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The Perception of yes-no questions across varieties of Brazilian Portuguese

*A Percepção das interrogativas globais entre variedades do Português do Brasil**

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Abstract: This paper studies the perception of information-seeking yes-no question intonation across varieties of Brazilian Portuguese spoken along the Atlantic Coast, namely Paraíba (North), Minas Gerais (Center) and Rio Grande do Sul (South). The hypothesis that the distinctions found in production studies, leading to major dialectal areas, are reflected in the perception patterns of native speakers was confirmed. Two main intonational areas were established: the

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Phonology and Prosody have now less variation, and the world (not only the world of sound) became less colorful. But we need to celebrate our colleague Gisela and all she has given us. She will always be around, through her work and in our memory.

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North, characterized by a rising nuclear contour, and the Center-South characterized by a rising-falling nuclear contour. Speakers from the North did not perceive differences between native and non-native patterns, whereas speakers from the Center-South clearly perceived them. This finding indicates a perception boundary across varieties. Developed within the *Interactive Atlas of the Prosody of Portuguese* Project, this work contributes to extend and deepen current knowledge of the intonational system of Portuguese, by offering an integrated approach (that combines production and perception) to the study of intonational variation in yes-no questions.

Key-words: Yes-no questions. Intonational variation. Perception across varieties. Brazilian Portuguese.

Resumo: Este artigo apresenta um estudo da percepção da entoação das interrogativas globais entre variedades do Português do Brasil falado ao longo da costa atlântica, nomeadamente Paraíba (Norte), Minas Gerais (Centro) e Rio Grande do Sul (Sul). A hipótese de que as distinções encontradas nos estudos de produção, que definem grandes áreas dialetais, se refletem nos padrões de percepção dos falantes nativos foi confirmada. Duas grandes áreas foram estabelecidas: o Norte, caracterizado por um contorno nuclear ascendente, e o Centro-Sul, caracterizado por um contorno nuclear ascendente-descendente. Os falantes do Norte não percebem diferenças entre os padrões entoacionais nativos e não-nativos, ao contrário dos falantes do Centro-Sul. Estes resultados apontam para uma fronteira perceptiva entre variedades. Desenvolvido no âmbito do Projeto *Atlas Interativo da Prosódia do Português*, este trabalho contribui para ampliar e aprofundar o conhecimento atual do sistema entoacional do Português, oferecendo uma abordagem integrada (que combina produção e percepção) ao estudo da variação entonacional em interrogativas globais neutras.

Palavras-chave: Interrogativas globais. Variação entoacional. Percepção entre variedades. Português do Brasil.

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1 INTRODUCTION

Previous studies on the role of intonation in the perception of yes-no questions have contributed to our knowledge of the prosodic system of many languages, including Portuguese and Spanish (e.g., Falé and Faria, 2005; Face, 2011; Gussenhoven and Chen, 2000) and of how the perception of intonation develops in early infancy (Frota et al., 2014), as well as to our understanding of relation between intonation and gestures (Cruz et al., 2017). However, there is little research on the perception of intonational variation across varieties of the same language (e.g., Fintoft, 1970; Gussenhoven and Udofot, 2010). Unlike for production, perception studies of intonational variation have only very recently started to emerge (Frota and Vigário, 2000; Cruz and Frota, 2011; Cruz et al., 2017; Nunes and Seara, 2015).

This paper examines the perception of information-seeking yes-no questions in Brazilian Portuguese (BP), as spoken in Paraíba, Minas Gerais and Rio Grande do Sul. These regions geographically belong to different areas, respectively the North, Center and South. The goal of the present study is to analyze the perception of native and non-native speakers from each region with respect to dialectal differences found in previous production research (Castelo and Frota, 2015; Castelo and Frota,

2017). These production studies, based on the *Autosegmental Metrical Framework* (Gussenhoven, 2004; Ladd, 2008 among others), showed that the nuclear contours of yes-no questions display different phonological patterns in these regions, which can be divided into two groups: North and Center-South. In the Northern variety (Paraíba), a rising nuclear contour is found, usually composed of a low nuclear pitch accent (L*) and a high boundary tone (H%). By contrast, Center-Southern varieties are characterized by a rising-falling nuclear contour, which may show two different phonological patterns: a bitonal pitch accent (L*+H) and a low boundary tone (L%) in the Center (Minas Gerais), and a monotonal pitch accent (L*) and a bitonal boundary tone (HL%) in the South (Rio Grande do Sul).

