processes in BP.

4.2.1. Degemination

The example of degemination analysed here occurs between the identical vowels /e/ (in the word ‘se’) and the /e/ of the first syllable of the lexical word ‘expressabilizando’, within the prosodic word (se expressabilizando)ω. The context of occurrence of the relevant prosodic word is presented in (1):

(1) ‘... que o certo é ficar (se expressabilizando)ω dessa maneira.’

The auditory transcription of (1) indicates that the prosodic word (se expressabilizando)ω was phonetically realized as:

- (i) “s[i]xpressabilizando” (53% (9 tokens))¹³
- (ii) “s[i]xpressabilizando” (41% (7 tokens))
- (iii) “s[e] xpressabilizando” (6% (1 token))

The results indicate a clear tendency for a binary rhythmic pattern, with an alternation of strong and weak syllables within trochaic feet (94%, considering the sum of (i) e (ii)). In only one token (6%), we observe a mixed pattern: an initial dactyl followed by a trochee. With regard to this apparently exceptional token, it is interesting to observe that an emphatic pronunciation was auditorily perceived by the transcriber. The prosodic word (se expressabilizando)ω was perceived as having been emphatically produced by the speaker, who also placed a relatively long pause between ‘se’ and ‘expressabilizando’. Emphasis on the word, a neologism created by the author of the text¹⁴, could be the reason why the speaker’s choice, in this case, was to place the secondary stress in the first syllable

¹³ Cf. fn. 8.

¹⁴ The text read by the informants contains, in fact, a great number of neologisms (verbs that have been recently introduced in BP and which are derived by use of the suffix *-izar*), and of verbs made up by the author to produce humor. ‘Expressabilizando’, e.g., would translate as ‘expressabilizing’, a non-existent word in Portuguese (and in English, for that matter). The verb that expresses this concept in Portuguese is ‘expressar’ (‘to express’). The text is a good-humored criticism of the introduction of such words in the language.

This particular derivational process of word formation can produce very long words (one of the words in the text has seven pretonic syllables), and the criterion for choosing this particular text for reading was the fact that such words provide an excellent context for secondary stress placement and variation.

of the word, thus producing an initial dactyl. The 94% of the tokens seem to represent the default rhythmic organization of prosodic words with a syllabic structure like that of (se expressabilizando)ω, whereas the exceptional case might represent the marked case, associated with emphasis¹⁵.

As to the relationship between the occurrence of degemination and the implementation of secondary stresses, and taking into account the results presented in (1), the following observations can be made. In (i), the application of the process in (1) (53%) favors the manifestation of a binary rhythmic pattern, as indicated by the secondary stresses, since by eliminating one syllabic nucleus, degemination avoids the occurrence of two consecutive weak syllables ‘se’ and ‘ex’ of a phonetic dactyl¹⁶, producing, instead, a trochee. Even in (ii) (41%), where degemination did not occur, we can still observe the implementation of an alternation binary rhythm, because secondary stress was placed on the first syllable of the prosodic word, ‘se’¹⁷.

The acoustic analysis of the same tokens showed the following results for the seventeen occurrences:

- (iv) degemination was attested in 59% (10) of the tokens, and the phonetic realization of the vowel in the relevant context was ‘s[i]xpressabilizando’;
- (v) degemination was not attested in 35% (6) of the tokens, and the phonetic realization of the vowel sequence in the relevant context was ‘s[i] [e]xpressabilizando’
- (vi) in 6% of the cases (1 token, auditorily perceived as representative of an emphatic pronunciation) no degemination was attested, and the phonetic realization was ‘s[e] [e]xpressabilizando’.

The results of the acoustic analysis, therefore, reveal an even greater number of occurrences of degemination that favor a binary pattern of feet than the auditorily based results.

¹⁵ Cf., in this respect, fn 9.

¹⁶ Produced by combination of the lexical stress of the phonological word (‘fícar’) ω that immediately precedes (se expressabilizando)ω, in (1).

¹⁷ Observe that, in this case, we have a stress clash produced by the occurrence of two consecutive stresses: the lexical stress of the phonological word (‘fícar’) ω and the initial secondary stress in (se expressabilizando)ω. In cases like this, speakers usually choose to place a short pause and/or to locally use a tonal configuration that minimizes the rhythmic problem created by the stress clash.

