Post-tonic syllables and prosodic boundaries in Brazilian Portuguese

Eneida de Goes Leal, Raquel Santana Santos

Department of Linguistics
University of São Paulo, São Paulo, Brazil
eneidaleal@yahoo.com
raquelss@usp.br

Abstract

This paper aims to verify how prosodic boundaries may affect the duration of post-tonic syllables in Brazilian Portuguese (henceforth BP). The results show that the only prosodic boundary that has significant lengthening is intonational phrase, and its application relates to both post-tonics and tonics. Additionally, we found that there is no relation between lengthening and higher prosodic levels, since there was no significant difference in the clitic group (C) and phonological phrase (Φ). Finally we found that there was no statistical correlation between duration and vowel quality, but there was a correlation between the consonant voicing and duration.

1. Introduction

The present paper discusses the relation between prosodic levels and duration in final post-tonic syllables in Brazilian Portuguese. Specifically, the first question addressed is whether lengthening in the post-tonics is due to the influence of the different prosodic boundaries, as reported in the literature for different languages [19], [13], [24], [9].

The second matter is whether this lengthening is affected differently depending on the level of the prosodic hierarchy: studies claim that lengthening is longer in the higher domains than in the lower ones [2], [1], [5], [22], [23]. Being the main acoustic correlate of primary stress in BP, duration can be used to disambiguate syntactic structures in this language: although with the same syntactic structure, the parsing of prosody is different and lengthening of weak syllables plays a role in disambiguation.

To our knowledge, there are no works regarding weak syllable lengthening associated with prosodic levels in Brazilian Portuguese and the present study could be useful to comprehend how prosodic boundaries influence on final syllable lengthening in Brazilian Portuguese.

2. Stress and acoustic correlates in Brazilian Portuguese

Since Fry [11], it is well known that primary stress is the linguistic codification of the following acoustic correlates: (1) fundamental frequency, (2) duration, and (3) intensity. As for Portuguese, different studies agree that the main acoustic correlate is duration [7], [17], [16] but only some of them controlled the prosodic aspects of the syllables analyzed.

Fernandes [7], for example, tested 200 utterances, which led to 74.5% of duration as the main correlate for stress assignment, followed by fundamental frequency (62.7%), and intensity (59%). The author only controlled the positions of syllables as pre-tonics, tonics and post-tonics. However Fernandes compared syllables with different consonants and vowels, different syllable structures, and different syntactic and prosodic contexts.

Focusing on the syllable duration, Major [14] carried out an experiment with the logatom /laˈlala/ inserted in the sentence *Repita a palavra lalala de novo* 'Say the word lalala again'. As can be noticed, Major controlled segments and prosodic placement (specifically, Φ boundary in both sides – cf. section 4). His results show that post-tonics are one time and a half (1.48) shorter than pre-tonics.

According to Moraes [17], the most constant correlates for word stress are intensity and duration – the author controlled stressed syllable position inside the word.

Finally, Massini-Cagliari [16] reports that word stress in BP is characterized by a longer duration in the stressed syllable; weak syllables have a decreasing intensity; and vowel quality also plays a role. The latter result is corroborated by Barbosa [1]: from [+anterior] to [+posterior] vowels, the higher the vowel the smaller duration is.

Summarizing, the authors agree that the stressed syllable for primary stress in BP is essentially longer than the weak syllables. Only Major characterizes the weak syllables and points that post-tonics are shorter than pre-tonics at Φ domain in BP.

3. Effects of the prosodic boundaries

Works is the literature examine the effects of syllables at prosodic domain boundaries: consonants are better uttered in the beginning of prosodic boundaries [4], [12]. Another common process is lengthening, which can occur either in initial phrase boundaries [19] or final boundaries [19], [13], [24], [9]. These studies show that lengthening is directly proportional to the height of the levels, i.e., the higher the level the longer the lengthening, both for initial boundaries [2], [4], [10], [5], [22], [12] and final boundaries [2], [1], [5], [22], [23].

According to Fougeron & Keating [9], the last stressed syllable is also lengthened in final intonational phrase boundary, due to the fact that this syllable also carries intonational accent.

Finally, lengthening spreads from one to three syllables apart from boundaries [3], and this effect is reduced once the distance from the boundaries increase.