The intonational patterns follow a geographical continuum in terms of their broad rising and rising-falling phonetic shapes. Although the rising nuclear contour is the major pattern in the North, the rising-falling nuclear contour is continuously distributed in a crescendo from the North to the Center-Southern varieties. In addition, dialectal differences were also found in the pre-nuclear region, in terms of initial peak height and tonal density (the relation between number of phonological words internal to the intonational phrase and number of pitch accents – Frota, 2014). By and large, higher peaks and less tonal density were found in Northern varieties compared to Center-Southern varieties (Cunha and Silva, 2015; Nunes, 2015). Nevertheless, other studies show that there are no differences between tonal density among Northern and Center-Southern varieties (Frota et al., 2015).

Based on the systematic variation found in yes-no questions, mainly in the rising and rising-falling nuclear patterns, this paper addresses the following research questions:

1. Do Brazilian speakers from different regions recognize the differences between native and non-native yes-no question nuclear contours?
2. Do speakers use the cues in the pre-nuclear region to identify native and non-native yes-no questions?
3. Are the dialectal areas found in the production studies of yes-no questions in BP reflected in the perception patterns of speakers?

Our hypothesis is that perception patterns will mirror production patterns. First, it is expected that the dialectal differences found in speech production impact on speech perception, i.e., the perception patterns of speakers from the Center and South are more similar compared to the perception of speakers from the North. Second, regional cues in the pre-nucleus stretch are expected to play a less relevant role than the nuclear contour, considering the fact that pre-nuclear cues are less systematic than the intonational patterns found in the nuclear contour.

This paper is organized as follows. Section 2 provides an overview of the studies on the production and perception of yes-no question intonation, specifically for Portuguese. In section 3, the methodology of the study is presented, including a detailed description of the stimuli and conditions used in the perception tests, and a description of task procedures and statistical analyses. In section 4, the results are presented, and in section 5 the answers for the initial research questions are discussed. The conclusions of the study are presented in section 6.

2 PREVIOUS STUDIES

The perception of yes-no question intonation seems to be an ability acquired early during language development. Infants from five to six months are successfully able to identify yes-no question contours as different from statement contours in European Portuguese (Frota et al., 2014). As noted in Frota et al. (2014), the acquisition of the ability to recognize the question/statement sentence types is an important skill that is required in interaction contexts and in communication. Studies on the perception of sentence types in adult speech have shown that yes-no questions are perceived as such in different languages (Gussenhoven and Chen, 2000; Face, 2011; D'Imperio and House, 1997), including Portuguese (Falé and Faria, 2005; Cruz and Frota, 2011; Cruz et al., 2017).

The nuclear contour is identified in many studies as the main intonational cue used by speakers to distinguish between sentence types (Ladd, 2008; Gussenhoven and Chen, 2000; Frota and Prieto, 2015). In many languages, statements are characterized by a final falling contour while yes-no questions are characterized by a final rising contour. Recent work on the foundations of intonational meanings shows that speakers use common cues in the frequency code, namely a high pitch feature, for expressing interrogatives in typological different languages, whether the high pitch is used in the boundary (H%) such as in Dutch, or is manifested in pitch height differences (higher in yes-no questions) such as in Chinese, or in alignment differences of the high tone (L* HL% interrogatives versus H* L% in statements) such as in Hungarian (Gussenhoven and Chen, 2000; Gussenhoven, 2002, 2016). This may suggest a bias both in the production and perception systems, thus favoring the recognition of yes-no questions when rising contours are involved (Gussenhoven and Chen, 2000). However, there are also languages (or language varieties) exhibiting rising contours in statements and low or falling contours in questions (Gussenhoven, 2004; Ladd, 2008). Thus, language-specific intonational systems may grammaticalize pitch cues in different ways, not always mirroring the frequency code (Gussenhoven, 2002, 2004; Ladd, 2008).