Figures 2 and 3, below, correspond, respectively, to phonetic realizations of the cases presented in (iv) and (vi), above:

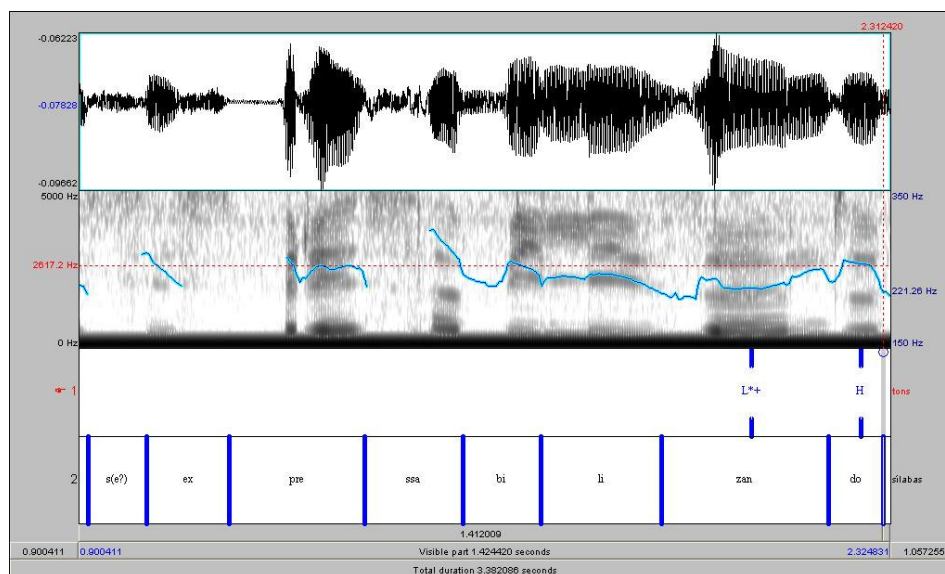


Fig. 2: ‘s[i]xpressabilizando’

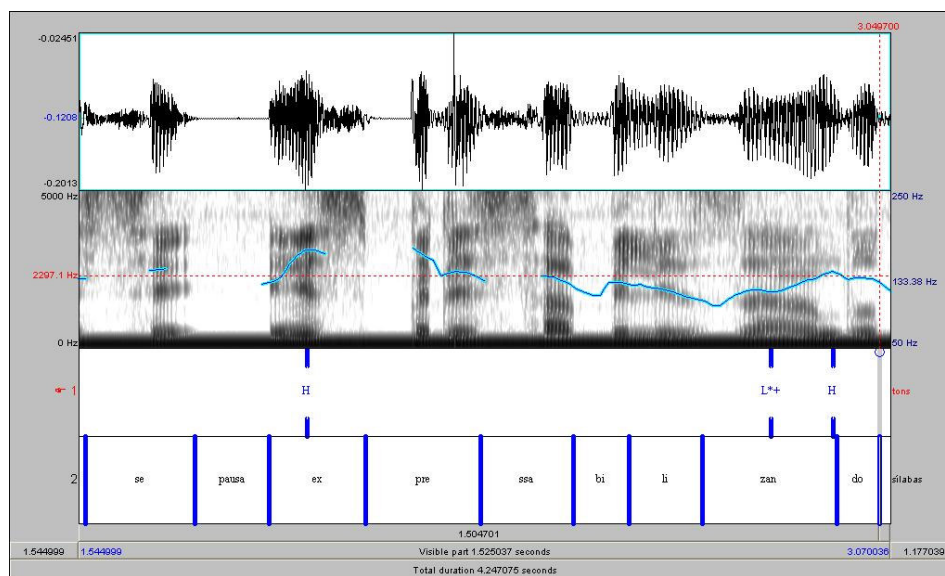


Fig. 3: ‘s[e] [e]xpressabilizando’

The comparison of figures 2 and 3 shows that, in the pronunciation ‘s[e] [e]xpressabilizando’ (fig. 3), the initial syllable ‘ex’, perceived with secondary stress, is produced after a pause, and is associated to an additional H tone. We notice, also, that in

the same token there is also a tonal accent L*+H associated to the tonic syllable ‘zan’ of the same prosodic word. In the pronunciation ‘s[i]xpressabilizando’ (fig. 2), with occurrence of degemination, no pause occurs in the same context, and there is only one tonal accent (L*+H) associated to the tonic syllable of the same prosodic word, but no other additional tones associated to other syllables. In the latter case, therefore, no additional tones were realized on syllables perceived as carrying secondary stress (‘pre’ and ‘bi’, according to the auditory perception).

