

The role of duration and intensity factors in the characterization of modal intonation in Brazilian Portuguese spoken in the North of Brazil

Exploration of AMPER-POR data

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The major aim of the current paper is to present an individual analysis of two physical parameters – duration (ms) and intensity (dB) – on four survey areas of Brazilian Portuguese spoken in the north of Brazil: Belém, Baião, Mocajuba and Curralinho. The selected data for this analysis stem originally from AMPER-POR database normalized by z-score. Formerly, statistics analysis has shown that duration and intensity play a secondary role in the modal intonation characterization. These results comply with the main analysis performed on intensity in prosody studies of Portuguese by the AMPER project where it emerges not as strong parameter in modal intonation discrimination. Contrastingly, ‘duration’ has shown up as a vigorous physical parameter for the characterization of modal intonation.

Keywords: acoustic analysis, prosodic variation, Brazilian Portuguese, AMPER project

1. Introduction

Despite the fact that fundamental frequency (henceforth F_0), intensity and duration are regarded as the main physical factors related to intonation, there is an agreement indicating that intensity and duration are not strong factors for the characterization of modal intonation among descriptions of prosodic variation in Portuguese (Moutinho & Coimbra 2010; Moutinho *et al.* 2008; Abraçado *et al.* 2007).

The variety of Brazilian Portuguese (henceforth BP) spoken in the state of Pará is being mapped by the UFPA¹ team committed to the AMPER-POR² project (*Atlas Multimédia Prosodique de l'Espace Roman* for the Portuguese Language) since 2007 (Cruz *et al.* 2012). As a direct contribution to the AMPER North project, nine survey areas from the state of Pará have been already mapped by the referred team, namely, the municipalities of Abaetetuba (Remédios 2013), Baião (Lemos 2015), Bragança (Castilho 2009), Cametá (Santo 2011), Currealinho (Freitas Neto 2013), Mocajuba (Costa 2015), Mosqueiro (Guimarães 2013), Santarém (Lima Forthcoming) and Belém (Cruz & Brito 2014).

All methodological procedures established by the AMPER-POR project's overall coordination are applied to both the formation of corpora and the processing of data. The purpose of using the same corpus for all Portuguese varieties is to enable a comparative analysis of the target varieties and to contribute to a deeper understanding of prosodic variation of the Portuguese language.

The description of the intonation modality and the identification of a prosodic pattern, jointly, correspond to the main objectives of the investigations associated to the AMPER project. The target modalities in this study primarily comprise the declarative (denoted by A) and yes/no question (denoted by I) sentences. The prosodic analysis focuses both on initial (pre-nuclear) and final (nuclear) nominal phrases of sentences.

Whereas the AMPER project investigates the contrasting behavior of modal intonation, the process of corpora constitution has adopted all methodological procedures defined by the overall project for the formation of data, organization and processing.

The AMPER-POR corpus is formed by 66 sentences structured in compliance with syntactic, phonetic and prosodic controlled conditions. Syntactically, the corpus contains exclusively SVO – Subject, Verb and Complement – sentences. The sentences have the same size and the same number of syllables [10, 13 or 14 syllables]. The noun placed at the core of the phrases represents the three kinds of Portuguese lexical stress: a) oxytone stress (cv.cv.CV); b) paroxytone stress (cv.CV.cv) or c) proparoxytone stress (CV.cv.cv). At the prosodic level, each sentence is pronounced in two distinct intonation modalities: 'declarative' and 'yes/no' question (Cruz *et al.* 2015).

¹ Federal University of Pará State. There is an institutional project at the UFPA named AMPER North project (Prosodic Multimedia Atlas of Northern Brazilian Portuguese)

² <http://fonetica.web.ua.pt/AMPER-POR.htm>

The corpus has been constituted with the purpose of verifying the role of the physical parameters – fundamental frequency (henceforth F0), duration and intensity – in distinguishing target intonation modalities.