In Portuguese, yes-no questions are signaled through intonation. In Standard European Portuguese (SEP), as spoken in Lisbon, the distinction between statements and yes-no questions is marked with a rising boundary tone (LH%) in yes-no questions and a low tone (L%) in statements (Frota, 2002). Both sentence types share the same falling nuclear pitch accent (H+L*). Perception research, based on the SEP variety, demonstrated that listeners recognize a yes-no question differently from a statement in the presence of a clear final rise (Falé and Faria, 2005).

In most European and Brazilian Portuguese varieties, yes-no questions are unambiguously produced as different from statements in some categorical intonational dimension, namely the nuclear accent and/or boundary tone (Frota et al., 2015). Nevertheless, in some European Portuguese varieties the difference between statements and yes-no questions is not displayed by different categorical units. Studies on the varieties spoken in Castro Verde (Alentejo - ALE) and Ponta Delgada (Açores - PtD) show that the final nuclear contour is composed of the same units (falling nuclear contour - (H+)L* L%). Results from perception tests revealed that native speakers from SEP are not able to recognize the difference between

statements and yes-no questions from ALE and PtD. Interestingly, native speakers from these varieties are able to distinguish between the sentence types (Cruz and Frota, 2011; Cruz et al., 2017). The findings on the native perception of ALE and PtD suggest that other cues might be relevant, besides the phonological units that compose the nuclear contours, possibly including cues from the pre-nuclear stretch. Although the final contour is widely described in the literature as the pragmatic core for sentence type interpretation (Gussenhoven, 2002), recent perception studies have shown that there are languages (or language varieties) where speakers are able to distinguish yes-no questions from statements from the beginning of the utterance (Face, 2011; Petrone and D'Imperio, 2011; Nunes and Seara, 2015). This finding is demonstrated for Castilian Spanish (Face, 2011), where the main cue is the boundary pitch (high in yes-no questions and low in statements), but pre-nuclear cues also play a role. Following the final pitch cues, the second most relevant cue is tonal density (with fewer internal pitch accents in yes-no questions than in statements) and the third the height of the initial peak (higher in interrogatives than in declaratives).

In BP, yes-no questions display different intonational patterns across regions, while contrasting with statements in nuclear accent and/or boundary tone (Frota et al., 2015). In the North (Paraíba), a rising nuclear contour is found, showing a H% tonal boundary following a L* nuclear accent, as illustrated in Figure 1 top left panel, or a L*+H accent. In center varieties of BP, yes-no questions are intonationally marked by the nuclear pitch accent (as in Rio de Janeiro, São Paulo and Minas Gerais). Statements and yes-no questions have a common boundary tone (L%), and different nuclear pitch accents (H+L* for statements and L*+H for yes-no questions). Therefore, a rising-falling contour characterizes yes-no questions, as shown in Figure 1, top right panel (an example from Minas Gerais). Finally, a monotonal pitch accent (L*) and a bitonal boundary tone (HL%) are found in the South (Rio Grande do Sul), as another instance of a rising-falling contour shown in Figure 1, bottom panel. These intonational patterns have been extensively studied in previous production research (Castelo and Frota, 2015; Castelo and Frota, 2017; Frota et al., 2015).