Another interesting fact that should be noticed refers to the realization ‘s[e] [e]xpressabilizando’ ((vi), fig. 3), where a secondary stress was perceived in the first syllable of the prosodic word (‘ex’), creating a ternary foot and resulting in a pronunciation usually interpreted as emphatic. The same was not observed in the cases presented in (iv) and (v). It could be the case that the realization of a secondary stress in the beginning of a prosodic word, which results in a dactyl in a significant number of words, is associated to strategies of emphasis placement in BP (cf. Abaurre & Galves, 1998). It could also be the case that, in some cases, such strategy is also related to the occurrence of an additional tone H, associated to the syllable perceived as carrying secondary stress, in the beginning of a prosodic word.

On the bases of such considerations, we can conclude that pauses and strategies of emphasis placement can interact with rhythmic implementation, changing the expected binary pattern of the language. Thus, the underlying binary pattern of BP may or may not be phonetically implemented, depending, among other factors, of the discursive context.

4.2.2. Elision

Differently from the other sandhi cases discussed here, the example of elision selected for analysis occurs across prosodic word boundary, and not within a prosodic word. The prosodic words involved in the process are “(contra)ω” and “(os verbos)ω”, and they occur in the following context, in our *corpus*:

- (2) ‘Sim. Estou me associando à campanha nacional (contra)ω (os verbos)ω que acabam em “ilizar”.’

The results of the auditory perception of BP speakers are as follows

- (vii) in 76% (13) of the tokens, the perceived realization was ‘**contr**[u]s **verbos**’;
- (viii) in 18% (3) of the tokens, the perceived realization was ‘**contr**[a] [o]s **verbos**’;
- (ix) in one token (6%), the speaker did not pronounce the article and realized the sequence ‘**contra verbos**’.

The results of the auditory perception reveal that, in 82% (14) of the cases ((vii) plus (ix)), a binary rhythmic pattern occurs, as a result of the alternation created by the primary stress of the two lexical words. Elision contributes to the manifestation of the binary pattern in all the cases in (vii), whereas in (ix) it is the elimination, by the reader, of the definite article ‘os’, present in the original text, that guarantees phonetic feet binarity. Only in 18% (3) of the tokens a mixed pattern was perceived (a dactyl followed by a trochee), as a result of the non-application of elision to the last vowel of the first word. (‘contra’).

As to the results of the acoustic analysis, they also show a greater number of tokens with elision of the [a] vowel in ‘contra’ than was auditorily perceived. Again, this fact supports the conclusion that a binary feet alternation is favored in BP rhythmic organization. According to the acoustic analysis:

- (x) elision of /a/ occurred in 94% (16) of the cases;
- (xi) elision of /a/ did not occur in only one token (6%).

In this latter case (ix), however, the informant simply did not read the definite article ‘os’, thus eliminating the context for the application of elision to the original sequence of vowels. The result, in rhythmic terms, was the same: a binary alternation of phonetic feet resulting from the placement of primary stresses in the two words. Figures 4 and 5, below, illustrate, respectively, the phonetic realization of one of the tokens representative of (x), and of the only token mentioned in (xi):

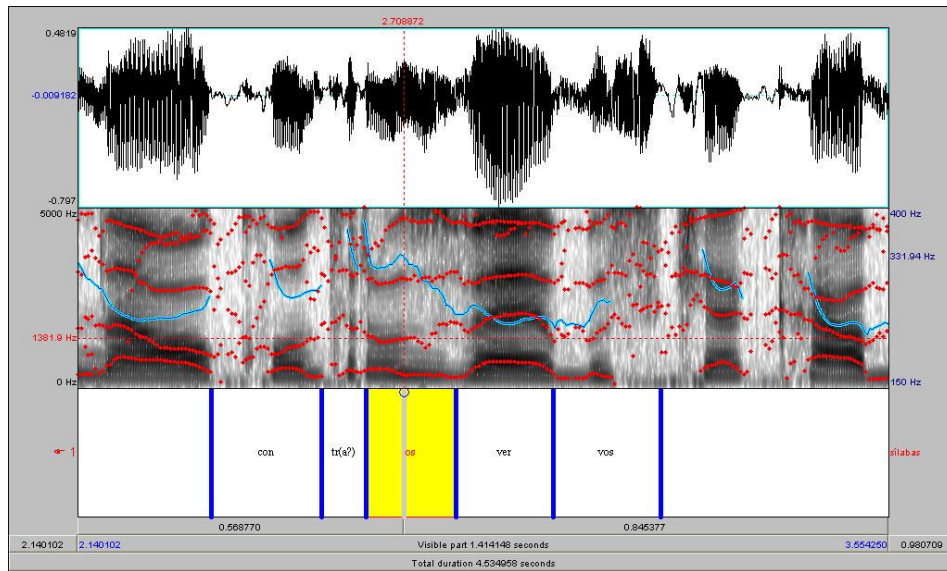


Fig. 4: 'contr[u]s verbos'