According to the AMPER-POR prosodic description reviews, the results deriving from acoustic analysis of data collected from the researched areas in Pará (Lemos 2015; Costa 2015; Guimarães 2013; Freitas Neto 2013; Remédios 2013) have indicated that F0 is the most important acoustic parameter in distinguishing between declarative and total interrogative modalities. Duration, the most significant aspect for the current work, is also indicated as an important factor in distinguishing declarative from total interrogative modalities, however, it's pointed out as playing a secondary role. Ultimately, intensity has not proven to be an important physical parameter for that distinction.

Accordingly, the motivation for this study emerges from the fact that several works led by the AMPER project present the physical factors - intensity and duration – not as highly important parameters for the distinction of modal intonation in Portuguese. The duration factor holds a secondary place, while the intensity factor is devoid of any significant power.

To foster deeper comprehension of the content of this paper, in section 2, we provide detailed description of the methodological procedures adopted for its elaboration; in section 3, we briefly present the preliminary results of the prosodic analysis regarding three acoustic parameters together [F0, duration and intensity] in Brazilian Portuguese spoken in the North of Brazil by employing AMPER data; in section 4, we present the performances of 'duration' and 'intensity' in the prosodic characterization of the BP spoken in North of Brazil; in section 5, we highlight our main findings and; in section 6 we present our references.

2. Methodology

We employed borrowed data from four descriptions of the BP varieties spoken in the state of Para linked to the AMPER project: Baião (Lemos 2015), Belém, Curralinho (Freitas Neto 2013) and Mocajuba (Costa 2015). Figure 1 presents the surveyed areas from Pará included by AMPER project. Highlighted in Figure 1, are the localizations of the areas selected for the current paper.

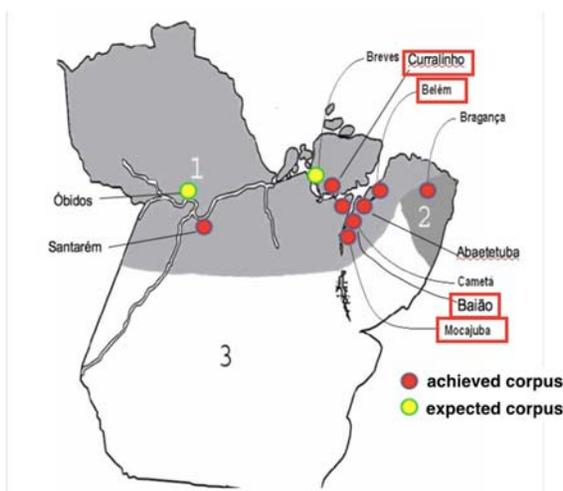


Figure 1. The prosodic mapping by AMPER-POR project in the state of Pará

Our intention with this conjoint analysis is to corroborate or refute the hypothesis obtained by these individual prosodic descriptions, namely:

- a. Is F0 the most relevant physical parameter for characterization of modal intonation in BP spoken in Para State?
- b. Are duration and intensity factors also relevant for characterizing modal intonation in BP spoken in the state of Pará? Do these physical parameters have a secondary role?
- c. Do the most important variations of physical parameters happen on final phrase, more precisely at the last stressed syllable of final phrase?

Finally, we intend to investigate the performance of physical parameters in dialectal characterization, controlling the type of lexical stress of the word, which occupies the core of the final phrase. In this sense, we selected sentences from the AMPER-POR corpus containing representative words of each type of Portuguese lexical stress, as demonstrated in Table 1 below.

Table 1. The twelve [12] sentences of the analyzed corpus, shown by lexical stress

	Oxytone	Paroxytone	Proparoxytone
Number	cv.cv.CV	cv.CV.cv	CV.cv.cv
1	O bisavô gosta do <i>bisavô</i> (The great-grandfather likes the great- grandfather)	O Renato gosta do <i>Renato</i> (Renato likes Renato)	O pássaro gosta do <i>pássaro</i> (The bird likes the bird)
2	O pássaro gosta do <i>bisavô</i> (The bird likes the great- grandfather).	O pássaro gosta <i>do</i> <i>Renato</i> (The bird likes Renato)	O Renato gosta do <i>pássaro</i> (Renato likes the bird)
3	O pássaro gosta do <i>bisavô</i> <i>nadador</i> . (The bird likes the swimmer great- grandfather)	O pássaro gosta do <i>Renato pateta</i> (The bird likes dumb Renato)	O Renato gosta do <i>pássaro bêbado</i> . (Renato likes the drunk bird)
4	O pássaro gosta do <i>Renato de Salvador</i> (The bird likes Renato from Salvador)	O pássaro gosta do <i>Renato de Veneza</i> . (The bird likes Renato from Venice)	O pássaro gosta do <i>Renato de Mônaco</i> . (The bird likes Renato from Monaco)