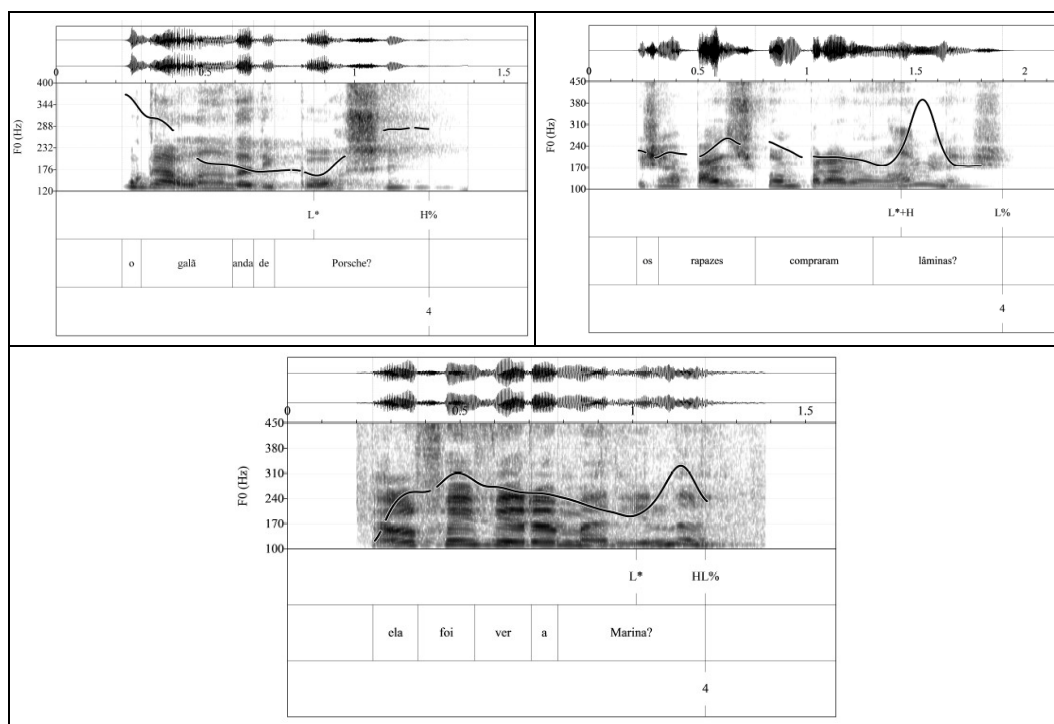


Figure 1 - The phonological patterns of yes-no question in BP: the rising contour L* H% (top left panel), the rising-falling L*+H L% (top right panel) and the L* HL% contour (bottom panel).

For BP, some studies have also shown that the pre-nuclear contour has slightly higher F0 values in interrogatives in the Rio de Janeiro (Moraes, 2008) and these values seem to be clearly higher for interrogatives in Northeastern varieties (Lira, 2009). It has been shown that the perception of yes-no questions in Sergipe, a Northeastern variety, and Santa Catarina, a Southern variety, may be guided by pre-nuclear cues, especially if the height of the initial peak is higher in yes-no questions than in the statements (Nunes and Seara, 2015). Results have also shown that speakers from Sergipe identify pre-nuclear cues more successfully than speakers from Santa Catarina.

The present study examines the perception of native and non-native speakers from Northern (Paraíba), Center (Minas Gerais) and Southern (Rio Grande do Sul) varieties with respect to the dialectal differences found in previous production research. From previous findings it is expected that BP speakers from different varieties show native-like perception patterns constrained by the set of cues that provides a more robust characterization of the sentence type distinction in their variety.

3 METHODOLOGY

3.1 Participants and language varieties

The perception experiments were conducted in three dialectal areas of BP: João Pessoa in Paraíba – PBA (North); Belo Horizonte in Minas Gerais - MG

(Center); and Porto Alegre in Rio Grande do Sul – RGS (South)¹. Forty-eight educated native speakers, of both genders (15 in Paraíba; 20 in Minas Gerais and 13 in Rio Grande do Sul) were tested by local researchers. Participants were aged between 18 and 55. Considering participants' performance in the training phase (cf. section 3.3 bellow), forty-five subjects were included in the final analysis: 15 in Paraíba; 18 in Minas Gerais and 12 in Rio Grande do Sul.