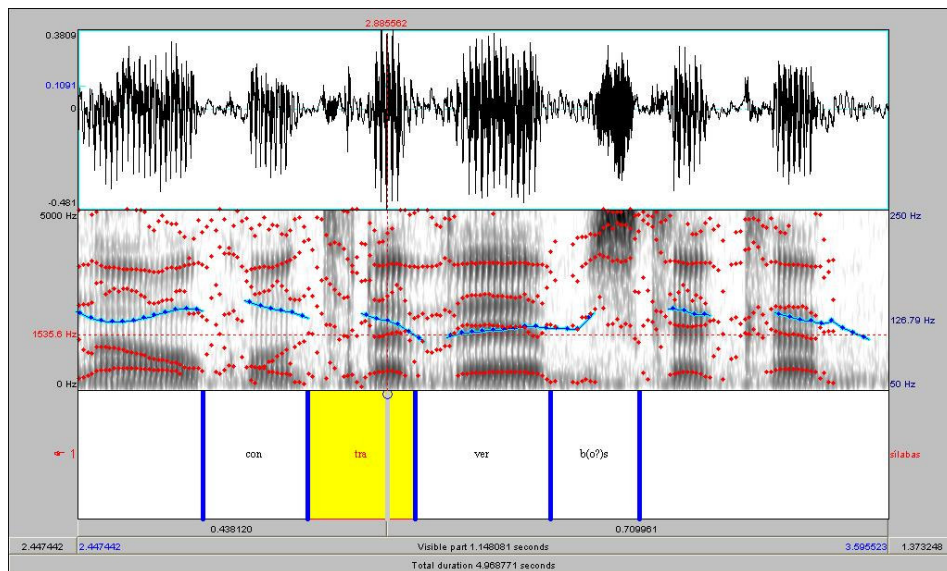


Fig. 5: 'contra verbos'

4.2.3. Diphthongization

The case of diphthongization analyzed here involves the sequence of vowels [i] and [o] within the prosodic word (me oferecer)ω, which, in our *corpus*, occurs in the following context:

(3) ‘Se você (me oferecer)ω, me der, me vender, me emprestar...’

Transcription based on auditory perception showed the following results for (3):

(xii) in 76% (13) of the tokens, the prosodic word (13) (me oferecer)ω was perceived as ‘m[jo]ferecer’;

(xiii) in 12% (2) of the tokens, the pronunciation was perceived as ‘m[I]oferecer’;

(xiv) in 12% (2) of the tokens, it was perceived as ‘m[I]oferecer’.

These results indicate that, in 88% (15) of the data (sum of the results in (xii) and (xiii)), the alternating binary rhythm was perceived within the prosodic word as a result of the application of diphthongization and/or of secondary stress placement. Notice that in (xii), where the diphthongization [mjo] was perceived, the alternating binary rhythm is favored, since the sandhi process forces resyllabification of the unstressed two-syllable sequence ‘me’ and ‘o’ (before the syllable ‘fe’, perceived with secondary stress) into one syllable, [mjo]. Even in (xiii), representative of cases with no diphthongization, the alternating rhythmic pattern can be observed, since secondary stress was perceived on the initial syllable, ‘me’. Only in 2 cases (12%), the two unstressed syllables were perceived as realized, with no application of the sandhi process to the vowel sequence. In these cases, the binary rhythm is altered, because we get a phonetic ternary foot resulting from the combination of the two initial unstressed syllables of the prosodic word ‘m[I]oferecer’ with the last stressed syllable of the preceding prosodic word, (se você) ω.