We selected the three best repetitions of each of these sentences in both intonation modalities (declarative and total question) and their corresponding AMPER files, the audio files in .WAV format, the .TXT files in ascii format containing the acoustic measurements of vowel segments and the .TextGrid files of PRAAT software containing the phonetic segmentation of audio files.

We selected speech samples from six speakers, which are part of the corpora constituted by 4 selected survey areas to undergo the intradialectal analysis proposed here. The speakers profiles are described in Table 2 below.

The statistical analysis of 1.728 data areas (12 sentences x 2 intonation modalities x 3 best repetitions x 4 survey areas x 6 speakers) that comprise the total corpus of this work, demanded an automated data processing.

Table 2. The Speaker's Profile

Sex	School level	Baião	Belém	Curralinho	Mocajuba
Female	Elementary School	BF91	BE01	BE41	BF51
	High School	BF93	BE03	BE43	BF53
	College	BF95	BE05	BE45	BF55
Male	Elementary School	BF92	BE02	BE42	BF52
	High School	BF94	BE04	BE44	BF54
	College	BF96	BE06	BE46	BF56

The F0 measures in Hz on segmentation of the vowel nuclei presented at the TXT files have been stylized by the Prosogram³ software. This has resulted in a stylization of intonation curve perceived as a set of straight lines. The tones were perceived as dynamic (carrying a perceived intonation variable) modeled as upward (+), downward (denoted by -), falls add up (denoted by - +), rises add down (denoted by + -) and flat (denoted by 0). This stylization fostered by Prosogram allowed comparing the data of male and female speeches, which is not accomplishable by using the standard methodology of AMPER.

In Figure 2, we can see an example of the same sentence - *O pássaro gosta do Renato* (The bird likes Renato) - from Baião (a), Belém (b), Curralinho and Mocajuba (d) after the stylization process fostered by Prosogram.

The intensity and duration were also normalized. For the duration, we grouped by V-to-V unities; the duration of the syllable has been measured between the vowels onsets (Barbosa 2007). Then, a normalization of duration by z-score of each speaker (Campbell 1992) has been estimated on the basis of the means for each of the last four syllables of every phrase.

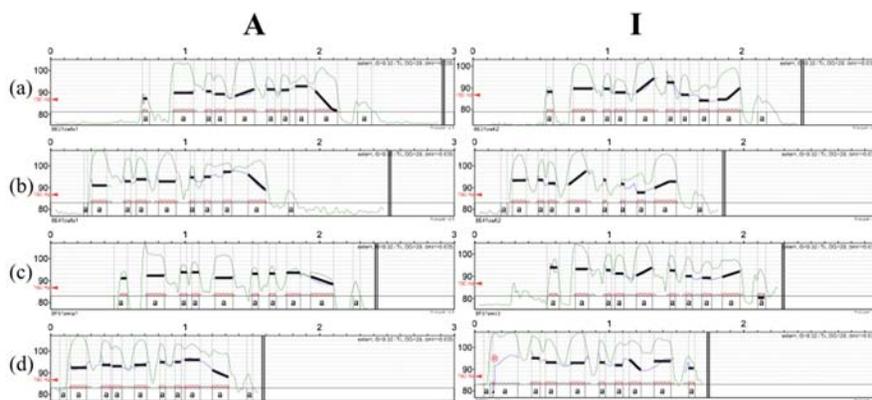


Figure 2. The pwt sentence – *O pássaro gosta do Renato* (The bird likes Renato) – in both modalities – A and I – stylized by Prosogram. (a) Belém, (b) Curralinho, (c) Mocajuba and (d) Baião