3.2 Materials

The stimuli were taken from the corpus of the InAPoP Project (*Interactive Atlas of the Prosody of Portuguese* - Frota, 2012-2015). They consist of read sentences, which were previously analyzed in a production study and evaluated for naturalness by native speakers. Both the natural versions and manipulated versions of the original sentences were used, in a total of 32 stimuli (16 natural and 16 manipulated). The natural and synthesized stimuli were equally distributed between each of two conditions, considering the melodic contour: the rising condition and the rising-falling condition. The rising condition was composed by 8 natural and 8 manipulated utterances showing a rising nuclear contour, as found in the North (either L* H% or L*+H H% as nuclear patterns). The rising-falling condition was composed by 8 natural and 8 manipulated utterances showing the rising-falling nuclear contour from the Center-South (either L*+H L% or L* HL%). Table 1 shows stimuli used according to nuclear contour shape, phonological representation, and location of word stress in the nuclear word.

In the manipulated condition, pre-nuclear cues (initial peak and internal pitch accents) were equalized using Praat in order to ensure that the perceived differences were restricted to the nuclear contour patterns. In other words, peak height and tonal density were the same for all the manipulated stimuli. Therefore, these features at the pre-nuclear region could not distinguish between varieties.

Three repetitions of each stimulus were randomly presented. Thus a total of 4320 responses were obtained (45 subjects x 32 stimuli x 3 repetitions).

Table 1 - Stimuli

Nuclear contour shape	<i>North</i>		<i>Center-South</i>	
	Rising		Rising-falling	
Phonological representation	L* H%	L*+H H%	L*+H L%	L* HL%
Penultimate stress	2	2	2	2
Antipenultimate stress	2	2	2	2
Total	8		8	

¹ The acronyms adopted follow the standardization defined in the InAPoP Project, which does not correspond to the official acronyms of the Brazilian states.

3.3 Perception task

The task consisted of an identification task divided into two phases: training and test. The utterances were presented randomly to the participant who must choose whether the sentence type was declarative or interrogative, on a scale from 1 (declarative) to 5 (interrogative). Participants were instructed to respond in a spontaneous way, and warned that they only had 3 seconds to respond. Otherwise, another utterance was automatically played and the item was left unanswered.

In the training phase, participants listened to natural native declarative and interrogative utterances. This phase was used to familiarize participants with the task and to measure participants' performance. Given that distinguishing between natural declarative and interrogative utterances was a baseline requirement, participants who obtained less than 50% accuracy at this phase were excluded from the final analysis. Participants could use the break at the end of the training phase for clarifying doubts. After the break, the test phase started. At this stage, participants must identify the sentence type of the utterances they hear. There were presented only yes-no question stimuli.

The task was implemented using the software *Super Lab 5.0*, which records participants' answers and reaction times. The entire task lasted 10 minutes and took place in a silent room, without external interferences.

3.4 Statistical analysis

A Mixed ANOVA was used to examine the effects of the variables region (North, Center and South) and type of stimulus (native versus non-native). Wilcoxon signed-rank non-parametric tests and Paired sample T parametric-tests were used to analyze the effect of the factor type of stimulus within each region. The non-parametric tests were used when significant results were found for the pre-tests of Normality and Homogeneity of data.

4 RESULTS

The analysis was based on the response scale used by the participants, where 1 means declarative and 5 interrogative. This scale represents the degree of certainty of the subject in relation to the given answer. The response groups 1 and 2 were taken to represent the choice of the declarative option, 1 (certainty) and 2 (almost certain); group 3 answers represent the choice of an uncertain response (doubt); and the response groups 4 and 5 were taken to represent the choice of the interrogative option, 4 (almost certain) and 5 (certainty). The results for the natural stimuli are presented first, followed by the results for the manipulated stimuli.

4.1 Natural condition

There was a significant main effect of type of stimulus in the perception of the native and non-native patterns of yes-no questions ($F(1,1032) = 21.503, p < .001$), and a significant interaction between type of stimulus and region ($F(2,1032) = 6.638, p = .001$). In other words, regional differences in intonation patterns of yes-no questions impact the perception of this sentence type as different from declaratives.