3.1. Duration and syntactic disambiguation

Magalhães & Maia [14] and Fonseca & Magalhães [8] show that syllable lengthening disambiguates sentences

structurally ambiguous in BP. For example, sentence (1) can have the meanings as represented in (1a) and (1b):

(1) O   pai   visitou   o   filho   embriagado.
   the   father   visited   the   son   drunken.
a) The father was drunk: [Φ o filho w]c]Φ] [Φ embriagado Φ]
b) The son was drunk: [Φ [c o [w filho w]c] [c[w embriagado w]c]Φ]

As can be seen, although they are syntactically ambiguous, the prosodic parsing is different. For the meaning in (1a), *o filho* and *embriagado* are in two different phonological phrases. For the meaning in (1b), *o filho* and *embriagado* can be inside a restructured phonological phrase. The authors did a reading test, and they claim that when the subjects intended the first meaning, they lengthened the syllable in *embriagado*. Interestingly, this is not the expected lengthening according to the prosodic domains. In both meanings *embriagado* is in the final boundary of phonological phrase. The difference in prosodic parsing is for the word *filho*. In (1a) it is in final phonological phrase boundary, while in (1b) it is in final clitic group boundary. If a lengthening would be used to disambiguate this two meanings, it would be expected a lengthening in *fi* or in *lho*. Unfortunately, the authors did not report what happened in these two syllables.

4. Prosodic hierarchy

There are two main phonological approaches of the interface between phonology and other grammatical components: Selkirk [21] and Nespor & Vogel [18]. Based on several phonological processes in different languages, the authors state that information from other grammatical components is mapped in phonology, organized in a hierarchy of prosodic levels. One of the differences between the two proposals lies on the number of levels presented. Nespor & Vogel present 7 units: syllable σ, foot Σ, phonological word ω, clitic group C, phonological phrase Φ, intonational phrase I and utterance U, while Selkirk asserts that there are no C nor U levels.
For the purposes of the present work (lengthening above word level) the question is whether there is a clitic group or not. We assume Nespor & Vogel's proposal since the only consequence we could get is reduplication in the results (that is, ω and C levels would be the same). In Portuguese, clitics adjoin to the left of a noun, causing a difference only for the initial boundary while the final boundary is the same, as can be seen in (2):

(2) [c [w o w] [w menino w]c]
        the   boy

This fact, however, will be not addressed here, since we are particularly interested in final boundary.

5. Hypotheses

The first hypothesis is whether post-tonic lengthening depends on phonological boundaries in BP, as it does in other languages (cf. [19], [13], [24], [9]). In addition post-tonics should be longer in Φ and I domains, rather than in C (that is, final post-tonic lengthening in BP obeys the following scale: I syllable duration > Φ syllables duration > C syllable duration) – this fact is based on studies for other languages which states the higher prosodic domain, the longer the syllable [2], [4], [10], [5], [22], [12], [1], [5], [22], [23].
Although we do not have a hypothesis before hand, we shall investigate whether vowel quality and the kind of consonant in the post-tonic syllable may affect syllable duration.

6. Methodology

We recorded 22 Brazilian subjects producing tri-syllabic words with stress in the second syllable (*madama* 'lady', *lapela* 'lapel' and *sumiço* 'disappearance') and pseudo-words (*fonofo*, *xumoxu*, *zutuzu*, *mutumu*, *jataja*, *fadufa* and *vapava*) inserted in sentences with 3 different prosodic boundaries:

- Clitic Group:
eu vi [Φ[c[w aquela w]c] [c[w **lapela** w]c] [c[w branca w]c]Φ]
 I saw   that   lapel   white
              'I saw that white lapel'

- Phonological Phrase:
diga [Φ[c[w **lapela** w]c]Φ] [Φ[c de novo c]Φ]
Say   lapel   again
            'Say lapel again'

- Intonational Phrase: [I[Φ[c[w **lapela** w]c]Φ]I]
                    'Lapel'

There were 660 sentences, but 22 of them were excluded either because of hesitation or wrong production of the target word. The Final total was 638 sentences (638 post-tonics; 319 with [+low] vowel and 319 [+high] vowels; 378 voiced consonants and 260 voiceless consonants).

7. Results

The results are shown in the following Figures 1-3. In Figure 1, we can see the duration of tonic and post-tonic syllables. As for the post-tonics, syllables in I boundary are longer in either C or Φ boundaries: average duration in I boundary is 1.37 greater than in C, and 1.47 larger than in Φ domain. The statistical tests (Gaussian log-linear model) confirm that the duration of the post-tonic syllable in I was significantly longer than the syllable in Φ (p-value<0.001) and C (p-value<0.001), and that the duration of the syllable in Φ was not significant compared to the syllable in C boundary (p-value 0.34).
When we compare the post-tonics to the tonics we can see that stressed syllables are always longer than post-tonics, even those that are in I boundary, unlike the results found in the literature for other languages (cf. section 3). Specifically, as for C domain, the strong syllable is 1.40 greater than the post-tonics; in Φ boundary, the stressed syllable is 1.48 longer than the post-tonics. The average duration in I boundary is very alike, and tonics are only 1.17 greater than the post-tonics. As a matter of fact, post-tonics are significantly more lengthened in I boundary, and the same happens to tonics (although with different relations). Post-tonics and stressed syllables have similar durations in C and Φ domains, but are longer in I boundary – in this domain, tonics are 1.12 greater than in Φ level.
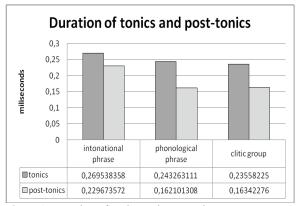
Figure 1: Duration of tonics and post-tonics.