A multidimensional or linear discriminant (LDA) analysis was carried out by each survey area and by speaker, 5 factors were considered:

³ <http://bach.arts.kuleuven.be/pmertens/prosogram/>

- a. F0 mean of nuclei vowel (Mean-F0);
- b. F0 (ST) difference between stressed syllable and unstressed syllable (pretonic), measure of the amplitude of the F0 rising on the stressed syllable (Delta-F0);
- c. the extension of the variation in the F0 within the vowel nuclei on the stressed syllable (EMPAN-F0);
- d. normalized intensity of syllable (INT);
- e. relative duration measured on vowel onsets (V2V).

3. Overall Prosodic Analysis (with F0)

As aforementioned, our data analysis focuses in the end of the sentences, more precisely in the three last syllables. Our main first results comprise the form of intonation contours on the final stressed syllable and the study of a final intonation movement on the prosodic contours of the final phrases, for each survey area and modality, considering the kind of lexical stress involved.

Table 3, below, contains the inventory of tones obtained with a melodic stylization by the Prosogram software on the final stressed syllable of the sentences.

Table 3. Percentage of identified movement, by form, variety and modality (Total of 1728 totens)

Final Stressed Syllable	BE0		BE4		BF5		BF9	
	A	I	A	I	A	I	A	I
0	59	58	79	51	78	79	65	66
-	38	3	20	0	20	0	32	3
++	3	0	0	1	0	0	1	0
+	0	37	0	42	0	20	1	19
+-	0	2	0	6	1	1	1	13

Table 3 allows us to observe that:

- a. a comparable quantity of flats (0) contours is found at both declarative (A) and total question (I), with an exception for the BE4 survey area, which presents more emphatically the dynamic movements for I;
- b. the dynamic movements of the assertions are essentially downward;
- c. the dynamic movements of the interrogations are essentially upward.

Once the tones are dynamic, we can see that the assertions are essentially produced with the downward movement, whereas the interrogations keep the upward tones, in all survey areas. The speakers of the BE0 area present more dynamic tones than the speakers of other survey areas.

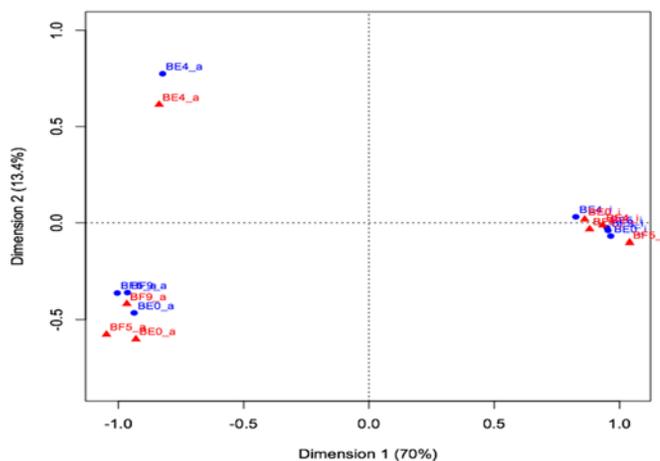


Figure 3. Discrimination of the survey areas from the North of Brazil by modality

In order to obtain a clear discrimination considering each survey area, we implemented a LDA analysis combined with a correspondence analysis. The results are demonstrated in Figure 3, in form of confusion matrices (Benzécri 1973). In the graphic present in Figure 3, the data stylized is indicated by the red color and the natural data in blue. The graphic is conceived in two dimensions: (i) dimension 1 explains 70% of variance and shows that the variation of prosodic parameters happens essentially by modality. It also evidences the declaratives sentences are perceptibly separated from the interrogative sentences; (ii) dimension 2, in the graphic, shows that data are grouped in three blocks and explains 13% of the variance, in dimension 2, the differences in duration are responsible for three groups of survey areas (the declarative sentences of BE4 has a longer stressed syllable). Table 4 contains a ranking of the classification power of each prosodic variable, taking into account the relationship between survey area and modality.