Table 2 shows the responses obtained for native and non-native questions in the three regions. The participants from PBA (North) did not show a different perception pattern for their native yes-no question contour and the non-native contour. The averages for the two groups were not statistically different: 4.3 for native and 4.28 for non-native perception ($Z = -0.008, p = .993$). By contrast, the participants from MG (Center) and RGS (South) display a different pattern of responses for native and non-native contours. In MG, the averages were 4.24 for native and 4.07 for non-native stimuli ($Z = -2.256, p < .05$). In RGS, the difference is even larger: 4.6 for native and 4.2 for non-native stimuli ($Z = -6.197; p < .05$) (see Table 3). These results suggest that there is a different perception behavior between speakers from the North, who are not sensitive to dialectal patterns, and the Center-Southern speakers, who are sensitive to dialectal differences, but are more so in the South than in the Center area. Brazilian speakers are gradually more sensitive to regional differences in the yes-no question pattern towards the South, and interestingly this perception pattern is parallel to patterns found in production data. Only the North is characterized by rising contours, and the distribution of the rising-falling contour gradually increases towards the South.

Table 2 - Mean and standard deviation of the responses to natural stimuli presented by condition (native and non-native) in the three regions analyzed.

	<i>Region</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>N</i>
Native yes-no question	PBA	4.3000	1.15242	350
	MG	4,2427	1,11583	412
	RGS	4,6227	,75766	273
	Total	4,3623	1,05787	1035
Non-native yes-no question	PBA	4,2829	1,23580	350
	MG	4,0728	1,29928	412
	RGS	4,1941	,94851	273
	Total	4,1758	1,19638	1035

Table 3 - Wilcoxon signed-rank test for the responses to natural stimuli within each region

	PBA	MG	RGS
Z	-,008b	-2,256b	-6,197b
Sig. (2-tailed)	,993	,024	,000

The differences among regions obtained in reaction times confirmed the findings from participants' responses. There was a main effect of stimulus type ($F(1,1033) = 5.914, p < .05$) and a significant interaction between stimulus type and region ($F(2,1033) = 13.160, p < .001$).

Table 4 shows the reaction times obtained for native and non-native questions in the three regions. Surprisingly, native speakers from PBA (North) did not process native stimuli faster than non-native stimuli (native, $M = 915.94$ ms; non-native, $M = 818$ ms), and the difference between native and non-native was statistically significant ($Z = -2,602, p < .05$). Native speakers from the Center-South, on the other hand, show the expected pattern, i.e., they processed native stimuli faster than non-native stimuli (see Table 4). The difference between the perception of native and non-native yes-no questions was significant both in MG ($Z = -4,646, p < .001$) and RGS ($Z = -2,144, p < .05$) (see also Table 5).

Table 4 - Mean and standard deviation of the reaction times of the responses to natural stimuli presented by condition (native and non-native) in the three regions analyzed.

	<i>Region</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>N</i>
Native yes-no question	PBA	915,9486	604,95967	350
	MG	831,5521	605,58745	413
	RGS	951,6447	587,91055	273
	Total	891,7104	602,34299	1036
Non-native yes-no question	PBA	818,0200	585,63611	350
	MG	1023,0339	671,46529	413
	RGS	1037,4725	615,81724	273
	Total	957,5772	636,21213	1036

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Table 5 - Wilcoxon signed-rank test for the reaction times to natural stimuli within each region

	PBA	MG	RGS
Z	-2,602b	-4,646b	-2,144b
Sig. (2 tailed)	,009	,000	,032

4.2 Manipulated condition

Unlike with natural stimuli, participants' responses with manipulated stimuli showed more uncertainty. Response means lower than 4 show a degree of uncertainty whether the utterances are or not interrogatives. In the manipulated condition, in which the pre-nuclear differences were equalized, a larger range of responses (between 3,8 and 4,5) was found than in the natural condition (between 4,0 and 4,6), reflecting the higher degree of uncertainty overall. This result suggests that participants also use pre-nuclear cues for perceiving yes-no questions.