The acoustic analysis of the same tokens, however, reveals that diphthongization occurred in 100% of the tokens, with the prosodic word (me oferecer)ω being realized, in

all cases, as '[mjo]ferecer'. Given that the syllable 'fe', according to the auditory perception, was perceived in all cases as bearing secondary stress, diphthongization, attested by analysis of the acoustic signal, can be interpreted as favoring the implementation of a binary rhythm when combined with secondary stress placement, in 100% of the occurrences of the prosodic word (me oferecer)ω. Fig. 6, below, represents one of the cases of diphthongization produced by one of the seventeen BP informants, as identified by analysis of the acoustic signal:

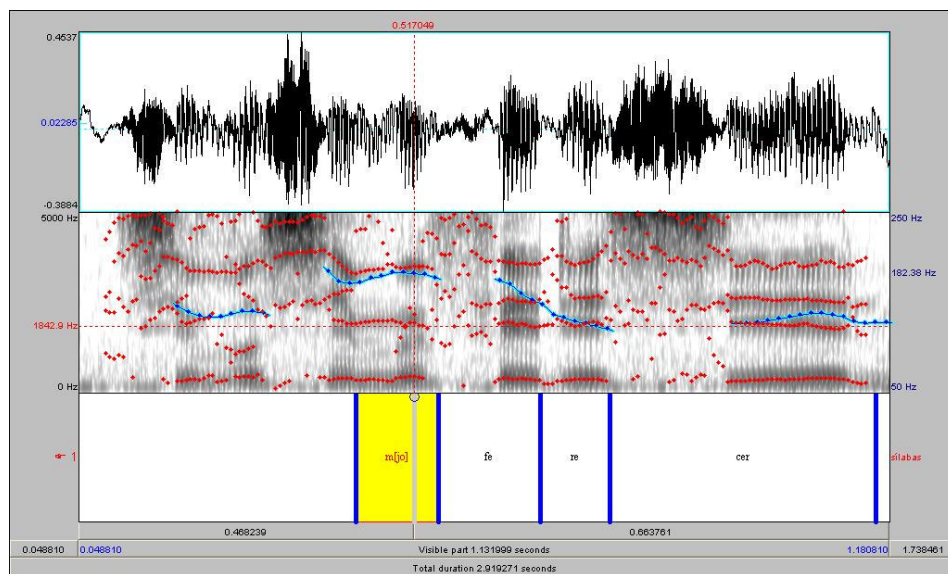


Fig. 6: '[mjo]ferecer'

4.3. Vowel deletion/reduction within the prosodic word and rhythm optimization

Other segmental readjustments, besides sandhi processes, were identified in our *corpus*, such as the deletion/reduction of pretonic vowels in syllables that occur within lexical words. The interesting thing to point out, in these particular cases, is that, differently from those cases previously discussed of sandhi application that could be considered representative of a rhythmically-oriented deletion (which occurs within or across prosodic word boundaries and seems to always lead to optimization of the binary pattern of

prominence alternation), vowel deletion/reduction processes that apply within lexical word boundaries may or may not optimize a binary distribution of prominences, as we will show in the following sections.

4.3.1. A case of vowel deletion/reduction leading to rhythmic optimization in BP

One of the cases identified in our *corpus* as favoring a binary rhythmic pattern in the distribution of prominences is [u] reduction in the syllable ‘pu’ of the second lexical word of the prosodic word (um computador)ω, in the context showed in (4):

(4) ‘Prefiro comprar (um computador)ω novo a reinicializar o antigo’.

For the 17 tokens of the prosodic word (um computador)ω in the above context, the following results were obtained, based on the auditory perception:

(xv) in 65% (11) of the cases, the prosodic word was perceived as ‘um **computador**’;

(xvi) in 35% (6) of the cases, it was perceived as ‘**um** computa **dor**’.

Such results seem to indicate that, in the majority of the cases (65%), a ternary pattern was perceived as resulting from secondary stress placement in this particular prosodic word. When we confront these results with the results of the acoustic analysis of the same data, however, we see that a binary pattern is still maintained, since a drastic reduction of the vowel [u], nucleus of the second syllable ([pu]), occurred in 100% of the 11 tokens represented in (xv). The reduction favors the implementation of a binary rhythmic alternation because the drastic reduction of one of the unstressed vowels, [u], in the ternary foot ‘**computa**’ (originally created by secondary stress placement in the first syllable, ‘com’) produces what is perceived as a binary foot.’ Let us now turn our attention to the spectrogram of one of the tokens of (um computador) ω, illustrated in fig. 7, below:

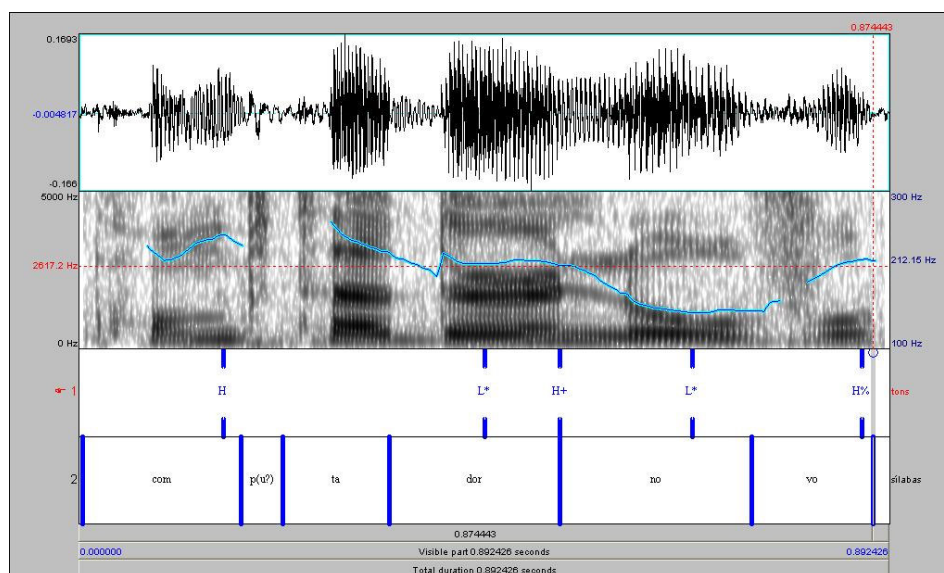


Fig. 7: 'um comp(u)tador'¹⁸

The observation of fig. 7 shows that 'pu', the syllable that should receive secondary stress attributed by the algorithm that places secondary stresses in BP (cf. fn. 7), undergoes a drastic reduction. Notice that, according to the perceptual analysis of this token, the syllable that bears secondary stress is 'com', and not 'pu'. Acoustic analysis of fig. 7 leads to the identification of an additional H tone placed on this same syllable. We believe that such additional H tone associated to 'com', as well as the drastic reduction of the vowel nucleus in 'pu', give support for the perception of a secondary prominence placed on 'com', first syllable of the second lexical word within the prosodic word. We can conclude, therefore, that the drastic reduction of the vowel, in this case, leads to rhythm optimization in BP, since the result of the segmental reduction process is a phonetic binary trochee.

4.3.2. A case of vowel deletion/reduction that does not lead to rhythmic optimization in BP

¹⁸ Parentheses indicate that the vowel was deleted or drastically reduced.

We also found some examples, in our *corpus*, where vowel reduction within the lexical word seems to disfavor the implementation of a binary rhythmic pattern in BP. The case that will be presented here refers to [i] deletion in the first syllable ('dis') within the second lexical word of the prosodic word (a disponibilizar)ω, which occurs in the context in 5:

(5) 'Depois que você fica alérgico (a disponibilizar)ω...'

According to the results of the auditory perception, the prosodic word (a disponibilizar)ω was realized as follows:

(xvii) in 71% (12) of the tokens, (a disponibilizar)ω was realized as 'a **disponibilizar**';

(xviii) in 12% (2) of the tokens, it was realized as 'a **disponibilizar**';

(xix) in 18% (3) of the tokens, the pronunciation was perceived as emphatic, and the prosodic word was realized as 'a **disponibilizar**'.

According to such results, it is possible to conclude that, for the majority of the tokens (71%), an alternating binary rhythm associated to secondary stress placement was perceived within the prosodic word. In only 29% of the data (corresponding to the sum of percentages in (xviii) and (xix)), a mixed pattern was perceived (cases described in (xix)), or a phonetic ternary foot was created by the association of the first unstressed syllable 'a' with the last of the two unstressed syllables of the preceding prosodic word (alérgico)ω, after application of segmental and sandhi processes to the segmental string (cases in (xviii)).

The acoustic analysis of the same tokens showed that:

(xx) in 59% (10) of the tokens, the prosodic word (a disponibilizar)ω was produced with deletion/drastring reduction of [i] in the syllable 'dis';

(xxi) in 41% (7) of the tokens, the same vowel did not show significant reduction. (3 of the 7 cases were perceived as emphatic pronunciations in the auditorily based analysis).