Table 4. Ranking of prosodic variables on BP spoken in the North of Brazil, survey areas x modality

	cor.Ratio	Wilks lambda	F statistic	p values
DELTA_F0	0.67551670	0.3244833	172.791282	0.000000e+00
MEAN_F0	0.33440231	0.6655977	41.699952	0.000000e+00
INT	0.32170302	0.6782970	39.365281	0.000000e+00
V2V	0.14040927	0.8595907	13.557579	2.220446e-16
EMPAN_F0	0.04586445	0.9541356	3.989736	2.829566e-04

As shown in Table 4, the values of vowel intensity are relevant for this discrimination, therefore; intensity is classified a strong parameter for the discrimination of the survey area by modality. This does not hold true for duration, though.

As our purpose is to achieve a better classification system, we decided to apply the same analysis procedure in order to verify the relationship between speaker and modality. Figure 4 exemplifies these results.

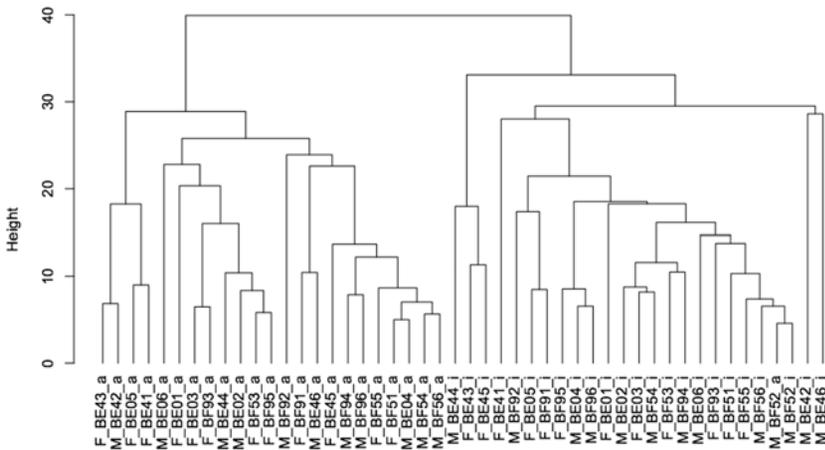


Figure 4. Discrimination of the speaker from the North of Brazil by modality

In Figure 4, the prosodic parameters produce almost perfect groupings for both modalities (just one single speaker - BF52 - is misplaced, his declarative data are placed in the interrogative group). Table 5 shows the classification of the power of ranking of prosodic variables for explaining the relationship between speaker and modality.

Table 5. Ranking of prosodic variables of BP spoken in the North of Brazil, speaker x modality

	cor.Ratio	Wilks lambda	F statistic	p values
DELTA_F0	0.7708571	0.2291429	81.024452	0
MEAN_F0	0.5014714	0.4985286	24.227282	0
INT	0.4955525	0.5044475	23.660406	0
V2V	0.4348132	0.5651868	18.529313	0
EMPAN_F0	0.2223342	0.7776658	6.885919	0

DELTA F0 still allows better discrimination between each of these categories. For this study, the most important observation is that intensity kept the third position, and now, the values of duration (even those presenting the weakest discrimination power) became relevant.

4. The role of duration and intensity factors in the prosodic characterization of the BP spoken in the North of Brazil

As the primary aim of the current work is to accomplish an individual analysis of the duration and intensity factors, we looked at the average prosodic contours at the final phrase, for each survey area and modality. The graphics below contain the results we came to.

Figures 5 and 6 respectively present intensity and normalized V-to-V duration, the means for each of the last four syllables of every phrases, grouped by survey area (color curves), for both modalities - declaratives (Assertion top) and interrogatives (Interrogation below) -, depending on the position of the stress on the last word, oxytone (right), paroxytone (middle) and proparoxytone (left). Analyzed data reveal evidences of identity among the spoken varieties in the North of Brazil with regard to modal intonation, mainly in relation to duration measures.