There was a significant main effect of type of stimulus in the perception of the native and non-native patterns of yes-no questions ($F(1,1033) = 20.05, p < .001$), and a significant interaction between type of stimulus and region ($F(2,1033) = 16.420, p < .001$). Again, regional differences in intonation patterns of yes-no questions impact the perception of this sentence type as different from declaratives. Thus, the manipulated condition displays the patterns found in the natural condition.

Table 6 shows the responses obtained for native and non-native questions in the three regions in the manipulated condition. In PBA, no significant difference in the perception of native and non-native patterns of yes-no questions was found (native, $M = 4.08$; non-native, $M = 4.25$; $Z = -1.75, p = .079$), as with natural stimuli. Participants from the Center-South, by contrast, show differential perception between native and non-native yes-no question patterns, with significant differences for both MG ($Z = -3.010; p < .05$) and RGS ($Z = -6.718, p < .001$) varieties (see also Table 7). Thus participants' responses in the manipulated condition corroborate the differences in perception across regions found for natural stimuli. This suggests that the nuclear pattern is a crucial cue for the perception of yes-no questions.

Table 6 - Mean and standard deviation of the responses to manipulated stimuli presented by condition (native and non-native) in the three regions analyzed.

	<i>Region</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>N</i>
Native yes-no question	PBA	4,0891	1,31083	348
	MG	4,0807	1,17817	409
	RGS	4,4588	,82948	279
	Total	4,1853	1,15571	1036
Non-native yes-no question	PBA	4,2557	1,25236	348
	MG	3,7995	1,39814	409
	RGS	3,8602	1,09536	279
	Total	3,9691	1,28875	1036

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Table 7 - Wilcoxon signed-rank test for the responses to manipulated stimuli within each region

	PBA	MG	RGS
Z	-1,757b	-3,010b	-6,718b
Sig. (2-tailed)	,079	,003	,000

Results from reaction times in the manipulated condition also confirmed that native yes-no questions are processed differently from non-native yes-no questions (main effect of stimulus type, $F(1,1034) = 17,412, p < .001$), and that there are significant differences in perception across dialectal areas (interaction stimulus type*region, $F(2,1034) = 13,466, p < .001$).

Table 8 shows the reaction times obtained for native and non-native questions in the three regions, in the manipulated condition. Reaction times had similar patterns to those found in the natural condition. For PBA participants there was no significant difference between native yes-no questions and non-native ones (native, $M = 843$ ms, non-native, $M = 818$ ms; $t = 1,72$; $p = .085$), whereas Center-Southern participants responded faster to native stimuli. The differences between native and non-native yes-no question perception were significant in MG ($t = -5.56$, $p < .001$) and in RGS ($t = -3,25$, $p = .001$). The main difference between the natural and manipulated conditions consisted of reaction times to non-native stimuli being generally higher in the manipulated than the natural condition. The slight increase in reaction times might be due to the absence of secondary cues in the pre-nuclear region that help the speaker to distinguish non-native from native yes-no questions.

Table 8 - Mean and standard deviation of the reaction times of the responses to manipulated stimuli presented by condition (native and non-native) in the three regions analyzed.

	<i>Region</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>N</i>
Native yes-no question	PBA	914,3037	569,43814	349
	MG	846,7946	601,66689	409
	RGS	968,1147	643,67356	279
	Total	902,1553	604,23077	1037
Non-native yes-no question	PBA	843,0029	674,59339	349
	MG	1071,2396	668,82541	409
	RGS	1133,9928	664,23474	279
	Total	1011,3105	680,02833	1037

5 DISCUSSION

The results demonstrated differences in the perception of yes-no questions among the dialectal areas considered. The research questions we addressed are discussed in the light of these findings.

1. Do Brazilian speakers from different regions recognize the differences between native and non-native yes-no question nuclear contours?