Fig. 8 illustrates one of the pronunciations described in (xx), and fig. 9 illustrates one of the pronunciations described in (xxi), perceived as emphatic:

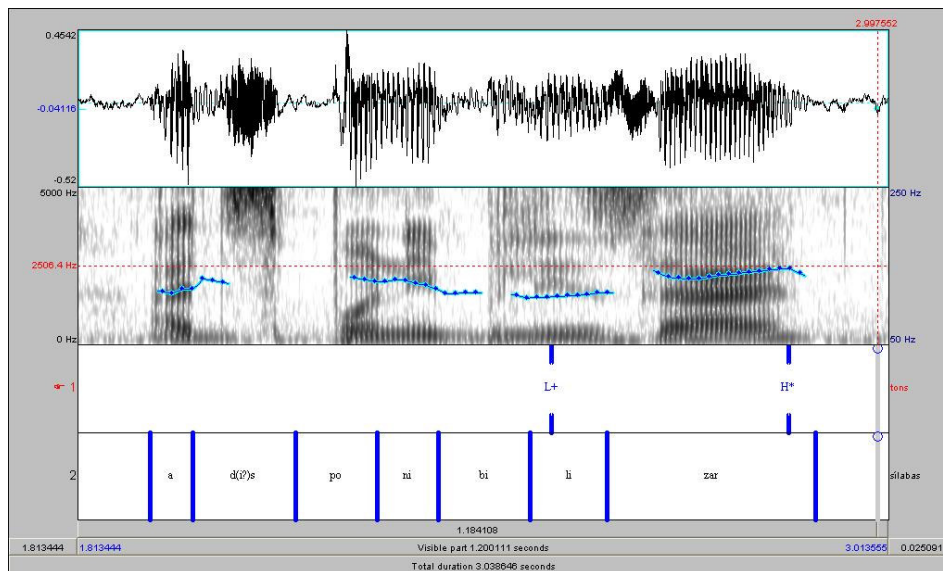


Fig. 8: 'a d(i)sponibilizar'¹⁹

¹⁹ Cf. fn. 18.

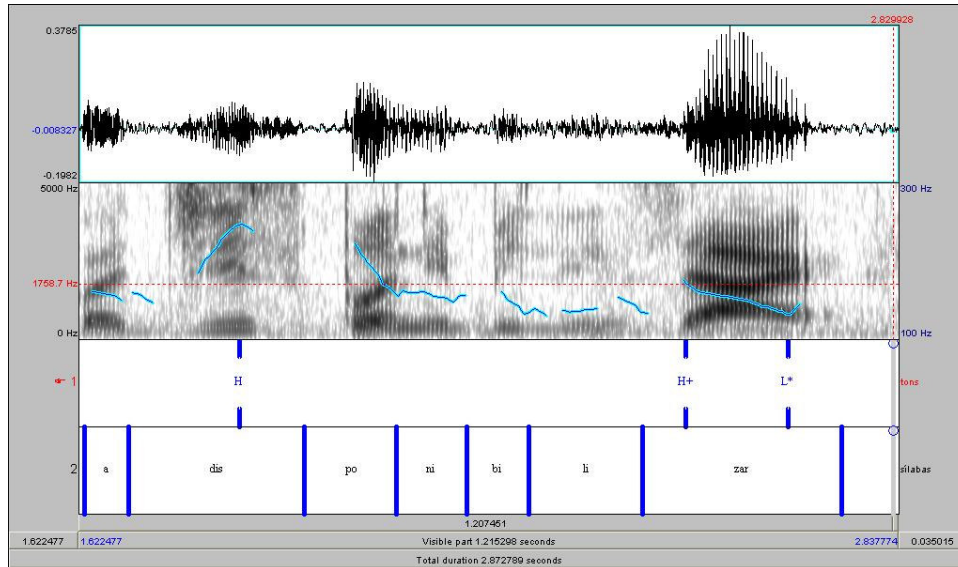


Fig. 9: ‘a disponibilizar’ (emphatic pronunciation)

The results in (xx) show that, for those cases where the prosodic word (a disponibilizar) was perceived as exhibiting an alternating binary pattern, as in ‘**a disponibilizar**’, deletion/drastring reduction of [i] in syllable ‘dis’ does not in fact optimize the rhythmic pattern, creating, instead, a stress clash between the secondary stresses perceived on syllables ‘a’ and ‘po’.