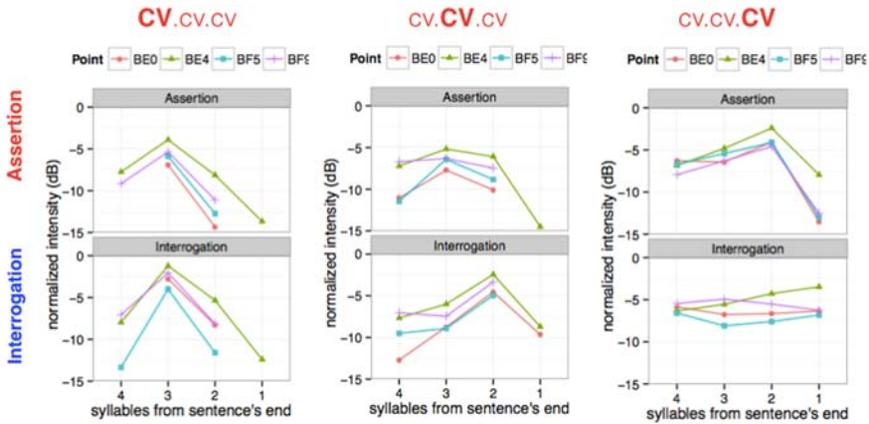


Figure 5. Variation of Intensity in final phrase distinguished by lexical stress

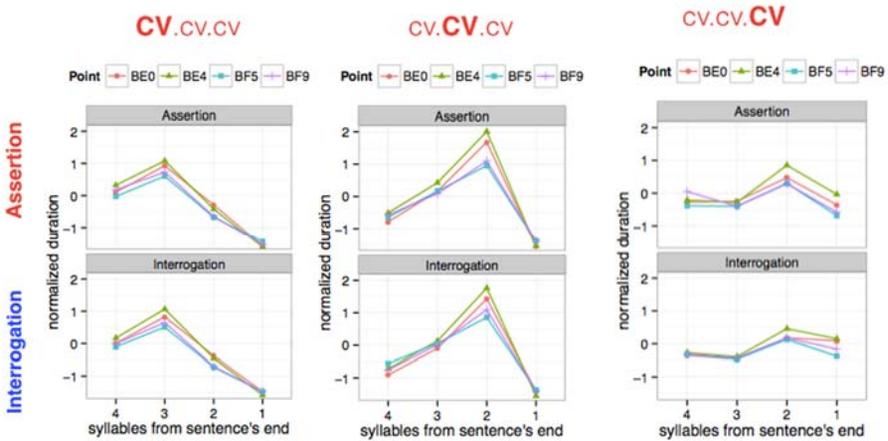


Figure 6. Variations of Duration in final phrase by modality, distinguished by lexical stress

These findings support the hypothesis of an existing *circumflex intonation contour* not only with the purpose of marking questions, but also with that of identifying the intonational behavior of Brazilian Portuguese spoken in the north of Brazil, because such *circumflex intonation contour* remains valid in all survey areas. These results substantiate descriptions made by Moraes (1998) concerning the interrogatives in PB, which present rising movement on the stressed syllable

and downward movement on the posttonic syllable when there is still phonetic material. It follows that the Brazilian Portuguese varieties are supposed to be fairly standard.

5. Conclusion

This paper presented the results of a research work linked to AMPER project. Four survey areas from a northern Brazilian state named Pará, where BP is spoken, were analyzed - Belém, Baião, Currálinho and Mocajuba. Our main purpose was to carry out an individual analysis of two physical parameters – duration and intensity – by means of an intradialectal analysis.

Considering all 4 target survey areas comprise AMPER corpus, a comparative analysis was enabled. Therefore, a balanced corpus of 1.728 data (12 sentences x 2 modalities x 3 repetitions x 4 survey areas x 6 speakers) was composed. The entire corpus was normalized by Prosogram software (F0 plots, intensity and V-to-V duration).

Data reveal similarities among the spoken varieties in the north of Brazil with regard to modal intonation.

Ultimately, the results support the hypothesis of an existing circumflex intonation contour to mark questions, validated in all survey areas, that reinforces the Moraes's description (1998) for the interrogative in BP. Conclusively, it follows that the Brazilian Portuguese varieties are supposed to be fairly standard.

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