Brazilian speakers' ability to differentiate between native and non-native patterns was found to depend on their native variety. Participants from the Center-Southern regions distinguished between native and non-native yes-no questions, unlike the participants from the North (PBA) whose responses (and reaction times) to native and non-native patterns were not significantly different. However, PBA participants' performance may be understood considering the fact that speakers from the North are generally bidialectal speakers, since they are exposed to, and also produce, the Center-South (non-native) yes-no question patterns, together with the North (native) pattern. The former pattern is usually taken to be the most prestigious one, and is frequently used as a standard variety in the media.

2. Do speakers use the cues in the pre-nuclear region to identify native and non-native yes-no questions?

The similarity in the findings for the natural and manipulated conditions clearly demonstrates that the nuclear pattern is a crucial cue for the perception of yes-no questions. In the manipulated condition, where potential pre-nuclear cues were removed, speakers from the Center-Southern regions kept their ability to differentiate native and non-native questions, as shown in their responses and reaction times. Although nuclear patterns were shown to play a decisive role, pre-nuclear cues also had an effect on perception. Unlike with natural stimuli, participants' responses with manipulated stimuli, where the pre-nuclear cues were absent, showed more uncertainty overall. In addition, reaction times to non-native stimuli were slower in the manipulated condition. These results suggest that participants also use pre-nuclear cues for perceiving yes-no questions. Pre-nuclear cues have a secondary role, but they were not distinctive and important enough to have a major impact on perception, as no differences were found in the performance of participants in the natural (containing pre-nuclear cues) and manipulated (without pre-nuclear cues) conditions.

3. Are the dialectal areas found in the production studies of yes-no questions in BP reflected in the perception patterns of speakers?

Production studies have described a North versus Center-South divide, with rising patterns in the North only, and rising-falling patterns in the Center and South. They have also found an increasingly more frequent use of the rising-falling contour from North to South (Castelo and Frota, 2015; Castelo and Frota, 2017; Frota et al., 2015). These two features were reflected in the perception data. Brazilian speakers from the Center-Southern regions, but not from the North, were shown to be sensitive to regional patterns. Furthermore, BP speakers were gradually more sensitive to regional differences in the yes-no question patterns towards the South, as speakers from RGS in the South were more sensitive than speakers from MG in the Center. The fact that both the rising and rising-falling nuclear contours were found in production in Northern varieties relates to the finding that subjects from the North do not distinguish their native rising pattern from the Center-Southern rising-falling patterns. By contrast, in the Center-Southern regions rising-falling contours were almost categorical in the production data, and speakers from these regions were sensitive to dialectal differences in perception. Thus, production and perception studies converge to indicate, first, that speakers from the North are bidialectal speakers, that is, they produce a local variant but they are also skilled at producing the Center-Southern variant, and that is why they have difficulties in perceiving the distinction between the native and non-native patterns. The variation found in yes-no questions in the North is probably conditioned to discursive styles and/or social variables, which need to be better investigated. Second, speakers from the Center-Southern areas are widely inclined to use their own variant, which they tend to recognize as standard BP and differentiate from the pattern that identifies Northern varieties, to which they are usually exposed mainly through immigration from the North to the Center-Southern areas.

6 CONCLUSION

Our hypothesis that perception patterns would mirror production patterns was borne out by the perception findings. Indeed, the perception patterns of speakers from the Center and South were similar, on the one hand, and different from the perception of speakers from the North, on the other. The prediction that regional cues in the pre-nuclear stretch would play a less relevant role than the nuclear contour patterns in the perception of yes-no questions was also confirmed. BP speakers showed native-like perception patterns constrained by the set of cues that provides a more robust characterization of the sentence type distinction in their variety.

In short, the current study demonstrated that examining the perception of intonational variation is a useful and complementary tool to our understanding of the intonational system. The correlations between production and perception in Portuguese point to a still unexplored field of research on PB prosody: the relation between production and perception of intonation. The more general question, which underlies the three research questions we addressed, ‘Do Brazilian speakers perceive the intonation differences between Brazilian Portuguese varieties?’, was answered by the present study through the main finding that perception patterns mirror production patterns. However, a limited number of varieties were investigated. Future studies need to include more varieties and examine whether dialectal areas found in production are indeed reflected in the perception of Brazilian Portuguese intonation.

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