

Secondary Stress in Brazilian Portuguese

Perceptual and Acoustical Evidence

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ABSTRACT

Phonological studies on Brazilian Portuguese (BP) consider that besides the main lexical stress, there is a secondary stress (SS), which would fall on each even prestressed syllable, counted from right to left, starting from the primary stressed one, characterizing a strong/weak alternation (trochaic foot). Based on perceptual tests with read speech material, it was showed that a SS was perceived regularly in words with more than one prestressed syllable, but its location admits variation, with two basic patterns: either the SS following the binary alternation rule, or the SS falling on the initial syllable, potentially creating a ternary foot. Acoustical analysis showed that there is no stable correlate of SS: it can be either fundamental frequency, or a combination of duration and loudness.

1. INTRODUCTION

Recent phonological studies on Brazilian Portuguese (BP) consider that besides the main lexical stress, limited to the three last syllables of the word, there is a rhythmic, secondary stress (SS), which would fall on each even prestressed syllable, counted from right to left, starting from the primary stressed one, characterizing a strong/weak alternation (trochaic foot) [1-5, 7]. In the examples below, syllables bearing SS are represented in capitals, italics and bold type; syllables bearing primary stress (S) are only in capitals.

2 1 S 3 2 1 S 4 3 2 1 S
PA ra LE lo pa ***RA*** le LIS mo ***PA*** ra ***LE*** le PI pe do
(parallel) (parallelism) (paralelepiped)

When there is an odd number of prestressed syllables, the first SS, which would fall on the second syllable of the word, is frequently anticipated to the word's first syllable, causing a ternary initial pattern, phenomenon referred in the literature as dactylic effect in the beginning of the word [1, 4, 7]:

3 2 1 S 3 2 1 S
pa ***RA*** le LIS mo or ***PA*** ra le LIS mo

2. GOALS

Although intuitively identifiable in BP, SS has not been carefully investigated from a phonetic perspective ([6] is an exception), leaving unanswered questions such as whether the alternation strong/weak is regularly manifested or if SS is a concept justified only on phonological grounds, without a phonetic counterpart in BP.

Based on perceptual tests and on acoustical analysis of read speech material, we tried to answer the following questions concerning SS:

- is this a regular phenomenon in BP, appearing in words that have more than one prestressed syllable?
- more than one SS can surface in a word?
- are there syntactic contexts which favor the surfacing of SS?
- does the length of the word interfere with the presence or the location of the SS?
- is the SS placement rigid or does it admit variation?
- which are the acoustical correlates of SS?

3. METHODS

Five groups of four related, segmentally similar words with an increasing number of prestressed syllables were read by four subjects. These words, with different predicted locations of SS (e.g. canibal/canibalismo/canibalizar/canibalização), were inserted in carrier sentences in two different positions. One prosodically strong, at the border of an intonational phrase, the other weak, internal to the intonational phrase:

[Ele disse _____]_I [de novo]_I (strong position)
(He said _____ again)

[Ele disse _____ hoje]_I [de novo]_I (weak position)
(He said _____ today again)

The groups of words were:

- a) canibal/canibalismo/canibalizar/canibalização
- b) secular/secularizo/secularizar /secularização
- c) parabéns/parabenizo/parabenizar/parabenização
- d) democrata/democracia/democratizar/democratização
- e) regular/regularizo/regularizar/regularização

The sentences were digitalized and measurements of F0, duration and amplitude were obtained. Ten subjects took part in a perceptual test in which they were asked to indicate, among the prestressed syllables of each word, which one(s) carried a SS, if any.

4. RESULTS

4.1 PERCEPCION

In order to verify the perceptual importance of SS and its distribution along the word, ten listeners were asked, after listening each sentence of the corpus as many times as necessary, to indicate, among the prestressed syllables of each word, which one(s) carried a SS, if any. The results can be seen in tables 1 to 8:

prestressed syl. \ word type	ca	ni	ba	li	za
Canibal	40	18	-	-	-
Canibalismo	12	50	20	-	-
Canibalizar	52	10	22	6	-
Canibalização	16	32	6	26	20

Table 1: speaker I, strong position. Percentage of votes received by each prestressed syllable as prominent; “word type” represents all the words in the corpus with the same metrical structure.