In Figure 2, we can find the results on vowel quality: [+high] vowels are longer than post-tonics [+low] vowels. Indeed, the difference is small (less than 20 ms), but it gets greater in I boundary (30 ms). Even so, the statistical analysis showed no effect of the vowel quality for the duration of the syllable (p-value 0.091).
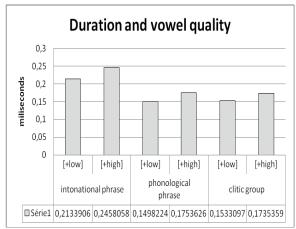

Figure 2: post-tonic duration and vowel quality.

Finally, Figure 3 shows the results of the kind of consonant in the post-tonics. Syllables containing voiced consonants are shorter than syllables with voiceless ones. The statistical analysis pointed to an effect of voicing (p-value 0.057), and it was always the same for all the prosodic levels.
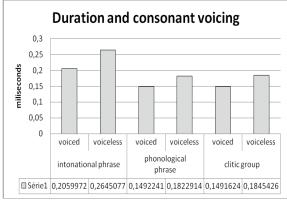

Figure 3: post-tonic duration and consonant voicing

8. Discussion

Final post-tonic is lengthened in I boundary (cf. Figure 1), which corroborates Oller, Klatt, Wightman et al, and Fougeron & Keating studies [19], [13], [24], [9]. Furthermore, lengthening also occurs with the stressed syllable, as stated by Fougeron & Keating and Byrd, Krivokapc & Lee [9], [3]. However, these results do not agree with Byrd & Saltzman, Byrd, Cho, Tabain and Tabain & Perrier analyses [2], [1], [5], [22], [23]: these authors report that the higher the prosodic domain, the longer the final syllable.

Also as presented in Figure 1, both post-tonics and tonics in C and Φ boundaries have the same duration (tonics have 229 ms in C and 234 in Φ, i.e., only a 51 ms difference; post-tonics are 163 ms in C and 158 in Φ, a 4.9 ms difference). It should not be expected that syllable duration could be a cue for disambiguation of syntactic ambiguous utterances, as the ones studied by Magalhães & Maia and Fonseca & Magalhães [14], [8]. However, a hypothesis that we are pursuing now is that, although there is no difference in the syllables that fill the boundaries of prosodic domains in the 'common' sentences of BP, speakers may lengthen these syllables in sentences that are syntactic ambiguous.

According to Byrd, Krivokapic & Lee [3], the post-tonic syllable, being closer to the boundary than the tonic, can end up longer than the tonic syllable. However, our results show that this was not the case: even the greatest lengthening in the post-tonic is never longer than the tonic duration (stressed syllable in I is 263 ms, while the post-tonic is 224 ms long). This discrepancy between our results and Byrd, Krivokapic & Lee's could be explained as the following: although duration is the main acoustic correlate for identifying the word stress, it is not the only one in PB. Therefore work should be carried out in order to verify how intensity is used as a cue to differentiate tonics and post-tonic syllables in BP, regarding to prosodic levels. In the distinction of tonic and post-tonic syllables fundamental frequency is greater in the former than in the latter, therefore there is no lack of identifying the stressed one.

Finally, it can be noticed in Figures 2 and 3 that vowel quality did not show any effect in the duration, while de voicing of consonants have an effect. It should be noted that voiceless fricatives are intrinsically shorter consonants in BP, that is, the consonants in *sumiço, fonofo, xumoxu* and fadufa are shorter than the consonants in *zutuzu, jataja,* and *vapava*. On the other hand, high vowels have smaller duration than low vowels. This fact is important mainly when working with naturalistic data (as opposed to pseudo-word tests): rather than comparing vowels and consonants separately, it would be more detailed measuring the whole syllable instead, taking care which strings of segments can be related to each other.

In sum, the work presented herein deals with the relation between final lengthening and prosodic domains. The results point out that the only boundary which has significant lengthening is I, with lengthening application both for tonics and post-tonics. We also found that there is no relation between lengthening and different prosodic levels, since there was no difference between clitic group and phonological levels.

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