It seems to be the case that, in contexts where unstressed [i] occurs between certain coronal segments, it is always deleted. The fact that /i/ and other non-low vowels can be deleted (or drastically reduced) in unstressed position between t_s has been observed by Bisol (1991), and the fact that non-low vowels can be deleted between homorganic (coronal) consonants in general has been noticed by Bisol & Hora (1993). The deletion discussed by these authors occurs regardless of the metrical structure of the word. In *satisfatória* ‘satisfactory’ and *satisfeito* ‘satisfied’ [i] is always deleted, independently of rhythmic patterning within the prosodic word. In the former case, *satisfatória*, [i] deletion optimizes binary patterning, since it reduces two unstressed syllables to one, thus changing the ternary feet into a binary one (*satsfatória*). In the latter case, *satisfeito*, on the other hand, [i] deletion creates a stress clash between the secondary stress and the lexical stress of the word, thus creating a rhythmic perturbation (*satsfeito*). In cases like these, we can say that vowel reduction is determined by the segmental context, which seems to have

precedence over rhythmic optimization. This would be an interesting topic for further research.

On the basis of the above considerations, it is possible to say that certain cases of vowel reduction within the lexical word (as the cases of [i] reduction in the syllable ‘dis’ of ‘disponibilizar’ , and of [u] reduction in ‘computador’, described in section 4.3.1) will most probably occur under normal pronunciation, regardless of rhythmic optimization results, if the segmental context thus determines. Notice that unstressed [u] reduction in the sequence [mpu] is favored by the segmental context, since [u] shares the feature [labial] with [m] and [p]. Coincidentally, such reduction also favors rhythmic binarity, given the observed secondary stress placement on ‘com’ in 11 of the 17 analyzed tokens (um **comp**(u)tador)ω. Segmentally conditioned unstressed [i] reduction in ‘disponibilizar’, however, disfavors implementation of a binary rhythm resulting from secondary stress placement, since it creates a stress clash (in the pronunciation (**a** d(i)sponibilizar)ω).

It should also be noticed that segmentally determined unstressed vowel reduction can only be blocked in cases of emphasis (cf. fig. 9), already discussed in section 4.2.1, above.

5. Preliminary conclusions and questions for further research

The results presented in this preliminary study lead to the following tentative conclusions:

- (i) the analyzed data seem to support the hypothesis that BP favors the construction of binary feet, which constitute the basis for rhythmic organization in the language;
- (ii) processes of vowel sandhi lead to syllabification and tend to optimize the binary organization of rhythm in BP, and could therefore be considered representative of a group of so-called rhythmically-oriented deletion processes;

- (iii) vowel reduction within the lexical word may or may not optimize the implementation of binary rhythmic units (there seems to exist a conflict between phonotactic restrictions and principles of rhythmic organization);
- (iv) strategies of emphasis placement also interact with rhythmic patterning, and may produce ternary feet (dactyls) as a result of secondary stress placement on unexpected syllables;
- (v) additional H tone is related to the presence of secondary stress on the syllable to which it is associated, and it occurs more frequently in cases of emphatic pronunciation.

For these preliminary findings to be effectively supported, however, systematic investigation must be conducted on larger *corpora* of other varieties of BP, with data samples representative of different styles of speech. We list, here, some of the relevant questions for further research:

- (a) the relationship between processes of vowel reduction/deletion determined by the segmental context and the optimization of a binary rhythm in BP;
- (b) the eventual precedence of segmentally motivated deletion processes over rhythmically-oriented deletion processes when conflict arises (an OT-based analysis would be a natural candidate to model such conflict);
- (c) the interaction of phenomena like pause insertion, emphasis and focus with rhythmic organization in BP;
- (d) the relationship between the association of an additional H tone to the tonal chain and the implementation of secondary stress in neutral and in emphatic cases;
- (e) the relationship between vowel sandhi processes (within and across prosodic word boundaries) and secondary stress placement / rhythmic implementation in BP
- (f) the interaction of unstressed post-tonic syllables and unstressed pretonic syllables across prosodic word boundaries, and the type of phonetic feet resulting from such interaction and its effects on the general rhythmic patterning of utterances.

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ABSTRACT: This paper presents some preliminary results of an investigation centered on the nature of the relationship between secondary stress placement, vowel reduction processes and additional tone assignment. Data obtained from auditorily based transcriptions and from acoustical analyses are presented, and the implications of the application of reduction processes and of secondary stress assignment for rhythmic organization and for the optimization of binary feet in Brazilian Portuguese is discussed.

KEY WORDS: *Brazilian Portuguese; secondary stress; binary rhythmic organization; segmental readjustments; vowel sandhi processes; tonal association.*