prestressed syl. \ word type	ca	ni	ba	li	za
Canibal	62	10	-	-	-
Canibalismo	78	12	14	-	-
Canibalizar	70	2	34	0	-
Canibalização	72	6	20	8	6

Table 2: speaker II, strong position. Percentage of votes received by each prestressed syllable as prominent.

prestressed syl. \ word type	ca	ni	ba	li	za
Canibal	54	12	-	-	-
Canibalismo	60	22	22	-	-
Canibalizar	66	10	20	0	-
Canibalização	70	12	16	12	4

Table 3: speaker III, strong position. Percentage of votes received by each prestressed syllable as prominent.

prestressed syl. \ word type	ca	ni	ba	li	Za
Canibal	44	20	-	-	-
Canibalismo	38	22	22	-	-
Canibalizar	76	2	10	6	-
Canibalização	66	4	16	8	10

Table 4: speaker IV, strong position. Percentage of votes received by each prestressed syllable as prominent.

prestressed syl. \ word type	ca	ni	ba	li	za
Canibal	40	18	-	-	-
Canibalismo	22	46	8	-	-
Canibalizar	46	20	26	4	-
Canibalização	18	50	16	18	8

Table 5: speaker I, weak position. Percentage of votes received by each prestressed syllable as prominent.

prestressed syl. \ word type	ca	ni	ba	li	za
Canibal	48	6	-	-	-
Canibalismo	64	14	14	-	-
Canibalizar	62	16	20	6	-
Canibalização	78	4	12	8	10

Table 6: speaker II, weak position. Percentage of votes received by each prestressed syllable as prominent.

Comments:

- Two distinct patterns of SS surface here, binary alternation (speaker I) and initial prominence (the other three speakers).
- In short words, i.e. with only two prestressed syllables, the prominence tends to be less perceived than in long words.
- Basically, there is only one prestressed syllable by word to be perceived as prominent, the first syllable in the word bearing a SS blocking the surfacing of another SS.
- The strong (external) or weak (internal) position of the word in the sentence [intonational phrase] doesn't interfere significantly with the perception of a SS.

4.2 ACOUSTIC ANALYSIS

The figures 1 and 2 show the behavior of F0, intensity and duration of the words in strong position, behavior that is similar to that observed in weak position.

Comments:

As pointed by the perceptual test for stress location here, too, two rhythmic strategies were detected:

Binary alternation pattern (speaker I) (caN/baLISmo) F0 correlates consistently with the first SS. A second SS could be considered present if we postulate that the prominence is established from left to right within binary groups, that is, without looking at the preceding syllable. Duration and intensity are present in the surfacing of SS only in words with an even number of prestressed syllables (*canibalizar*, for instance), a pattern that leads to the location of the first SS on the initial syllable, and characterizes the ideal condition for the surfacing of SS, in all four speakers.

F0 is the most consistent among the acoustic parameters for this speaker, and is enough for signaling SS.

Intensity behavior is the less clear here, masked by the *decrecendo* observed along the prestressed syllables of the word. These remarks are valid for strong and weak position.

Initial prominence pattern (speakers II, III, IV) (CAnibaLISmo) F0 doesn't indicate the initial syllable, perceived as stressed in these speakers, whether because of the displacement of the melodic peak to the next syllable (speaker II), or because of a pattern of regular, continuous fall along the word, the declination line (in the others speakers).

Duration and intensity are acoustic correlates of perceived

SS on the initial syllable, in strong and in weak position, in all three speakers, except for speaker IV, who, in the strong position, uses only intensity.

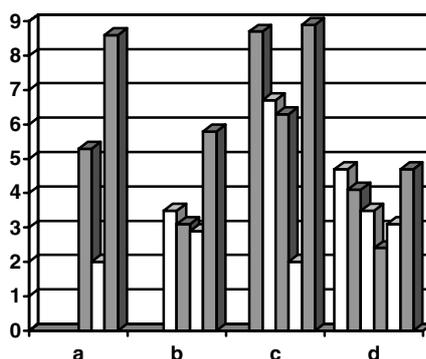
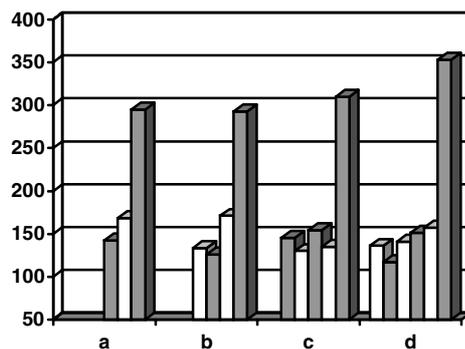
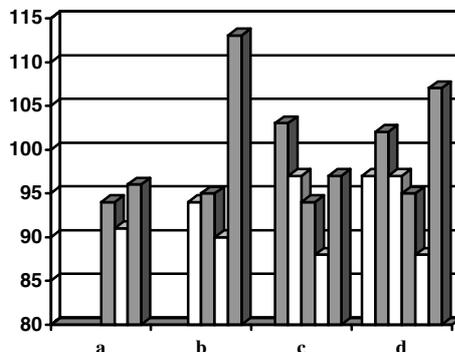


Figure 1: Behavior of fundamental frequency in Hertz (high), duration in milliseconds (middle) and intensity in dB (bottom) in manifestation of secondary stress in strong position, speaker I. In the x axis, letters a to d stand for words like *canibal*, *canibalismo*, *canibalizar* and *canibalizaçao*, respectively.

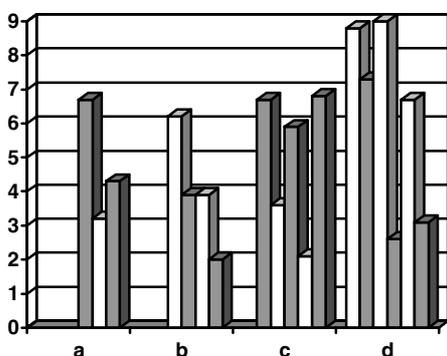
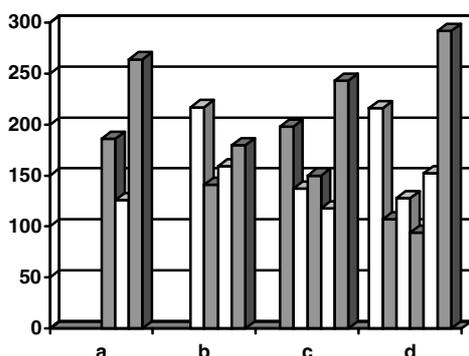
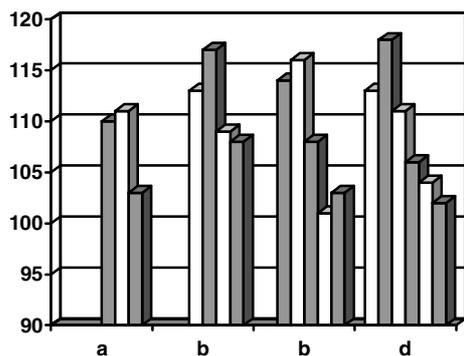


Figure 2: Behavior of fundamental frequency in Hertz (high), duration in milliseconds (middle) and intensity in dB (bottom) in manifestation of secondary stress in strong position, speaker II. In the x axis, letters a to d stand for words like *canibal*, *canibalismo*, *canibalizar* and *canibalização*, respectively.

5. CONCLUSIONS

The results showed that:

- i) a SS was perceived regularly in words with more than one prestressed syllable;
- ii) in words from two up to five prestressed syllables, there was a strong tendency to identify a single SS per

word, the first one (the farthest to the left) blocking the phonetic realization of the second one, expected by the application of the binary rhythm rule usually proposed;

iii) the location of the perceived prominent syllable admitted variation, with two basic patterns: the SS following the binary alternation rule, or the SS falling on the initial syllable, creating potentially a ternary foot;

iv) the length of the word interferes with the presence of the SS: short words (two prestressed syllables) show the phenomenon less consistently;

v) syntactic contexts (strong or weak positions in the sentence) did not interfere with the surfacing of the SS;

vi) although there is a clear correspondence between the perceived SS and modifications of the acoustical signal, there is no stable correlate of SS: it can be either fundamental frequency, or a combination of duration and loudness.

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